Microprocessors and Assembly Languages

CSE 231

Referred Books

1. **Microprocessors and Interfacing
    Programming and Hardware
    Second Edition
    D.V. Hall**
2. **Assembly Language Programming
    Ytha Yu and Charles Marut**

Introduction to the Microprocessor and Computer

Outlines

▶ Historical Background

▶ The Electrical Age

▶ Microprocessor

▶ The Pentium Microprocessor

Historical Background

▶ Babylonians invented the **abacus** in 500 B.C

▶ Blaise Pascal invented a calculator in 1642 that was constructed of gears and wheels. Each gear contained 10 teeth.

▶ Charles Babbage began to create what he called his **Analytical Engine.** This machine was to generate navigation tables for the Royal Navy.

▶ The engine stored 1000 20-digit decimal numbers and variable program.

Analytical Engine
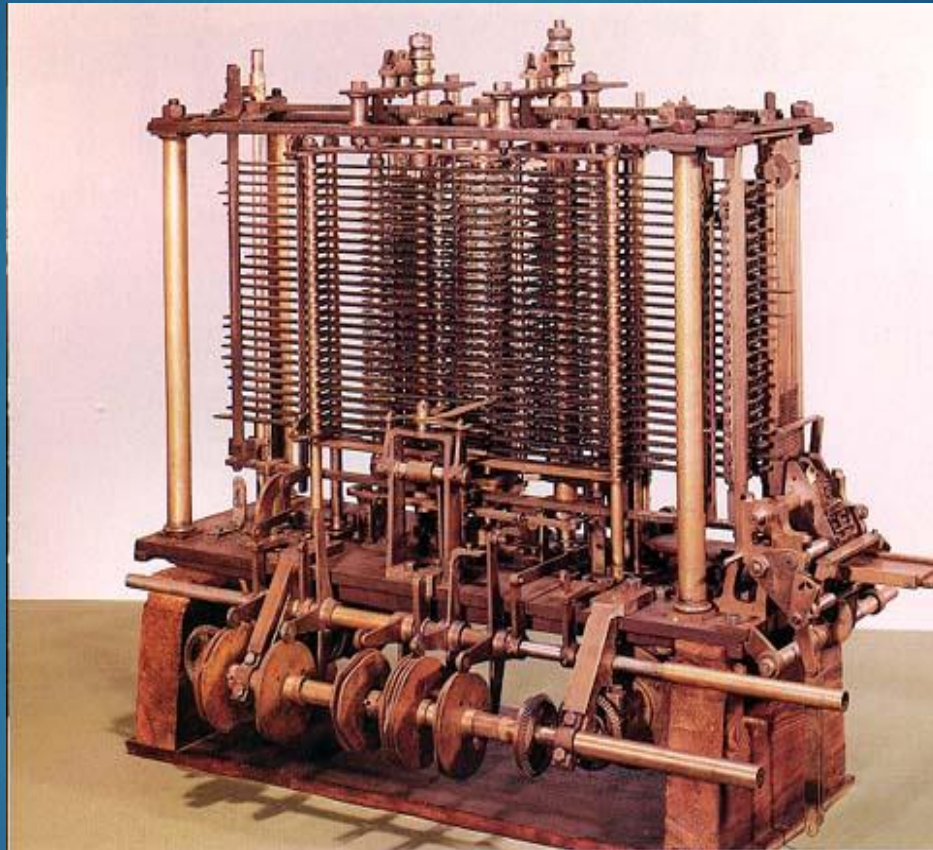
•Input to engine was through punched cards.

The Electrical Age

► The 1800s saw the arrival of the electric motor which conceived by Michael Farady

► In 1889,Herman Hollerith developed the punched card for storing data and he was commissioned for the 1890 census.

► In 1896, Hollerith formed a company called the Tabulating Machine Company.. After a number of mergers the Tabulating Machine Company was formed into the International business Machiness Corporation.

► The punched cards used in computer are called Hollerith cards. The 12-bit code used on a punched card is called Hollerith code.

# Herman Hollerith Tabulating Machine

The Electrical Age ..

- The first electronic calculating machine in 1941 by Konrad Zuse. He called Z3, was used in aircraft and missile design during World War Ⅱ for the German was effort.

- This first electronic computing system, which used vacuum tubes, was invented by Alan Turing . He called his machine **Colossus**.

- Colossus design allowed it to break secret German military codes generated by the mechanical **Engima machine**.

- Colossus was not programmable — it was a fixed-program computer system, which today is often called a **special-purpose computer**.
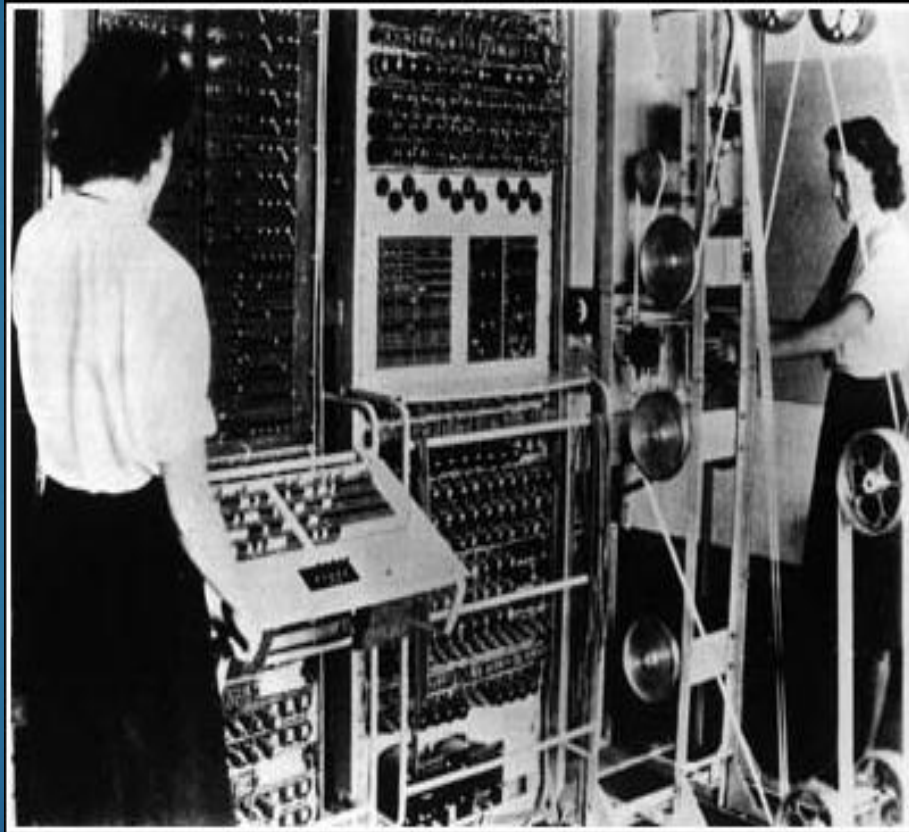
The Electrical Age

Z3
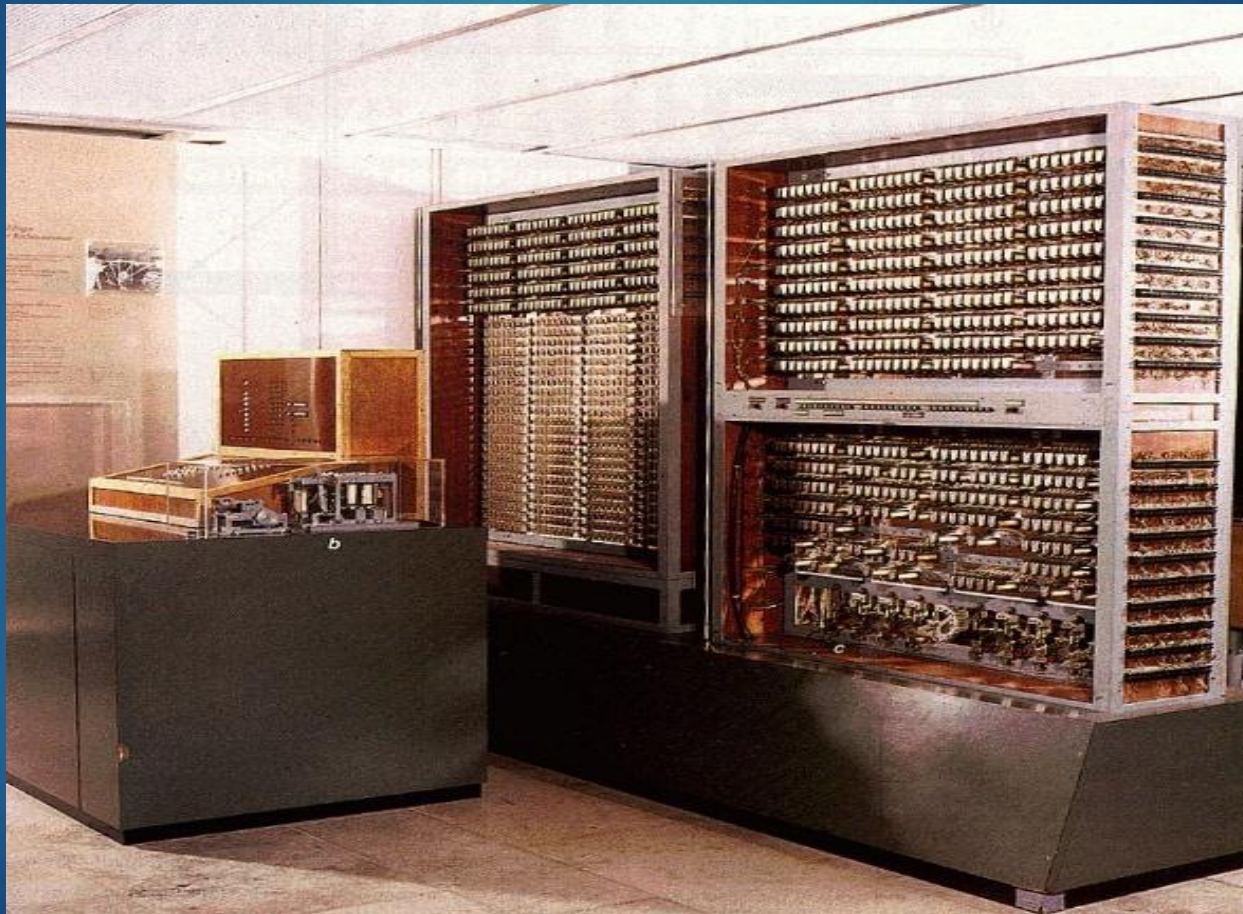
The Electrical Age

Colossus
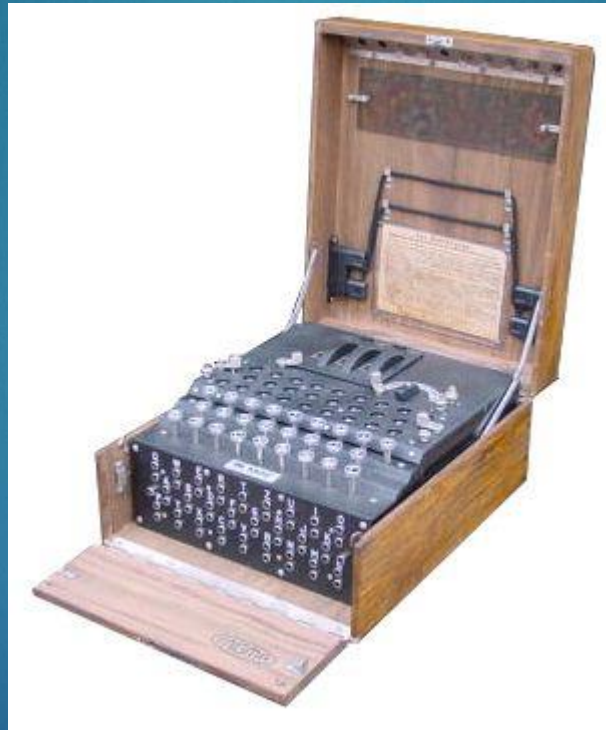
The Electrical Age

Enigma Machine

The Electrical Age
ENIAC

► The first general-purpose, programmable electronic computer system was developed in 1946 at the University of Pennsylvania.

► This first modern computer was called the ENIAC **(electronics Numerical Integrator and Calculator).**

► The ENIAC weighed over 30 tons, yet performed only about 100,000 operations per second.
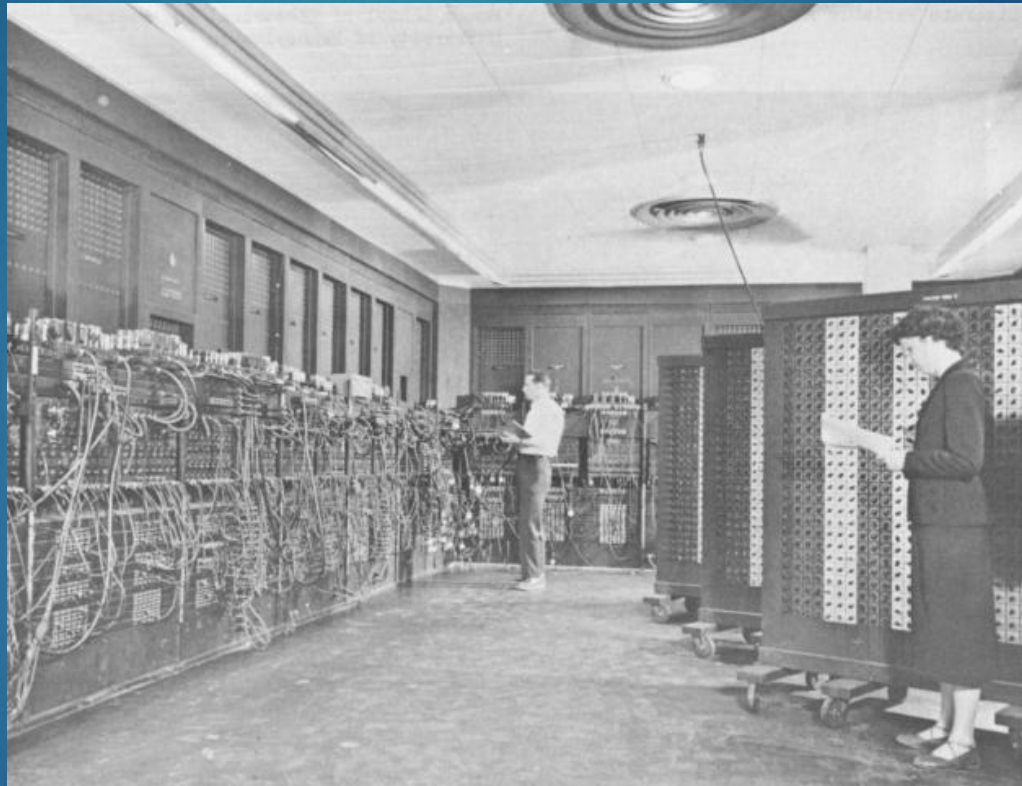
The Electrical Age..

The Disadvantages of ENIAC

- ▶ The ENIAC was programmed by rewiring its circuits —a process that took many workers several days to accomplish.

- ▶ ENIAC was the life of the vacuum tube components, which required frequent maintenance.

The Electrical Age ..

ENIAC

•containing over 17,000 vacuum tubes and over 500 miles of wires.

The Electrical Age..

▶ The development of transistor in 1948 at Bell Labs. In 1958 invent the integrated circuit by Jack Kilby of Texas Instruments.

▶ The IC led to the development of digital integrated circuits (RTL, or resistor-to-transistor logic) in the 1960s and the first microprocessor at Intel Corporation in 1971.

▶ Marcian E. Hoff, developed the 4004 microprocessor.

The Electrical Age ..

Intel 4004
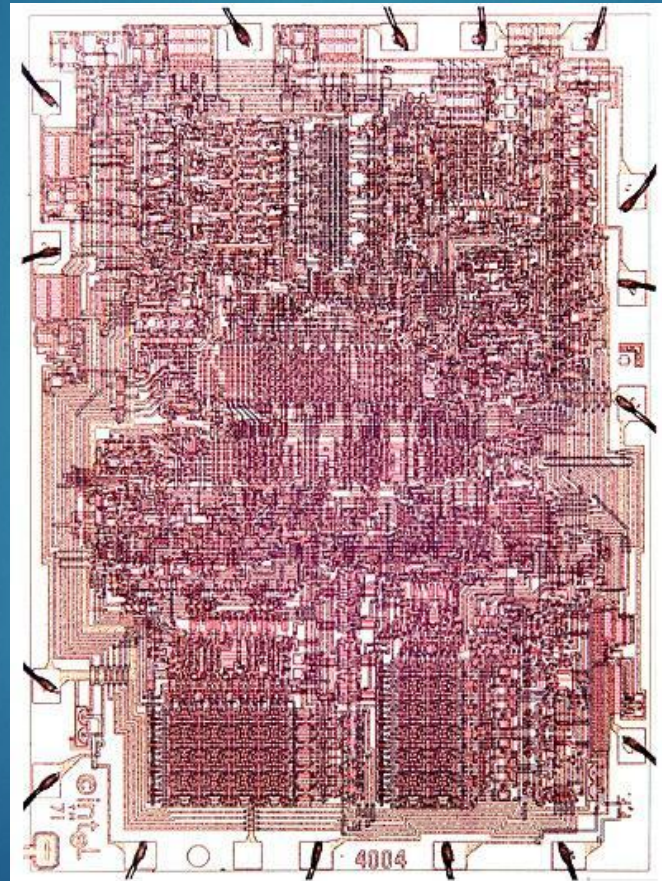
Programming Advancements

▶ The first language is **machine language**

▶ Mathematician John von Neumann was the first person do develop a system that accepted instructions and stored them in memory.

Programming Advancements..

- Assembly language was used to simplify the chore of entering binary code into a computer as its instructions. computer systems such as the UNIVAC.

- In 1957 Grace Hopper developed the first high-level programming language called FLOW-MATIC.

- In the same year, IBM developed FRTRAN (FORmula TRANslator). A year after FORTRAN, was ALGOL(ALGOrithmic language).

UNIVAC
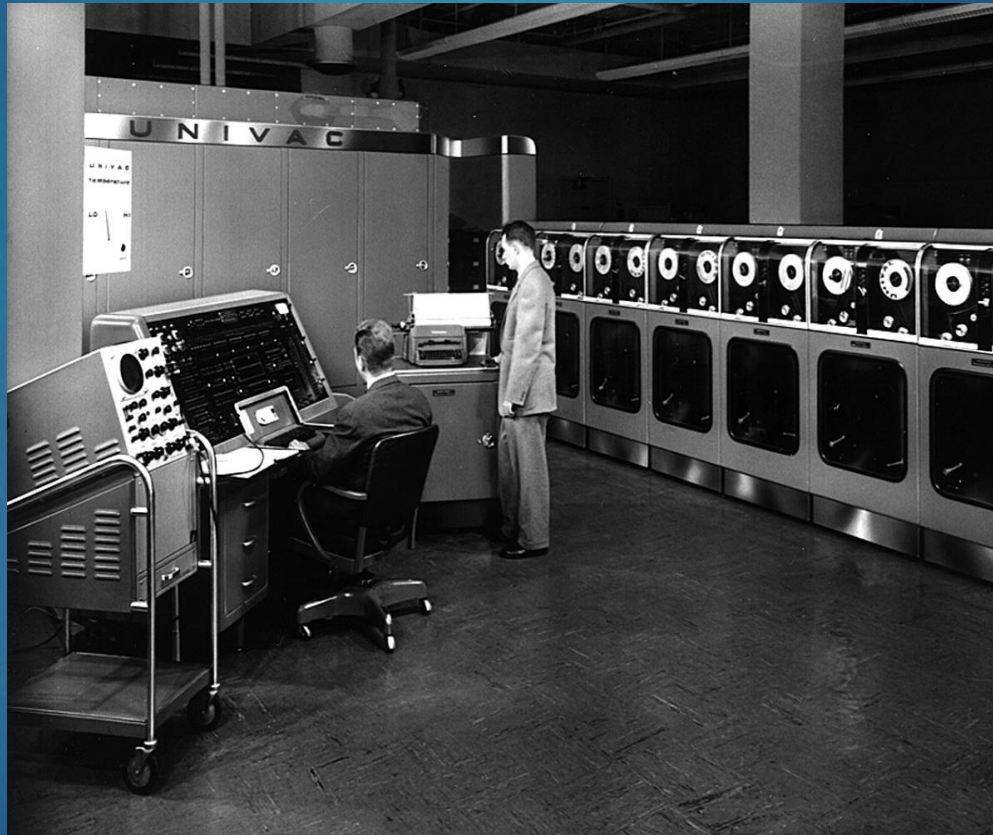
Programming Advancements..

▶ The first truly successful programming language for business application was COBOL(**Computer Business Oriented Language**).

▶ Another once-popular business languages is RPG (Report Program Generator)

Programming Advancements...

- Some of the languages BASIC, C/C++, PASCAL, and ADA are more common.

- A new version of basic, VISUAL BASIC, has made programming in the WINDOWS environment easier.

- Most video games written for the personal computer are written almost exclusively in assembly language.

- Assembly language is also interspersed with C/C++ and PASCAL to perform machine control functions efficiently.

- The ADA language is used heavily by the Department of Defense.

The Microprocessor Age

▶ The world's first microprocessor, the Intel 4004, was microprocessor—a programmable controller on a chip. It addressed a mere 4096 4-bit wide memory locations.

▶ It was fabricated with the then-current state-of-the-art P-channel MOSFET and execute instructions at the slow rate of 50 KIP (kilo-instructions per second).

▶ Other companies, particularly Texas Instrument (TMS-100), also produced 4-bit microprocessors.

Intel 4004
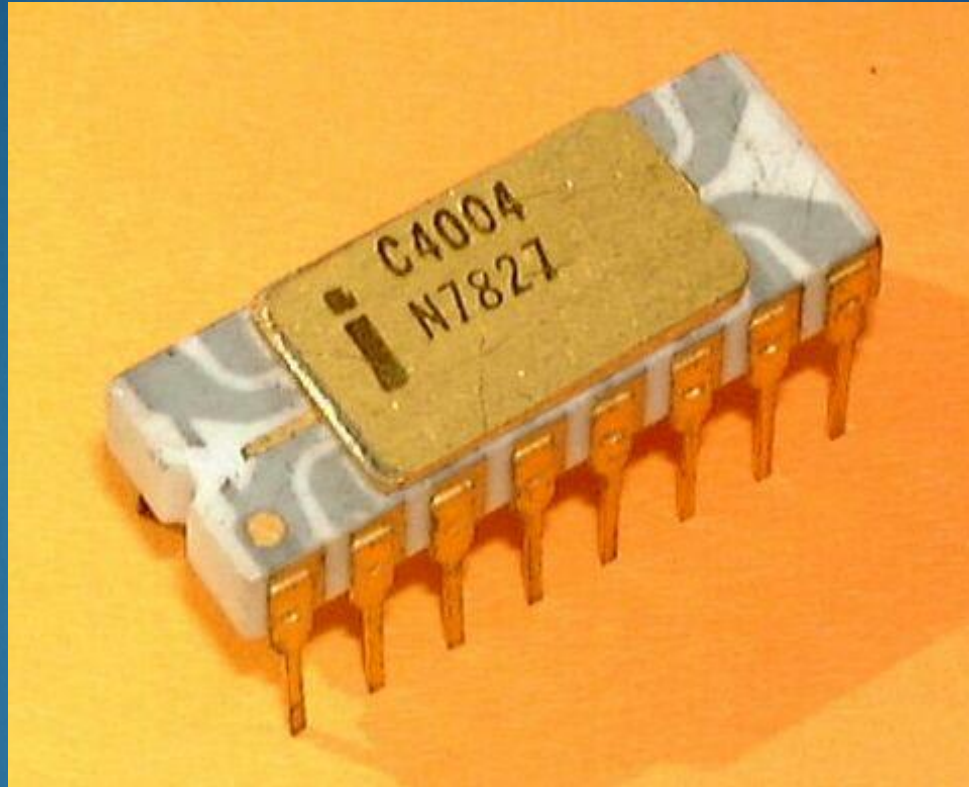
▶ The 4-bit microprocessor debuted in early video game systems and small microprocessor-based control system.

The Main Problems with 4004

- Speed
- Width
- Memory size
- Intel released the 4040, an update version of the earlier 4004.
- The 4-bit microprocessor debuted in early video game systems and small microprocessor-based control systems.
- Most calculators are still based on 4-bit microprocessor.

Intel 8008

▶ In 1971, Intel corporation released the 8008, an extended 8-bit version of the 4004 microprocessor.

▶ The memory size are 16K bytes

▶ The instructions are 48

Intel 8008
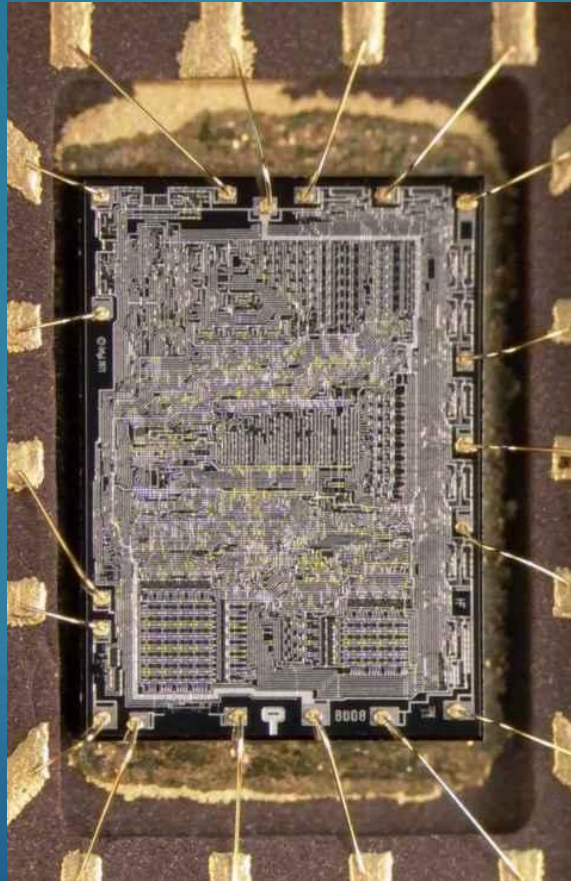
Other 8-bit Processors

► RCA 1802
=> with a different architecture than other 8-bit processors.

► IBM 801
=>based on RISC design principles.

► Moto 6800
=>with 78 instructions and probably the first microprocessor with an *index register*.

► MOS 6502
=>Motorola's design team quit en masse and formed their own company, MOS Technology.

► Fairchild F8
=>The 8-bit Fairchild F8 (also known as the 3850) microcontroller was Fairchild's
     first processor.

8-bit Processor

▶ Intel introduced the 8080 microprocessor in 1973. The first modern 8-bit microprocessors.

▶ Motorola Corporation introduced its MC6800 microprocessor.

MC6800

Early 8-bit Microprocessor

Manufacturer	Part number
Fairchild	F-8
Intel	8080
MOS Technology	6502
Motorola	MC6800
National semiconductor	IMP-8
Rockwell International	PPS-8
Zilog	Z-8

8-bit Processors

▶ Zilog remained in the background, concentrating on microcontrollers and embedded controllers.

▶ Rockwell has all but abandoned microprocessor development in favor of modem circuit.

Features of 8080

▶ Executed them 10 times faster than the 8008. an addition that took 20μs on an 8008-based system required only 2.0μs on 8080-based system

▶ Compatible with TTL.

▶ 8080 address memory with 64K bytes than the 8008 with 16K bytes.

Personal Computer (PC)

▶ The first personal computer, the MITS Altair 8800, was released in 1974.

▶ The basic language interpreter was developed by Bill Gates.

▶ The assembler was written by Digital Research Corporation, which once produce DR-DOS for the computer.

The 8085 Microprocessor

▶ In 1977, Intel corporation introduced an update version of the 8080—the 8085. the last 8-bit microprocessor developed by Intel.

▶ An addition that took 2.0μs on the 8080 required only 1.3 μs on the 8085.

▶ Adding two instructions to enable/disable three added interrupt pins.

8-bit Microprocessors

▶ the main advantages of the 8085 were its internal clock generator, internal system controller, and higher clock frequency.

▶ Another company that sold 500 million 8-bit microprocessors is Zilog Corporation, which produced the Z-80 microprocessor.

Intel 8085
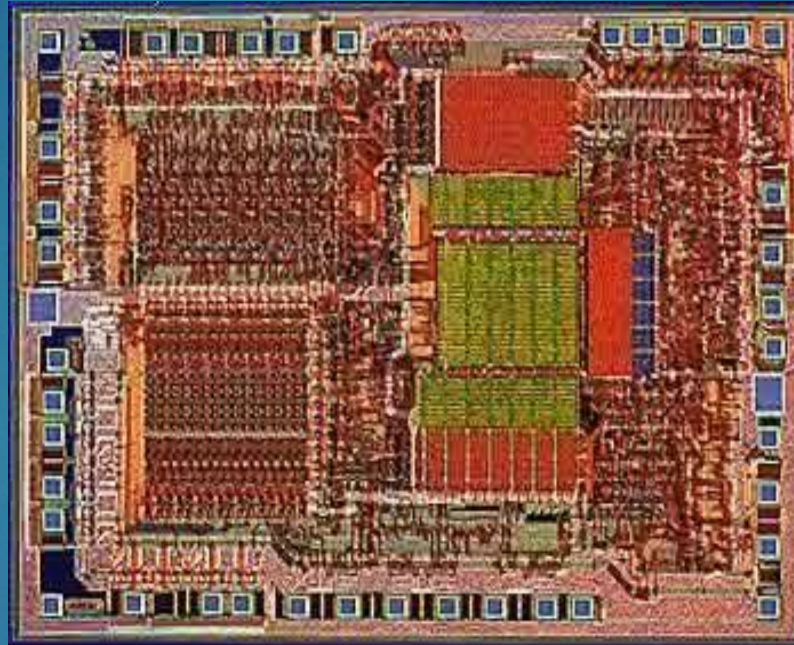
▶ The most successful 8-bit, general-purpose microprocessor is 8085.

The 8086 Microprocessor

Intel® 8086 Processor
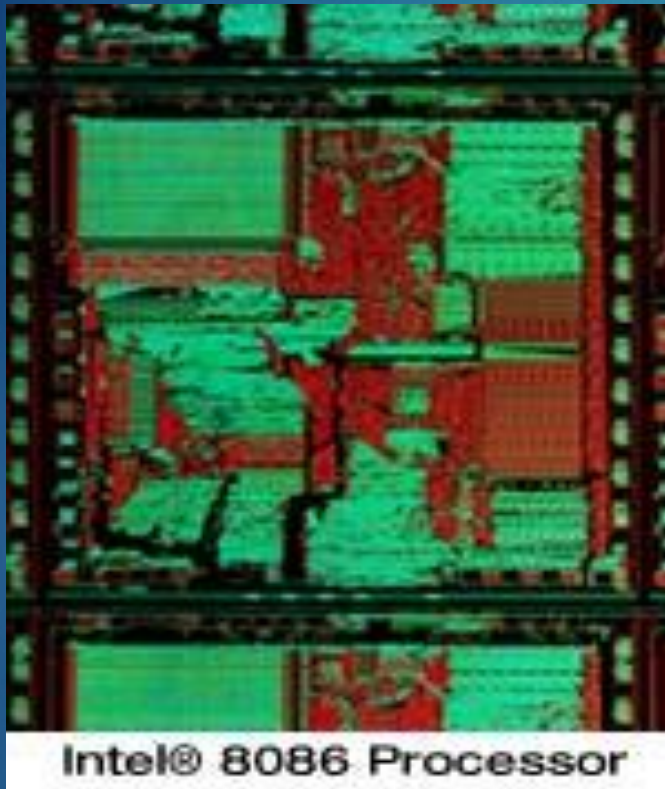
- ▶ Introduced in 1978, contained only 29,000 transistors and ran at 5 MHz.

- ▶ Containing 800,000 instructions.

The Modern Microprocessor

- MIPS

- CISC and RISC

- In 1979, Intel released the 8088 microprocessor 16-bit microprocessor, which executed instructions in as little as 400 ns(2.5 MIPS)

- 8088 having 29,000 transistors.

- 8086 and 8088 microprocessors were called CISC because of the number and complexity of instructions

- In 1981, IBM Corporation decided to use the 8088 microprocessor in its personal computer.

The Feature of the 8086 and 8088

▶ 8086 and 8088 addressed 1M bytes of memory.

▶ A small 4- or 6-byte instruction cache or queue that prefetched a few instructions before they were executed.

▶ 20,000 variations on the 8086 and 8088 microprocessors.

▶ 16-bit microprocessor provided more internal register storage space than the 8-bit microprocessor.

The 80286 Microprocessor

▶ The 80286 (also a 16-bit architecture) addressed a 16M byte memory system instead of a 1M byte system.

▶ The clock speed of the 80286 was increased it executed some instructions in 4.0MIPS with the original release 8.0 MHz version.

Intel 80286
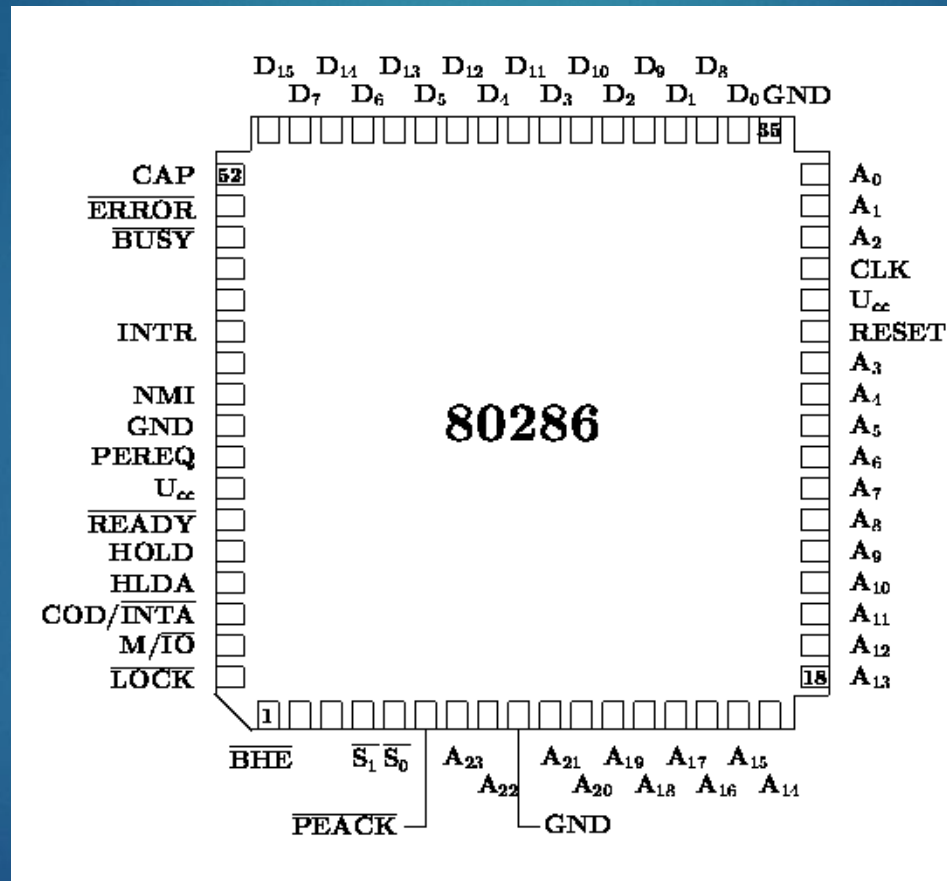
The 32-bit Microprocessor

▶ The 80386 was Intel's first practical 32-bit microprocessor.

▶ Contained a 32-bit data bus and 32-bit memory address. addressed up to 4G bytes of memory.

▶ 80386 included a memory management unit.

The 32-bit Microprocessor ..

▶ The 80386 was available in a few modified version such as the 80386SX which addressed 16M bytes of memory through a 16-bit data and 24-bit address bus.

▶ The instruction set of the 80386 microprocessor was upward-compatible with the earlier 8086, 8088,and 80286 microprocessors .

Other 32-bit Microprocessors

- BELLMAC-32A
  =>AT&T's Computer Systems introduced the
    world's first single-chip 32-bit microprocessor.

- Motorola 68010

- NS 32032

- In 1983, Acorn Computers Ltd develop its own processor called the Acorn RISC Machine, or ARM

The 32-bit Microprocessor

► Applications that require higher microprocessor speeds and large memory systems include software systems that use a GUI.

► The least sophisticated VGA (variable graphics array) video display has a resolution of 640 pixels per scanning line with 480 scanning lines.

► We often call a GUI a WYSIWYG (**what you see is what you get**) display.

The 80486 Microprocessor

▶ In 1989, Intel released the 80486 microprocessor, and an 8K byte cache memory system into one integrated package.

▶ The internal structure of the 80486 was modified from the 80386 so that about half of its instructions executed in one clock instead of two clocks.

▶ 80486 was available in a 50 MHz version.

80486

▶ Double-clocked version are 80486DX2 with 66MHz.

▶ Triple-clocked version are 80486DX2 with 100MHz

▶ AMD has produced a triple-clocked version that runs with a bus speed of 40MHz and a clock speed of 120MHz.

▶ Other versions of the 80486 were called Overdrive processors

TABLE 1–2 Many modern Intel and Motorola microprocessors.

Manufacturer	Part	Data Bus Width	Memory Size
Intel	8048	8	2K internal
	8051	8	8K internal
	8085A	8	64K
	8086	16	1M
	8088	8	1M
	8096	16	8K internal
	80186	16	1M
	80188	8	1M
	80251	8	16K internal
	80286	16	16M
	80386EX	16	64M
	80386DX	32	4G
	80386SL	16	32M
	80386SLC	16	32M + 1K cache
	80386SX	16	16M
	80486DX/DX2	32	4G + 8K cache
	80486SX	32	4G + 8K cache
	80486DX4	32	4G + 16K cache
	Pentium	64	4G + 16K cache
	Pentium Overdrive (P24T) (replaces 80486)	32	4G + 16K cache
	Pentium Pro processor	64	64G + 16K L1 cache + 256K L2 cache
	Pentium II	64	64G + 32K L1 cache + 512K L2 cache
	Pentium II Xeon	64	64G + 32K L1 cache + 512K or 1M L2 cache
	Pentium III, Pentium 4	64	64G + 32K L1 cache + 256K L2 cache
Motorola	6800	8	64K
	6805	8	2K
	6809	8	64K
	68000	16	16M
	68008Q	8	1M
	68008D	8	4M
	68010	16	16M
	68020	32	4G
	68030	32	4G + 256 cache
	68040	32	4G + 8K cache
	68050	32	Proposed, but never released
	68060	64	4G + 16K cache
	PowerPC	64	4G + 32K cache

The Pentium Microprocessor

- The Pentium, introduced in 1993, was similar to the 80386 and 80486 microprocessors.

- The two introductory versions of the Pentium operated with clocking frequency of 60 MHz and 66MHz, and a speed of 110MIPS.

- Double-clocked operating at 120 MHz and 133 MHz, as were higher-speed versions (the fastest version is the 233 MHz).

Pentium

- The Pentium contained an 8K byte instruction cache and an 8K byte data cache.

- Cache size was increased to 16K bytes

- The memory system contained up to 4G bytes, with data bus 64 bits. The data bus transfer was either 60 MHz or 66 MHz.

- Recent versions of the Pentium included addition instructions, called multimedia extensions, or MMX instructions.

80486

▶ Intel released the long-awaited Pentium OverDrive(P24T) for order 80486 systems that operate at earlier 63MHz or 83 MHz clock.

▶ Most ingenious feature of the Pentium
a. Dual integer processors: contains two independent internal integer processors call superscalar technology.
b. jump prediction technology: speeds the execution of programs that include loops.

iCOMP-rating index

FIGURE 1–2 The Intel iCOMP index.

Processor	iCOMP rating
Pentium 200	1810
Pentium 166	1570
Pentium 133	1110
Pentium 120	1000
Pentium 100	815
Pentium 90	735
Pentium 75	610
Pentium 83*	583
Pentium 66	567
Pentium 60	510
Pentium 63*	443
486 DX4 100	435
486 DX4 75	319
486 DX2 66	297
486 DX 50	249
486 DX2 50	231
486 SX2 50	180
486 DX 33	166
486 SX2 40	145
486 SX 33	136
486 DX 25	122
486 SX 25	100
486 SX 20	78
386 DX 33	68
386 SX 33	56
386 DX 25	49
386 SX 25	39
386 SX 20	32
386 SX 16	22

Note: * = Pentium OverDrive, the first part of the scale is not linear, and the 166 MHz and 200 MHz are MMX technology

replace some of the RISC (**reduced instruction set computer**) machines that currently execute one instruction per clock. Note that some newer RISC processors execute more than one instruction per clock through the introduction of supersca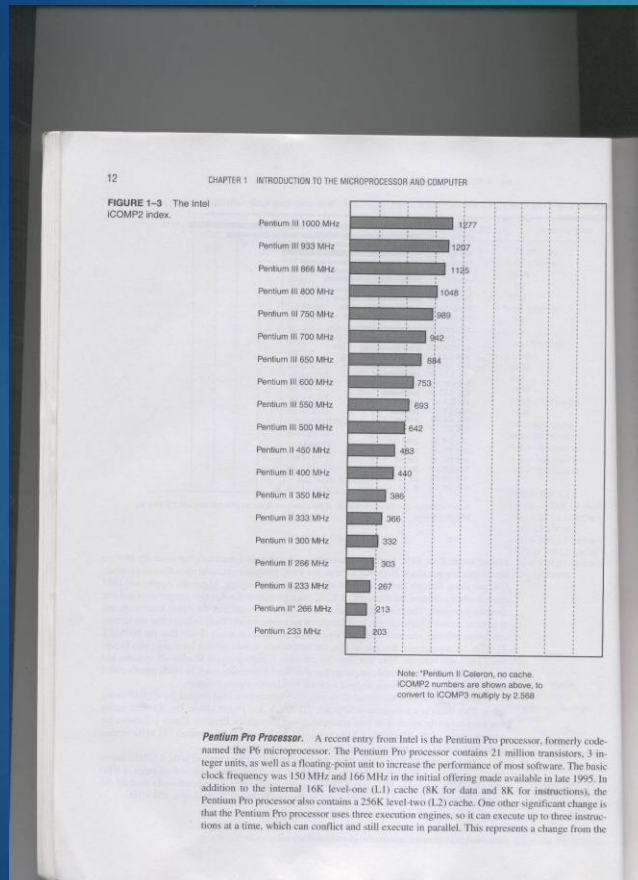ler technology. Motorola, Apple, and IBM have recently produced the PowerPC, a RISC microprocessor that has two integer units and one floating-point unit. The PowerPC certainly boosts the performance of the Apple Macintosh, but at present is slow to emulate the Intel family of microprocessors. Tests indicate that the current emulation software executes DOS and Windows applications at speed slower than the 80486SX 25 MHz microprocessor. Because of this, the Intel family should survive for many years in personal computer systems. Note that there are currently 6 million Apple Macintosh[3] systems and well over 260 million personal computers based on Intel microprocessors. In 1998, reports stated that 96 percent of all PCs were shipped with the Windows operating system.

In order to compare the speeds of various microprocessors, Intel devised the iCOMP-rating index. This index is a composite of SPEC92, ZD Bench, and Power Meter. The iCOMP1 rating was used to rate the speed of all Intel microprocessors through the Pentium. Figure 1–2 shows the relative speeds of the 80386DX 25 MHz version at the low end to the Pentium 233 MHz version at the high end of the spectrum.

Since the release of the Pentium Pro and Pentium II, Intel has switched to the iCOMP2 index, which is scaled by a factor of 10 from the iCOMP1 index. A microprocessor with an index of 1000 using iCOMP1 is rated as 100 using iCOMP2. Another difference is the benchmarks used for the scores. Figure 1–3 shows the iCOMP2 index listing the Pentium II at speed up to 450 MHz.

[3]Macintosh is a registered trademark of Apple Computer Corporation.

iCOMP2 index

▶ scaled by a factor of 10 from the iCOMP1 index

Pentium Pro Processor

▶ contains 21 million transistors, 3 integer units, as well as a floating-point unit to increase the performance of most software.

▶ The basic clock frequency was 150MHz and 166 MHz in the initial.

▶ The internal 16K level-one(L1) cache and contains a 256K level-two(L2) cache.

Pentium Pro Processor

▶ The Pentium Pro processor uses three execution engines, so it can execute up to three instructions at a time.

▶ Pentium pro can address either a 4G byte memory system or a 64G byte memory system.

Pentium Microprocessors

▶ The main reason for the change is that the L2 cache

▶ The L2 cache and microprocessor are on a circuit board called the Pentium module. This on-board, L2 cache operates at a speed of 133 MHz and stores 512K bytes of information.

▶ In 1998, Pentium Microprocessors rated at 350MHz, 400MHz, and 450 MHz all user higher 100 MHz memory.

Pentium Xeon Microprocessors

▶ In mid-1998 Intel announced a new version of the Pentium called Xeon

▶ Designed for high-end workstation and sever applications.

▶ Xeon is available with a L1 cache size of 32K bytes and a L2 cache size of either 512K, 1M, or 2M bytes.

Pentium Microprocessors

▶ uses a faster core than the Pentium

▶ available in the slot 1 version mounted on a plastic cartridge and a socket 370 version called flip-chip.

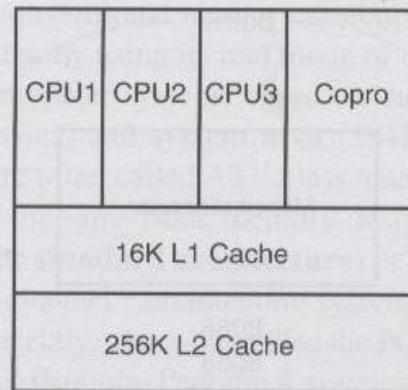▶ The slot 1 version contains a 512K cache and the flip-chip version contains a 256K cache.
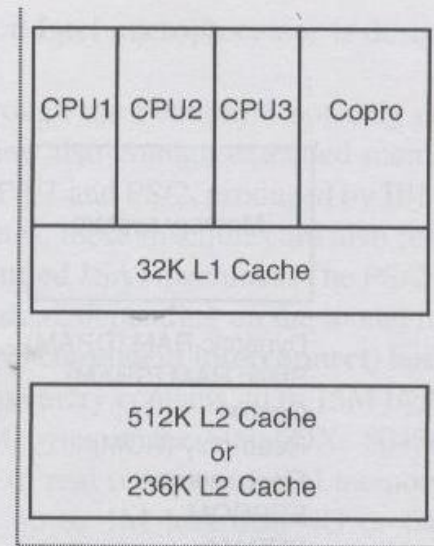
Pentium Microprocessors..

▶ Both versions use a memory bus speed of 100 MHz, while uses a memory bus clock speed of 66 MHz.

▶ The speed of the front side bus, PCI controller, is now either 100 MHz or 133 MHz.

▶ the Pentium is available to clock frequencies of 1 GHz.

Conceptual views of the Pentium Pro and Pentium, Pentium and Pentium 4

1–2   THE MICROPROCESSOR-BASED PERSONAL COMPUTER SYSTEM

CPU1	CPU2	CPU3	Copro

16K L1 Cache

256K L2 Cache

Pentium Pro

CPU1	CPU2	CPU3	Copro

32K L1 Cache

512K L2 Cache
or
236K L2 Cache

Pentium II, Pentium III,
or Pentium 4 Module

Pentium 4 Microprocessors

▶ Pentium 4 is available in a 1.3, 1.4, and 1.5 GHz speed version.

▶ the chipset that supports the Pentium 4 uses the RAMBUS memory technology in place of SDRAM technology.

▶ Another change we are likely to see is a shift from aluminum to cooper interconnections.

▶ We may see the front side bus speed increase from the current maximum of 133 MHz to 200 MHz or higher.

The Future of Microprocessors

▶ More likely a change to RISC.

▶ Parallel processing without any change to the instruction set or program.

▶ Currently, the superscaler technology uses many microprocessors, but they all shall the same register set.

▶ This new untried technology, to be used in the next version of the Intel microprocessor, will contain many microprocessors, each containing its own register set that is linked with other microprocessors' registers.

Pentium Processors

▶ In 2002, Intel plans to release a new microprocessor architecture. that is 64 bits in width and has a 128 bit data bus. This new architecture, code-name Merced.

▶ These include 128 general-purpose integer registers, 128 floating-point registers, 64 predicate registers.

Conceptual Views of the 80486 and Pentium

FIGURE 1–4 Conceptual views of the 80486, Pentium Pro, Pentium II, Pentium III, and Pentium 4 microprocessors.
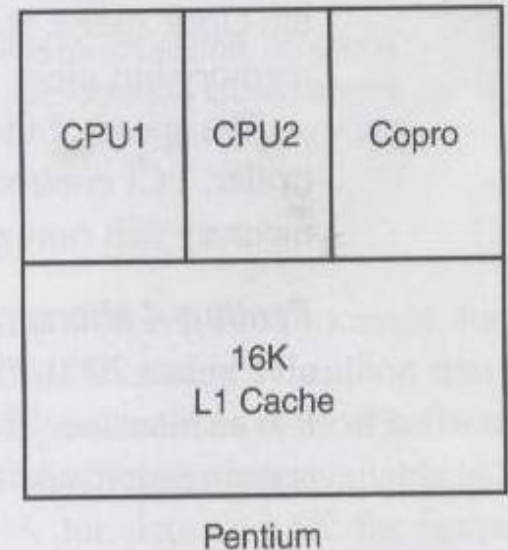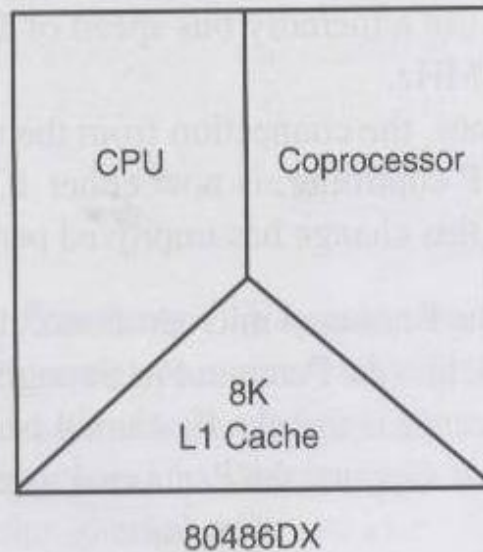
Thank you all for enjoying the class