Microprocessor System Design

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Outline

- **Objectives**
- **Administration**
- **Digital System Design**
- **Microprocessors - History**
- **Structure, Registers**
- **Assembly language, Programming**

Objectives

- **Basic understanding of the operation of microprocessors.**
  - **Assembly language for control and interfacing applications**
- **Basic Techniques for using microprocessors.**
- **Intel 80x86 family**
- **Microcontrollers and embedded design**
- **AVR, 8051 , PIC, ARM based microcontrollers**
- **Interfacing**
- **Embedded and real-time system design**

Administration

- **Text book:**
  - **The 80x86 IBM PC and Compatible Computers (Vol. 1 and 2)**
  - **ARM**
  - **AVR Microcontroller and Embedded Systems**

- **Instructor: Omid Fatemi (omid@fatemi.net)**

  Office: new building, room 608

  Office Hours: Sat. 11:00 – 12:00 or by appt.
- **Web: http://mec.ut.ac.ir/course/view.php?id=17449**
- **Course: 3961810120701 1 ریز پردازنده**

- شرایط دانشجویی خود به عنوان کاربری و کد ملی به عنوان گذرواژه

– دانشجویانی که از ترم گذشته در سامانه ثبت نام کاربری و گذرواژه قبلی با دانشجویان جدید وارد سامانه شوند.

– دانشجویانی که مشخصات آنها از قبل شماره تماس و کدپستی در گلستان کامل نباشد در سامانه آموزش الکترونیکی ثبت نخواهند شد.

– راهنما: http://utec.ut.ac.ir/web/offering/166

Administration (2)

- **Class is flipped**
  - **Lectures: out of class**
  - **Fast review in class**
- **Class work:**
  - **In group.**
  - **Discussion is allowed**
  - **Writing should be own work.**
- **Quiz:**
  - **Closed book, no discussion and talking.**
  - **Copying, looking at other's work is not allowed**
- **Everything is in site.**
- **Next session:**
  - **Because of watching video and assignment: Monday**

Grading

- **Class is flipped**
- **5% Video watching (how to assess? Closed quiz, class work and quiz)**
- **15% lab work (bring your laptops. Possible?)**
- **Projects (5) – 25% (bonus: 10%)**
  - **PCB should be designed**
  - **written report**
- **55% Final Exam and Mid-term**
- **5% bonus for class material**

Digital System Design Applications

- **Signal processing**
- **Control systems**
- **Communications**
- **Micro-computers**
- **Robotics**
- **Multimedia**
- **Internet , Distance learning**

Solutions

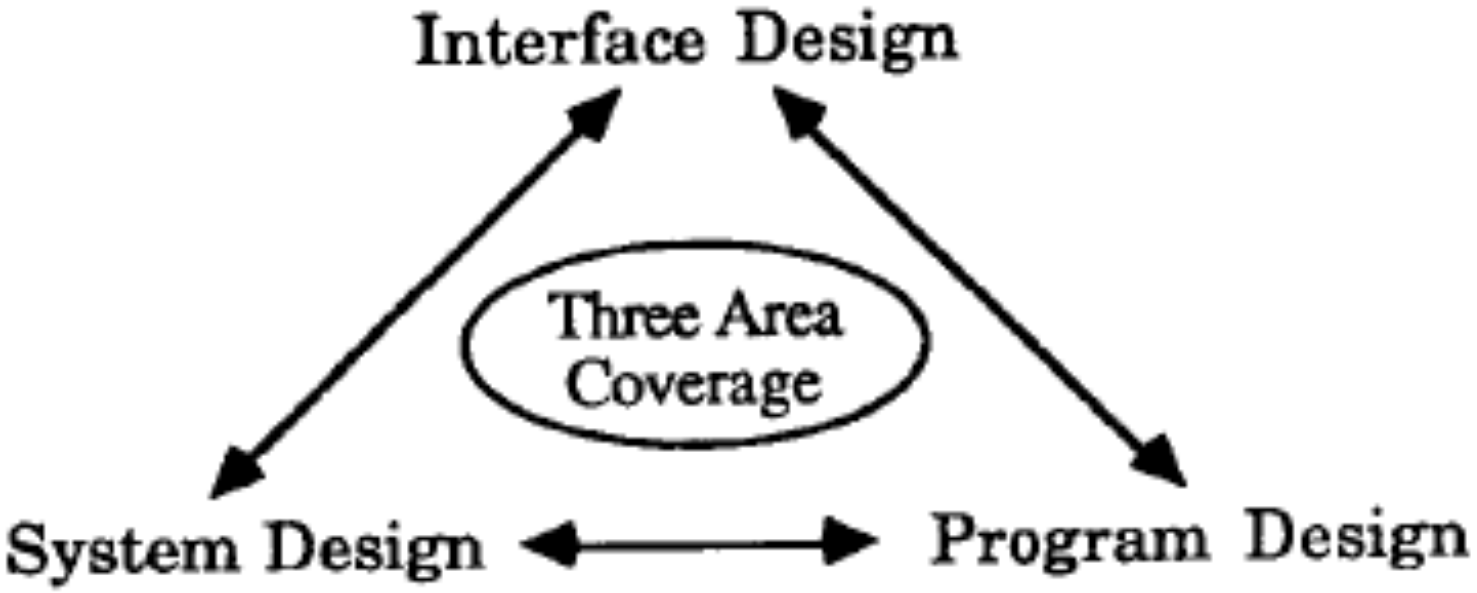
- **LSI chips**
  - **PCB, 74 series**
- **VLSI design (ASIC)**
  - **Standard cells**
  - **Gate arrays**
  - **FPGA**
- **Embedded micro controllers, Real-time Operating systems**
- **General purpose processors**
- **Special purpose processors**
- **System on a chip (SoC)**
- **Hardware, Firmware and Software**

Microprocessor Based

- **More reliable**
- **Less expensive**
- **Easier to debug**
- **Easier to maintain**
- **Easier to upgrade**

- **Disadvantage:**
  - **Speed**
  - **Less flexible in terms of signals**
  - **More power consumption**

Design Process

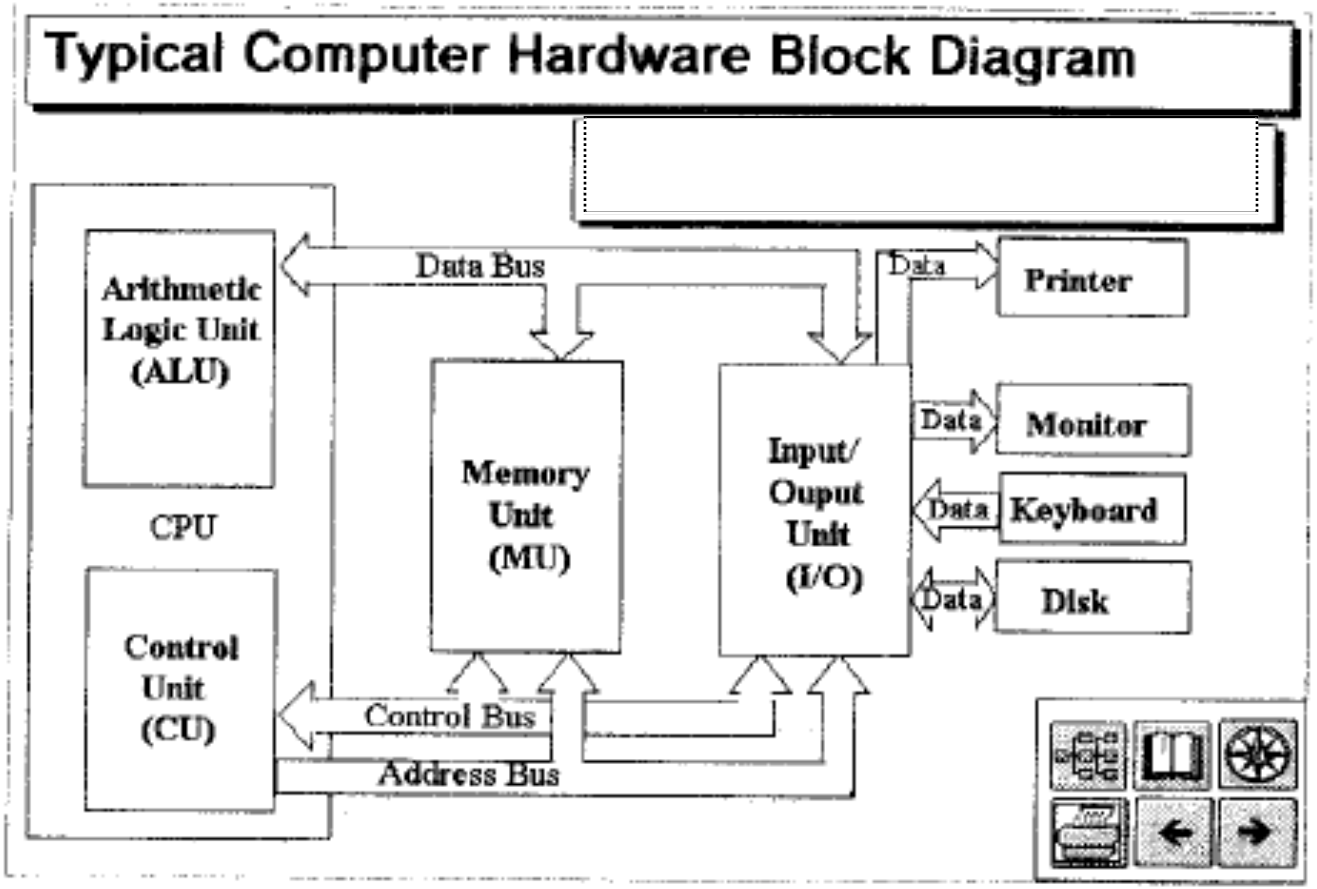


Hardware, Firmware and Software

Design Process Steps

- **Define requirements**
- **Develop specifications**
- **Preliminary design**
- **Intermediate design**
- **Detailed design**
- **Implementation**
- **Verification and acceptance**

Microprocessors

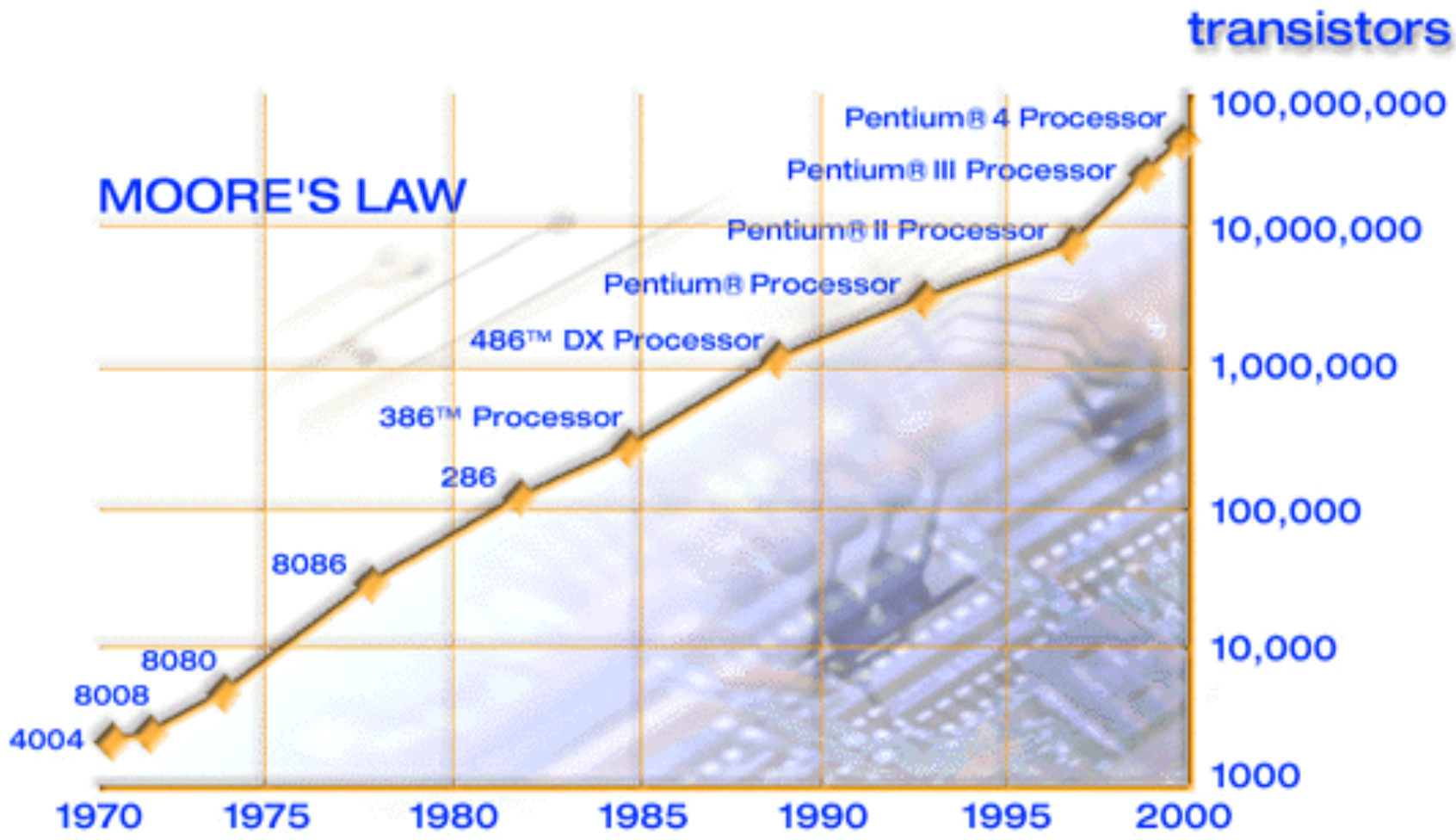


They accept programs

History

- 1940: vacuum tubes
  - ENIAC: 130000 watts, 150 square meter
- 1950: transistors
  - 1959: first IC
- 1971: 4004 by Intel
  - 4-bit, 2300 transistor
- 1970s: 8080/85, Z80, 6800, 6500
  - Appliances, computers
- 1980s: RISC
- 1990s: Embedded
- 2000s: Multi-cores

Intel's Microprocessors and Moore's law



From Intel Site

It all started 30 years ago, November 1971

- **Intel began development of the first microprocessor in 1969 as part of a project to design a set of chips for a family of programmable calculators from Japanese calculator manufacturer Busicom.**
- **Originally, Busicom owned the rights to the microprocessor having paid Intel $60,000. Realizing the potential for the "brain" chip, Intel offered to return the $60,000 in exchange for the rights to the microprocessor design.**
- **Busicom agreed and Intel introduced the 4004 to the worldwide market on November 15, 1971. The 4004 sold for $200 each. The key to the success of the microprocessor idea was to provide a software programmable device. Prior to the invention of the programmable microprocessor, chips were designed to perform specific "fixed" functions.**

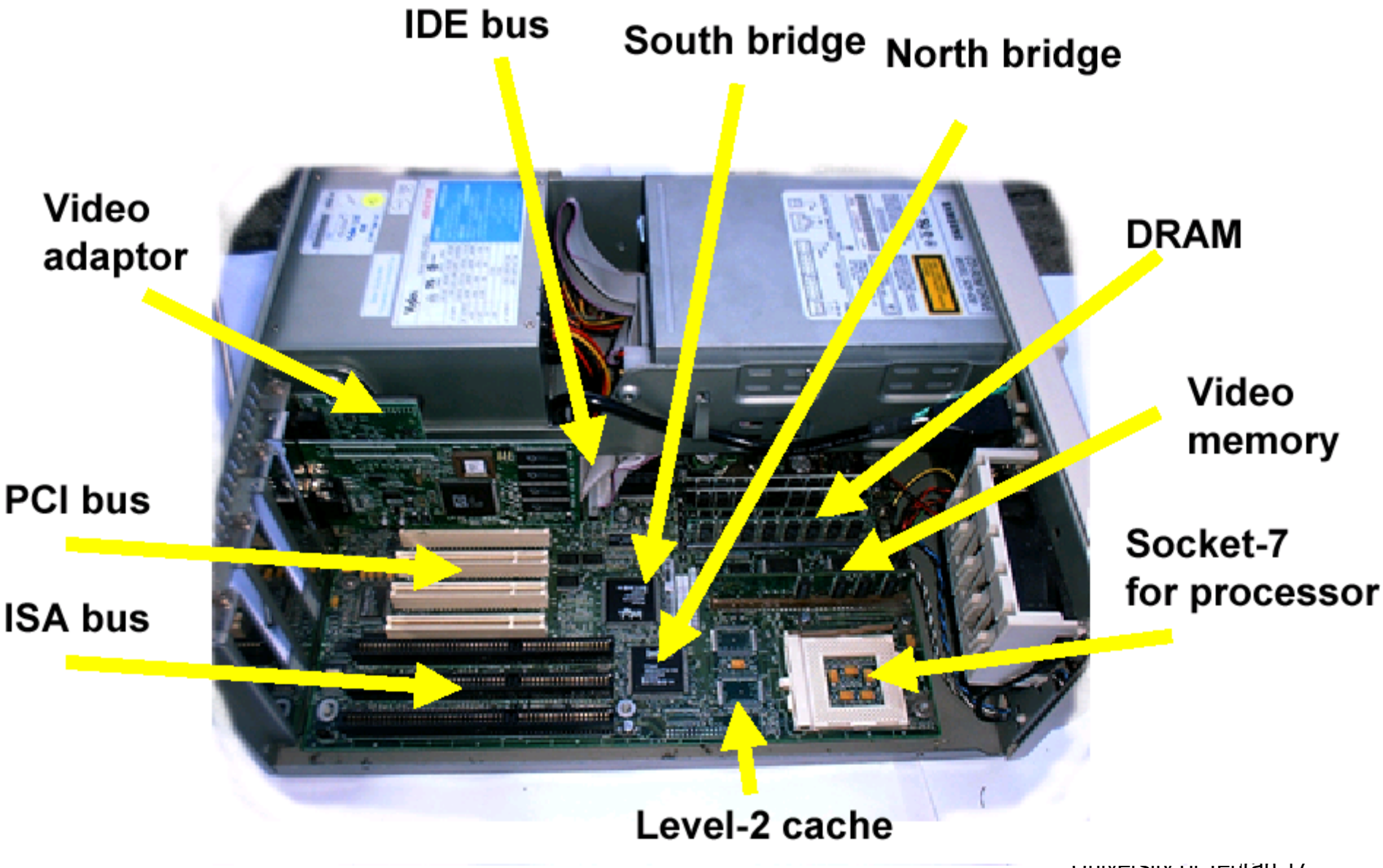
Today's state-of-the-art Pentium® 4 Processor

- **The latest direct descendant of the 4004 is the Intel® Pentium® 4 processor for desktop personal computers.**
- **Today's cutting edge Pentium 4 microprocessor operates at 2 billion cycles per second.**
- **It took 28 years to go from a speed of 108,000 cycles per second performance in the 4004 brain chip to1 billion cycles per second (1 gigahertz) with the Intel® Pentium® III processor - and only 18 months to break the 2 gigahertz barrier with the August announcement of the latest Pentium 4 microprocessor.**

Pentium 4 processor-based personal computers (at price points ranging from under $1,000 to $2,000) are fueling the latest trends in home computing - from digital music and home digital movie making to photo-realistic 3D images and visual environments delivered on and off the net in advanced games, education and shopping experiences.

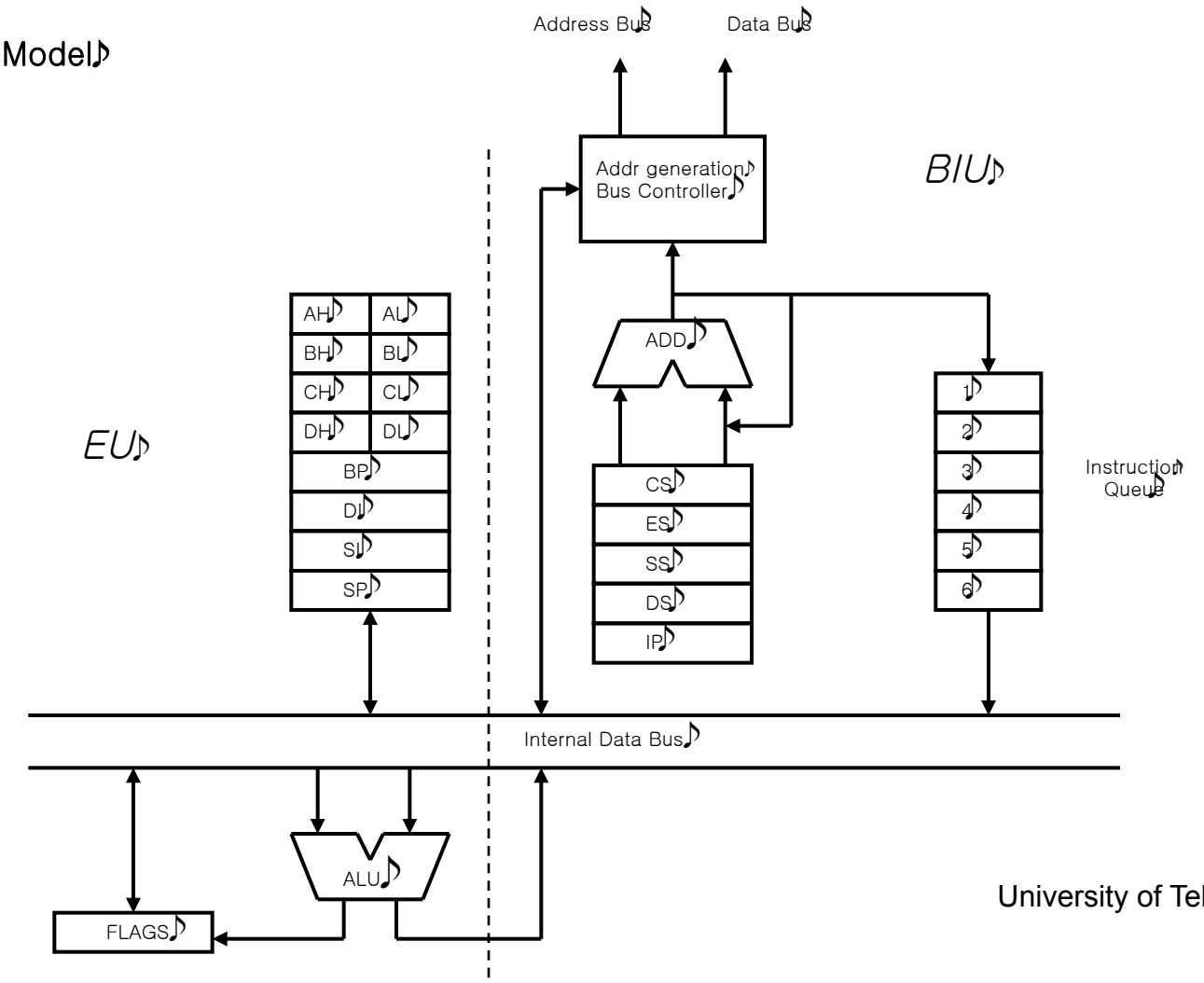
Numbering and Coding Systems

- **Decimal and binary systems**
- **Converting**
- **Hexadecimal and converting**
- **Counting and addition**
- **2's complement and subtraction**
- **ASCII code, Unicode, utf-8**
- **Bit, Nibble, Byte, Word,**


IDE bus
South bridge
North bridge
Video adaptor
DRAM
Video memory
PCI bus
Socket-7 for processor
ISA bus
Level-2 cache

8086/8 Internal Organization

Processor Model



How does a CPU work?

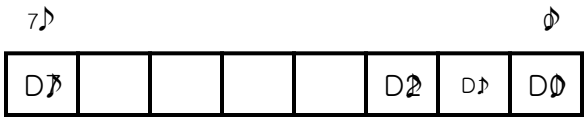
- **Combinational or sequential?**
  - **Hybrid → sequential**
- **Inputs to the state machine (sequential circuit)?**
  - **Clock**
  - **Program**
- **What it does with a program?**
  - **Reads from memory, where?**
  - **Program counter, Instruction pointer (IP)**
  - **Understands it (decode), then?**
  - **Execute, then?**
  - **Next instruction**

A Simple Program

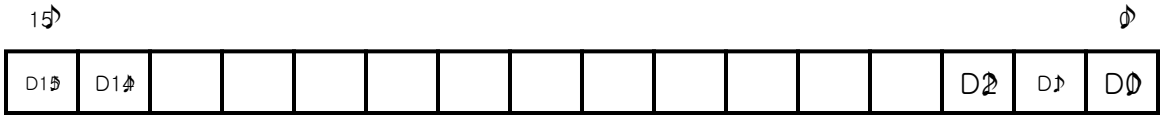
- **Program:**
  - **Move value 21H into register AL**
  - **Add value 42H to register AL**
  - **Store AL in memory location 33D0H**
- **Memory contents (instruction part)**
  - **1500 B0**
  - **1501 21**
  - **1502 04**
  - **1503 42**
  - **1504 35 (A2 in pentium)**
  - **1505 D0**
  - **1506 33**
- **Execution?**

Registers
(Temporary Storage)

- **One or two bytes (in 8088)**
- **8-bit register:**



- **16-bit register:**



- **Registers:**
  - **AX, BX, CX, DX**
  - **AH, AL, BH, BL, CH, CL, DH, DL**

Registers by Category

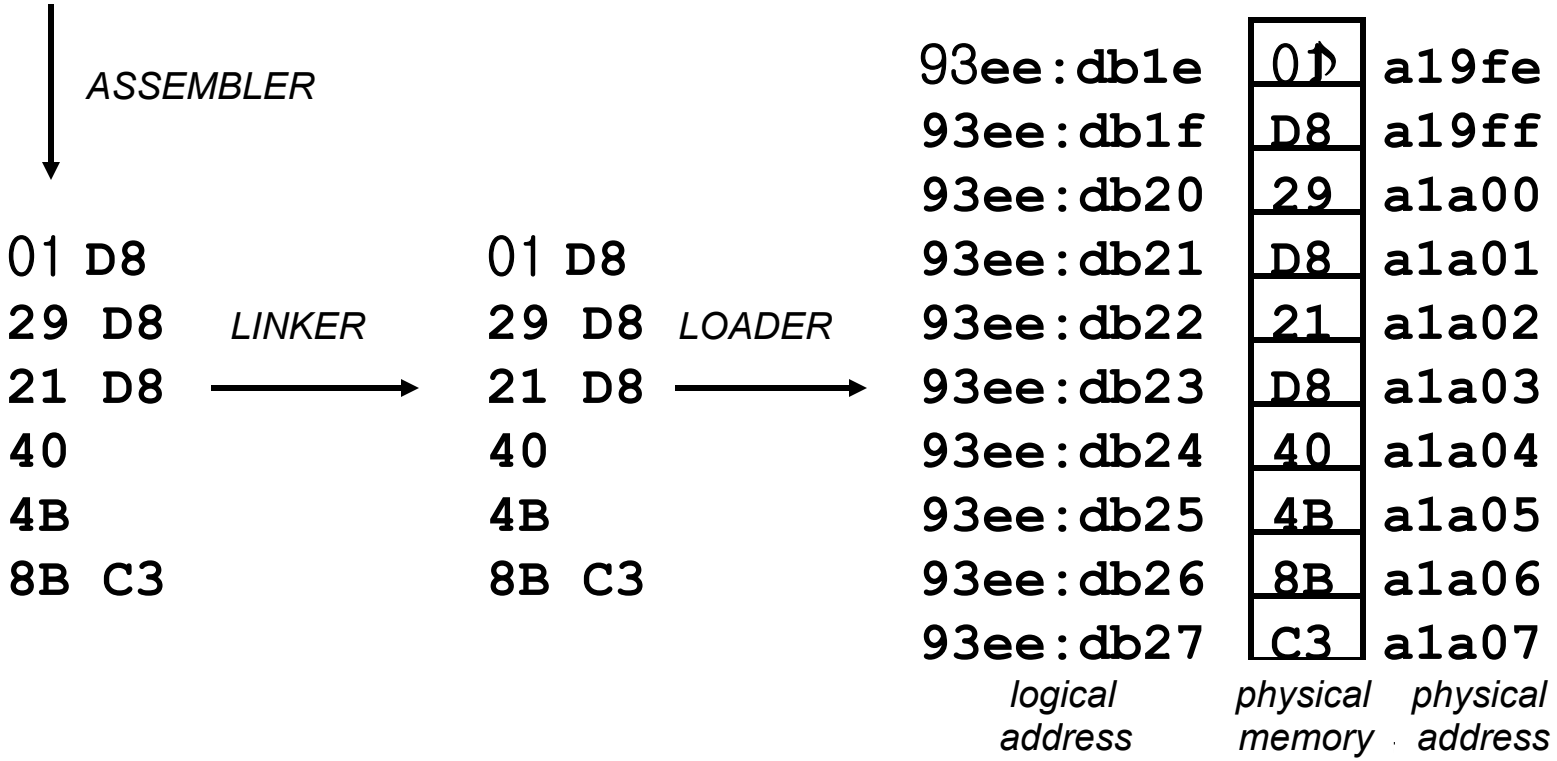
Category	Bits	Register Names
General	16	AX, BX, CX, DX
	8	AH, AL, BH, BL, CH, CL, DH, DL
Pointer	16	SP (stack pointer), BP (base pointer)
Index	16	SI (source index), DI (destination index)
Segment	16	CS (code segment), DS (data segment), SS (stack segment), ES (extra segment)
Instruction	16	IP (instruction pointer)
Flag	16	FR (flag register)

Assembly Programming

- **CPU works in binary**
- **All instructions, data are in binary**
- **Binary instructions (0, 1) are Machine Language**
  - **Or even hexadecimal representation**
- **Assembly language**
  - **Mnemonics**
  - **Low level**
- **Assembler**
- **Linker**

Assembler versus Machine Code

```
ADD    AX, BX        ;AX gets value AX+BX
SUB    AX, BX        ;AX gets value AX-BX
AND    AX, BX        ;AX gets bitwise AND of AX and BX
INC    AX            ;AX gets its original value plus 1
DEC    BX            ;BX gets its original value minus 1
MOV    AX, BX        ;AX gets values in BX
```



Summary

- **Digital System Design**
  - **Microprocessor based**
  - **Hardware, software and firmware**
- **Microprocessors**
- **History**
- **Numbering systems**
- **Internal Organization**
- **Registers, segments**
- **Assembly language**