Embedded Systems Laboratory

Catedra de Calculatoare
Facultatea de Automatica si Calculatoare

PROIECTAREA CU MICROPROCESOARE

Facultatea de Automatică și Calculatoare
Universitatea Politehnica București

Sper că sunteți aici din cauza asta

POO, PP, PA

- Cum ajunge un program scris într-un limbaj de nivel înalt să fie executat pe mașina de calcul?
- Ce se intâmplă la mijloc?
- Cum putem să proiectăm un procesor complex pornind de la porți logice și conexiuni?

CN1 & 2

Perspectiva programatorului asupra felului în care funcționează un sistem de calcul

Perspectiva Architectului de Sistem: Cum să proiectez un sistem de calcul care să satisfacă cerințele de design.

Perspectiva inginerului HW asupra felului în care merge un calculator

About me

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- Office: ED422
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- https://elf.cs.pub.ro/wsn/wiki/dan.tudose
- PhD in Computer Science
- Research & teaching:
  - Computer architecture, hardware/software interaction
  - Embedded and Pervasive Computing
  - Wireless Sensor Networks
  - Low Power Computing Architectures, Energy Harvesting
  - Fault tolerance

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Echipa de Asistenți

http://cs.curs.pub.ro/wiki/pm/administrative/echipapm

Iulian Mateșică
Marius Andrei
Răzvan Bărbascu
Vlad Corneci
Dorin Ioniță
Cristi Trancă
Ana Drăgan
Alexandru Predescu
Ovidiu Știru
Mihaela Lungoci
Adrian Mocanu
Adrian Stratulat
Adriana Drăghici
Andrei Bîrlică
Andrei Voinescu
Daniel Ghilință
Ioana Popescu

Important Stuff

Curs: Moodle

Laboratoare: http://cs.curs.pub.ro/wiki/pm/

Notare:

- 1 punct activitatea laborator
- 1 punct lucrare laborator
- 3 puncte proiect
- 5 puncte examen final

Cerințe minime pentru a promova:

- minim 6 prezente la laborator
- minim 2.5 puncte din cele 5 puncte din examenul final
- Activitate la curs!

Organizarea generală a unui calculator

Memorie – Stochează programe și date

CPU – Central Processing Unit

UAL – Unitate Aritmetică și Logică

Control – Secvențiază transferurile de date

I/O – comunică cu exteriorul

Arhitectura sistemelor de calcul

Organizarea clasică (von Neumann) a unei mașini de calcul:

- Programe stocate sub formă de instrucțiuni
- ”General-purpose”
- Datele și instrucțiunile stocate în memorie
- Instrucțiunile executate în ordine

Arhitectura unui sistem este determinată atât de hardware cât și de software.

Programarea calculatoarelor înainte de von Neumann

Putting things into perspective

10 µm – 1971
6 µm – 1974
3 µm – 1977
1 µm – 1985
600 nm – 1994
250 nm – 1997
130 nm – 2001
90 nm – 2004
65 nm – 2006
32 nm – 2010
22 nm – 2012
14 nm – 2014
10 nm – 2017
7 nm – ~2018
5 nm – ~2020

Tranzistor - 10nm

Influenza A virus – 100nm

Microprocesoare

High performance, general purpose, pentru PC & workstations
Instruction decode and control, arithmetic/logic operations, registers, timing, external control
Cost tipic: $75 - $500

Cerere anuală: zeci de milioane

Microcontrollere

Nivel mult mai mare de integrare pentru controlul embedded
Funcții de microprocesor, plus memorie și periferice on-chip (ex. porturi, timere)
"Swiss army knife" al tehnologiei
Cost tipic: $1- $25

Cerere anuală: miliarde!

Baseline Microcontroller

8051 - Intel

External Interrupts
Interrupt Control
Program Memory (4k)
RAM (128 Bytes)
Timer 0
Timer 1
Counter Inputs
Central Processing Unit
OSC
Bus Control
Four I/O Ports (P0 P1 P2 P3)
Serial port
TxD
RxD
P0 P2 P1 P3
Address Data
www.CircuitsToday.com

P8051AH 0649
8736041
93X3903 Y15
©INTEL '80

ATmega324 - Atmel

MSP430 – Texas Instruments

SAM E70 - Atmel

World-Changing Microprocessors

Zilog Z80

- Released 1976
- 8-bit architecture
- Enhanced clone of Intel 8080
- Nintendo Game Boy
- Sega Master System
- Texas Instruments graphing calculators
- Still sold for embedded applications

Zilog

MOS Technology 6502 (1975)

- 6502 - inexpensive and capable
- Intel 8080 sold for $149
- 6502 sold for only $25
- **Apple II (1977)**
- Atari 2600
- Nintendo Entertainment System (NES)

Motorola 68000

- Released 1980
- 16/32 bits
- UNIX workstations
- Apple Macintosh

MOTOROLA

AIM PowerPC 601

- 1992
- Apple, IBM & Motorola ”unholly alliance”
- Break the Intel + Microsoft monopoly
- Used in Apple Macintosh from 1994 to 2006
- Nintendo Wii
- Xbox 360
- Sony PlayStation 3 (part of Cell processor)

A Brief History of Intel

Intro

- Fairchild Semiconductors (founded in 1957) invented the first IC in 1959
- In 1968, **Robert Noyce, Gordon Moore, Andrew Grove** resigned from Fairchild Semiconductors
- They founded their own company **Intel** (Integrated Electronics)
- Intel grown from 3 man start-up in 1968 to industrial giant by 1981

➢ It had 20,000 employees and $188 million revenue.

4-BIT MICROPROCESSORS

INTEL 4004

- Introduced in 1971
- First Intel uP
- Word width: 4-bit
- 2300 transistors
- Clock: 108KHz/500/740
- 46 instructions
- Registers: 16 x 4-bit
- Stack: 12 x 4-bit
- Address space
  - 1Kb of program, 4Kb of data

INTEL 4040

- Introduced in 1974
- 60K instructions/sec.
- 3000 transistors
- Support chips:
  - 4201 – Clock Generator 500 to 740 kHz using 4 to 5.185MHz crystals
  - 4308 – 1KB ROM
  - 4207 – General Purpose byte Output port
  - 4209 – General Purpose byte Input port
  - 4211 – General Purpose byte I/O port
  - 4289 – Standard Memory Interface
  - 4702 – 256 byte UVEPROM
  - 4316 – 2KB ROM
  - 4101 – 256 4-bit word RAM

8-BIT MICROPROCESSORS

INTEL 8008

- Introduced in 1972
- First 8-bit uP
- Word width: 8-bit
- Clock: 800KHz
- 3500 transistors
- 48 instructions
- Registers: 6 x 8-bit
- Stack: 17 x 7-bit
- Address space: 16KB

INTEL 8080

- Introduced in 1974.
- Clock speed 2 MHz.
- It had 6,000 transistors
- 10 times faster than 8008.
- Clock: 2M-3MHz
- Address space: 64KB
- Registers: 6 x 8-bit
- Distinct Address & Data Buses
- IO ports, Stack pointer

INTEL 8085

- Introduced in 1976
- Binary compatible with 8080
- Clock speed 3MHz
- 8-bit data bus 16-bit address bus
- 6,500 transistors.
- 64 KB of addressable memory
- 246 instructions
- Over 100 million copies sold

16-BIT MICROPROCESSORS

INTEL 8086

- Introduced in 1978
- First 16-bit µP
- 4.77 MHz, 8 MHz and 10 MHz
- 16-bit data bus and 20-bit address bus
- 29,000 transistors
- 2.5 million instructions per second
- Could access 1 MB of memory
- 22,000 instructions
- ***Multiply*** and ***Divide*** instructions

INTEL 8088

- Introduced in 1979.
- Created as a cheaper version of Intel's 8086
- 16-bit processor with an 8-bit external bus
- 2.5 million instructions per second
- This chip became the most popular in the computer industry when IBM used it for its first PC.

INTEL 80186 & 80188

- Introduced in 1982
- Clock speed was 6 MHz
- 80188 was a cheaper version of 80186 with an 8-bit external data bus
- Additional components like:
  - Interrupt Controller
  - Clock Generator
  - Local Bus Controller
  - Counters

INTEL 80286

- Introduced in 1982
- Clock speed 8 MHz
- 16-bit data bus and 24-bit address bus
- 16 MB of addressable memory
- 4 million instructions per second

32-BIT MICROPROCESSORS

INTEL 80386

- Introduced in 1986
- First 32-bit µP
- 32-bit data bus & 32-bit address bus
- 4 GB of addressable memory
- 2,750,000 transistors
- Clock speed varied from 16 MHz to 33 MHz depending upon the various versions.
- Different versions:
  - 80386 DX
  - 80386 SX
  - 80386 SL

The best selling microprocessor in history.

INTEL 80486

- Introduced in 1989
- 1.2 million transistors
- 8 KB of cache
- Clock speed varied from 16 MHz to 100 MHz depending upon the various versions.
- Five different versions
  - 80486 DX
  - 80486 SX
  - 80486 DX2
  - 80486 SL
  - 80486 DX4

INTEL PENTIUM

- Introduced in 1993.
- Originally named 80586
- Clock speed 66 MHz
- Its data bus is 32-bit and address bus is 32-bit
- Could address 4 GB of memory
- Could execute 110 million instructions per second
- Cache memory
  - 8KB Data
  - 8KB Instructions

INTEL PENTIUM PRO

- Introduced in 1995
- 21 million transistors
- Primarily used in server systems
- Cache memory:
  - 8KB for instructions
  - 8KB for data
- L2 cache of 256KB

INTEL PENTIUM II

- Introduced in 1997
- Clock speed was 233MHz to 500MHz
- Could execute 333 million instructions per second
- MMX technology was supported
- L2 cache & processor were on one circuit

INTEL PENTIUM II XEON

- Introduced in 1998
- Designed for servers
- Clock speed was 400MHz to 450MHz
- L1 cache of 32KB & L2 cache of 512KB, 1MB or 2 MB
- It could work with 4 Xeons in same system

INTEL PENTIUM III

- Introduced in 1999
- Clock speed varied from 500MHz to 1.4GHz
- 9.5 million transistors

INTEL PENTIUM IV

- Introduced in 2000
- Clock speed from 1.3GHz to 3.8GHz
- L1 cache of 32KB & L2 cache of 256KB
- 42 million transistors

INTEL DUAL CORE

- Introduced in 2006
- Hybrid32-bit/64-bit µP
- Both the cores have there own internal bus and L1 cache, but share the external bus and L2 cache
- SMT: Simultaneously Multi- Threading
- E.g.: Adobe Photoshop

64-BIT MICROPROCESSORS

INTEL CORE 2

- Introduced in 2006.
- Clock speed from 1.2GHz to 3GHz
- 291 million transistors
- It has 64 KB of L1 cache per core and 4 MB of L2 cache
- Launched in three different versions:
  - Intel Core 2 Duo
  - Intel Core 2 Quad
  - Intel Core 2 Extreme

INTEL CORE I7

- Introduced in 2008
- 4 physical cores
- Clock speed from 2.66GHz to 3.33GHz
- 781 million transistors
- 64 KB of L1 cache per core, 256 KB of L2 cache and 8 MB of L3 cache

INTEL CORE I5

- Introduced in 2009
- 4 physical cores
- Clock speed is from 2.40GHz to 3.60GHz
- 781 million transistors
- 64 KB of L1 cache per core, 256KB of L2 cache and 8MB of L3 cache

INTEL CORE I3

- Introduced in 2010
- 2 physical cores
- Clock speed is from 2.93GHz to 3.33GHz
- 781 million transistors
- 64 KB of L1 cache per core, 512KB of L2 cache and 4MB of L3 cache

COMPUTER RESEARCH @ UPB

Calculatoare proiectate de membrii Departamentului Calculatoare @ UPB

Electrointegrator pentru soluționarea unor probleme de câmp.

Adrian Petrescu (1963)

MAC-1 Calculator Analogic cu 30 de amplificatoare operaționale.

Adrian Petrescu, Petre Dimo, Ivan Sipos (1965)

Calculatoare proiectate de membrii Departamentului Calculatoare @ UPB

Microcalculatorul MC-1

Adrian Petrescu, Nicolae Țăpuș, Trandafir Moisa
(1972)

Microcalculatorul FELIX MC-8

Adrian Petrescu, Nicolae Țăpuș, Trandafir Moisa
(1975)

Calculatoare proiectate de membrii Departamentului Calculatoare @ UPB

Microcalculatorul FELIX M-18

Adrian Petrescu, Nicolae Țăpuș, Trandafir Moisa (1978)

Microcalculatorul aMIC

Adrian Petrescu, Francisc Iacob (1984)

Calculatoare proiectate de membrii Departamentului Calculatoare @ UPB

Microcalculatorul FELIX HC-85

Adrian Petrescu, Francisc Iacob (1985)

Microcalculatorul FELIX-PC

Adrian Petrescu, Nicolae Țăpuș, Trandafir Moisa, Irina Athanasiu (1985)