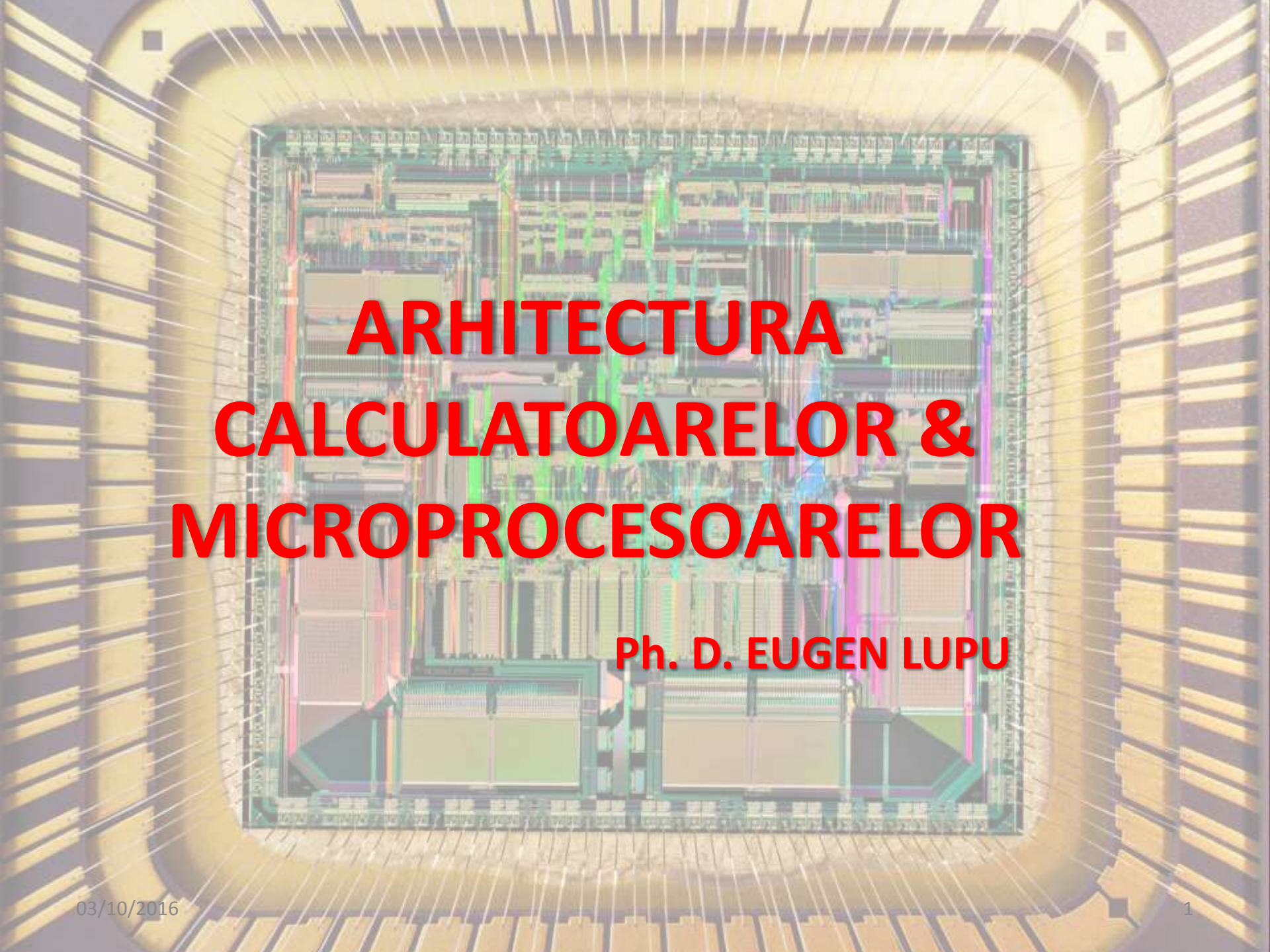


ARHITECTURA CALCULATOARELOR & MICROPROCESOARELOR

Ph. D. EUGEN LUPU

Obiectivele cursului

- Familiarizarea cu arhitecturile calculatoarelor
- Studierea de arhitecturi de microprocesoare
- Familiarizarea cu arhitectura software Intel
- Asimilarea setului de instructiuni de baza (8086) + x86
- Dezvoltarea de aplicatii in limbaj asamblare (LA)

CERINTE EVALUARE

NOTA:

- 65% examen scris (teorie+probleme) cu minim de documentatie
- 35% teste laborator

OBS: Intrare la examen: maxim 2 absente laborator

BONUS:

- Prezenta la curs, > 50% = rotunjirea notei finale in favoarea studentului proportional cu prezenta (la nota de trecere > 4.5)

BIBLIOGRAFIE RECOMANDATA

1. J. L. Hennessy, D. A. Patterson ***Computer Architecture A Quantitative Approach*** Morgan Kaufmann Publishers 2007

2. D. A. Patterson, J. L. Hennessy ***Computer Organization Design.*** *The hardware/ software interface,* Morgan Kaufmann Publishers 2005

3. Lungu, V. *Procesoare Intel. Programare în Limbaj de Asamblare.* TEORA, 2004

4. Burileanu, C. şi col. *Microprocesorul x86 - o abordare software* Ed. Albastră, 1999

5. Hyde, R. The *Art of Assembly Language,* 2000

6. Buchanan, W. *PC interfacing, Communications and Windows Programing* Addison Wesley, 1999

7. Carter, Paul A., PC assembly language, 2003, www.computer-books.us

8. Lupu, E. si col. Initiere in *Limbajul de Asamblare x86. Lucrari practice, teste si probleme. Ed. Galaxia Gutenberg 2012*

9. [***] www.intel.com

10. [***] www.x86.org

11. [***] www.softwareforeducation.com

12. [***] www.programmersheaven.com

13. etc.

Slide-uri cursuri MP1: http://users.utcluj.ro/~elupu/Curs/index.php

http://www.arm.com/products/processors/

Curs 1

1. INTRODUCERE
2. SCURT ISTORIC – Evolutia calculatoarelor si µP
3. ARHITECTURI DE PRELUCRARE
4. LIMBAJ de ASAMBLARE . COD MASINA.
- Tema

1. INTRODUCERE

Sistem numeric - O structura de dispozitive asamblate in vederea prelucrarii, stocarii sau transmiterii informatiei numerice

- *Avantajele prelucrarii numerice:*

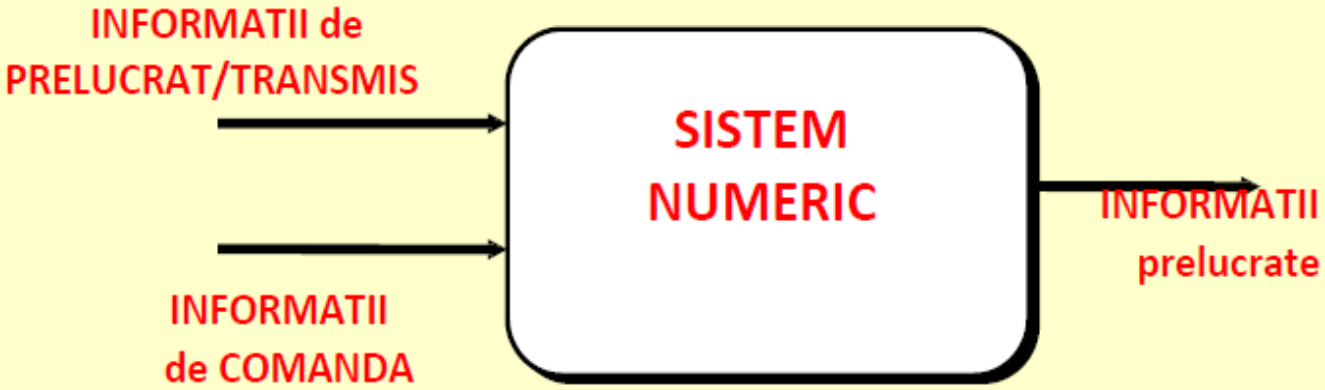
> stabilitate si imunitate la perturbatii, temperatura

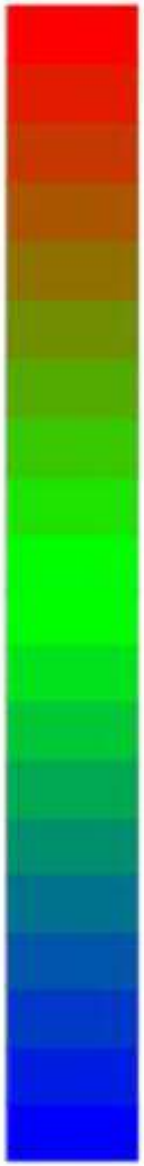
> siguranta in functionare, chiar la variatii ale parametrilor in timp

> precizie (nu e nevoie de reglaje/compensari ca la circuitele analogice)

> afisare digitala

- *Problemele practice sunt de diverse complexitati si vitezele proceselor urmarite au o gama larga de desfasurare*
- ***Logica cablata / Logica programata***





	You choose
Full Custom	polygons (Intel)
ASIC	circuit (Sony)
Gate Array	wires
FPGA	logic network
PLD	logic function
GP Processor	program (e.g., Pentium)
SP Processor	program (e.g., DSP)
Multifunction	settings (e.g., Ethernet)
Fixed-function	part number (e.g., 74LS00)

Flexibility

Calculator - Este un dispozitiv electronic care proceseaza datele de intrare conform unui program (secventa de instructiuni/comenzi) si furnizeaza la iesire un rezultat.

Calculatoarele se pot clasifica dupa mai multe criterii astfel:

- *Dupa principiul de functionare*
  - **numerice/digitale**
  - **analogice**
  - **hibride**

- *Dupa domeniul de utilizare*
  - **de uz general**
  - **specializate**

- *Dupa nr. de procesoare*
  - secventiale
  - paralele

- *Dupa lungimea datelor prelucrate:* 8,16,..64biti…

- *Dupa nr. de utilizatori:* monoutilizator, multiutilizator, retea.

- *Dupa marime si performante*

- microcomputere (PC)

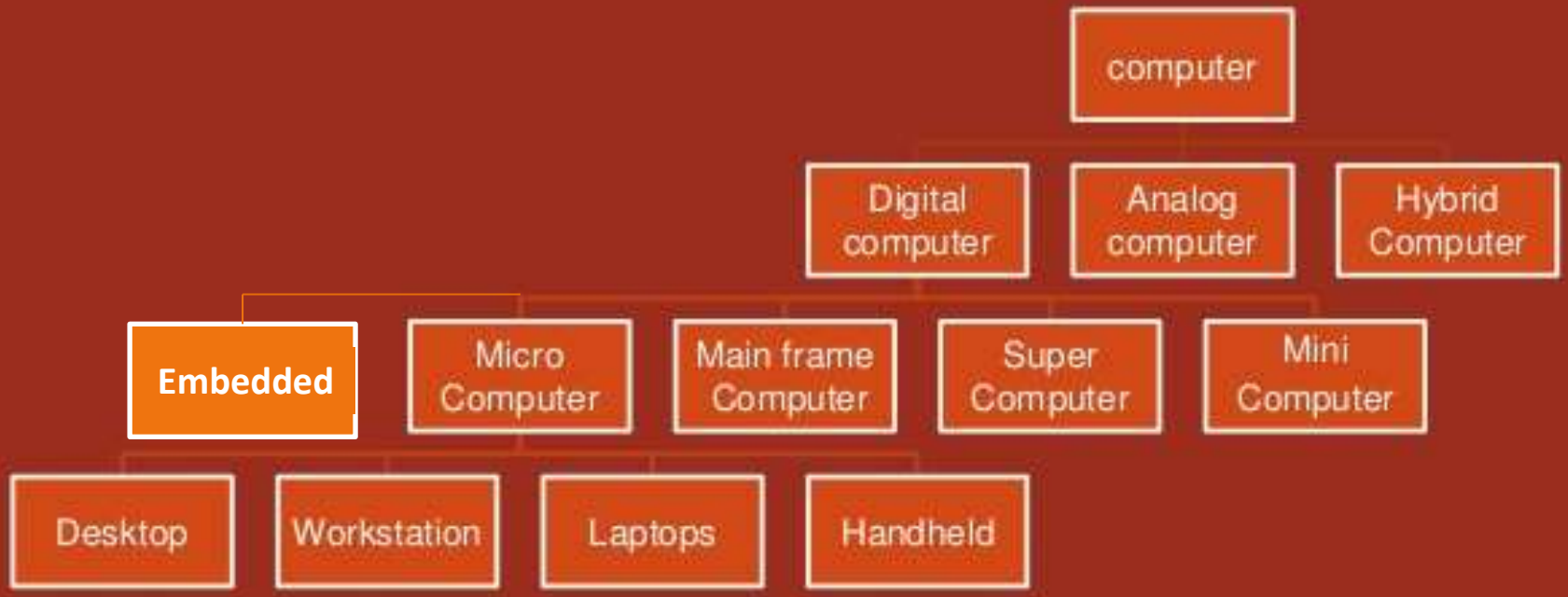
- minicomputere *(Digital Alpha, Sun Ultra)*- multiuser

- **computere mainframe** : - cu mari posibilitati de stocare si viteza mare de prelucrare (comparate cu mini sau microcomputere). Suporta un numar mare de terminale ptr. utilizare simultana (ex. transactii ATM). Folosite ca si calculatoare gazda in sistemele de procesare distribuita a datelor. *(ex. IBM 370, S/390).*

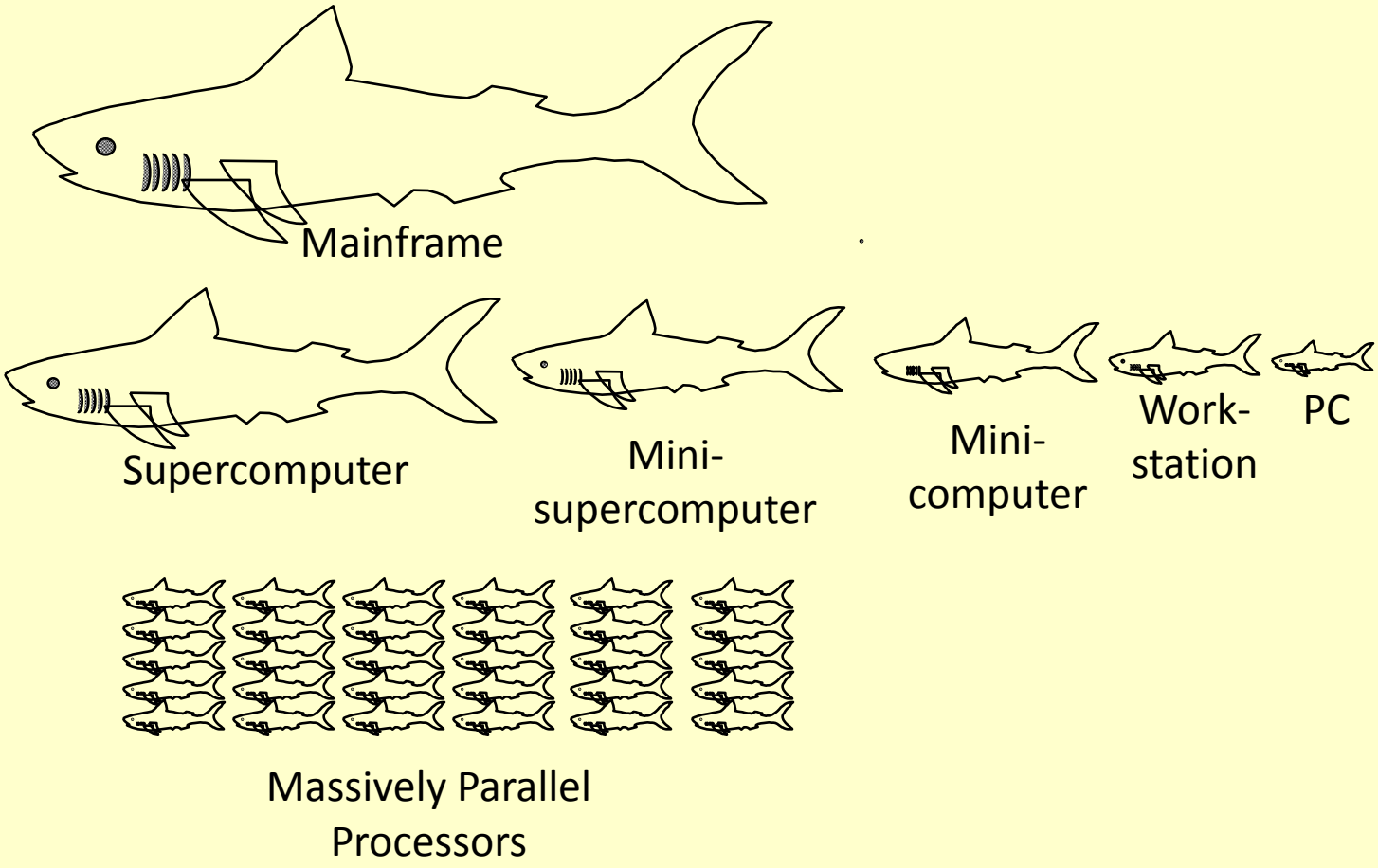
- Supercomputere: au capacitate ft. mare de stocare si viteza de procesare fiind de cateva ori mai rapide decat celelalte computere *(ex. IBM Deep Blue)*- analiza vremii.

- **Sisteme Embedded :** mici calculatoare incapsulate in produse, cu aplicatii specifice, ptr. anumite functii si sarcini precise

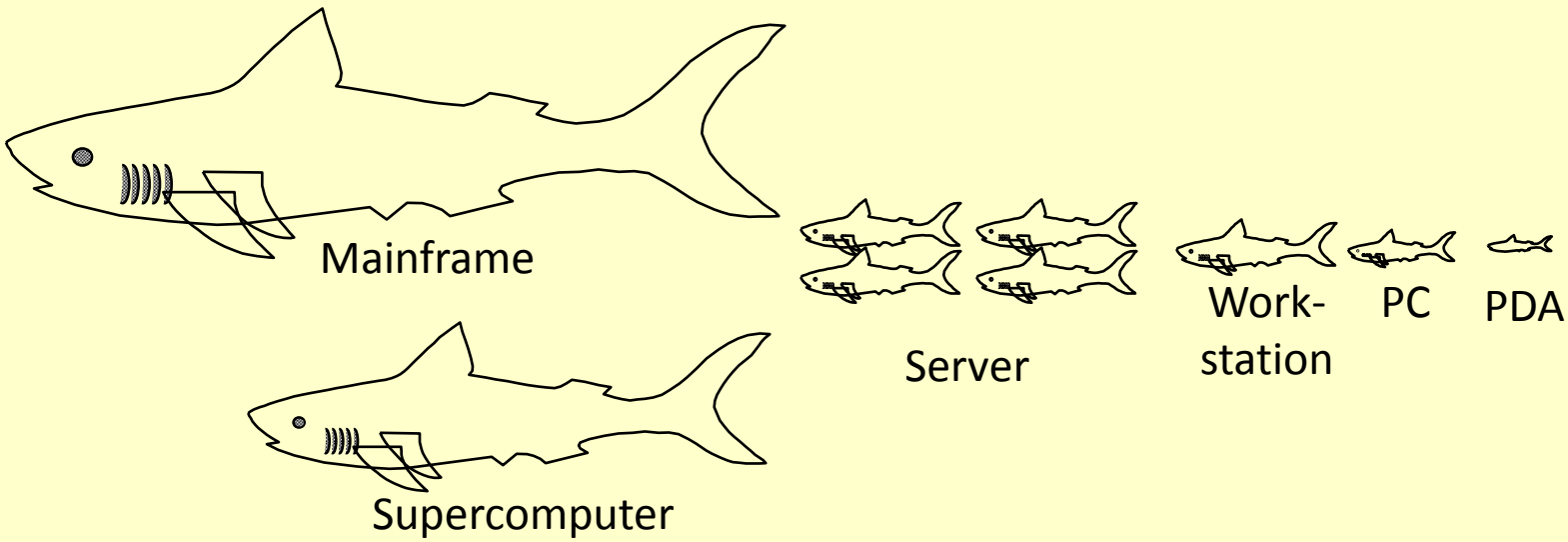
TYPES OF COMPUTERS



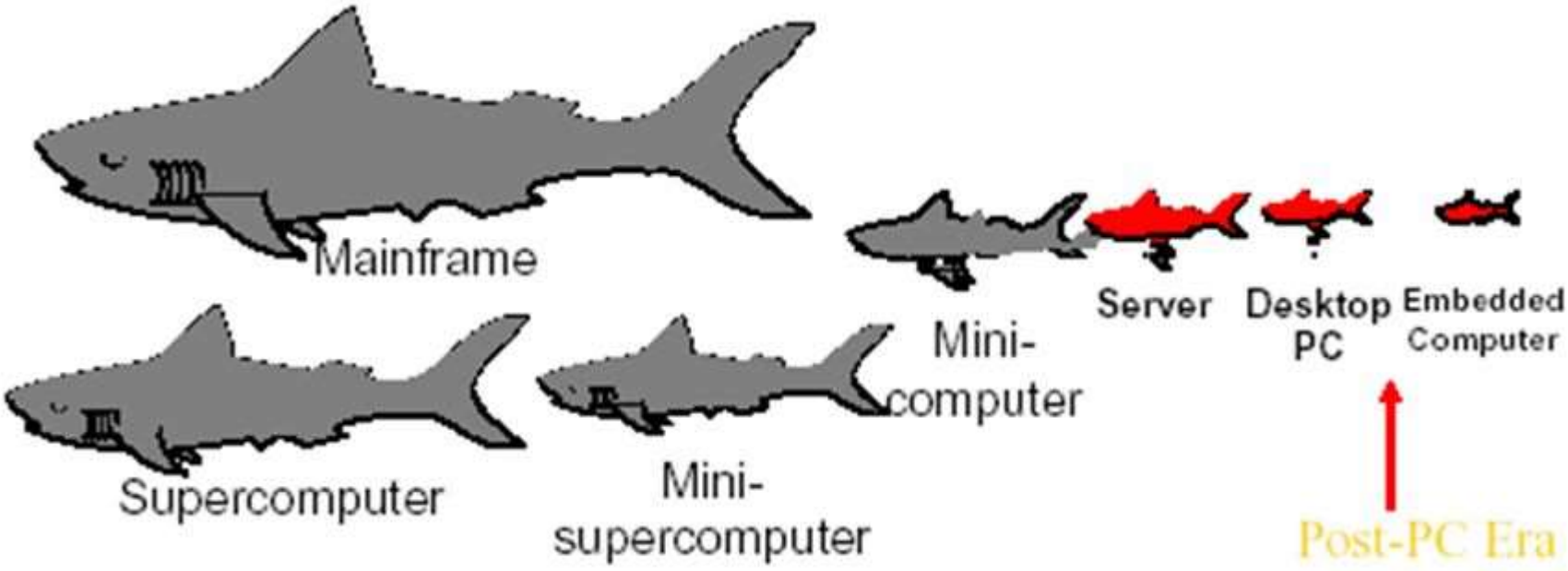
1988 Computer Food Chain



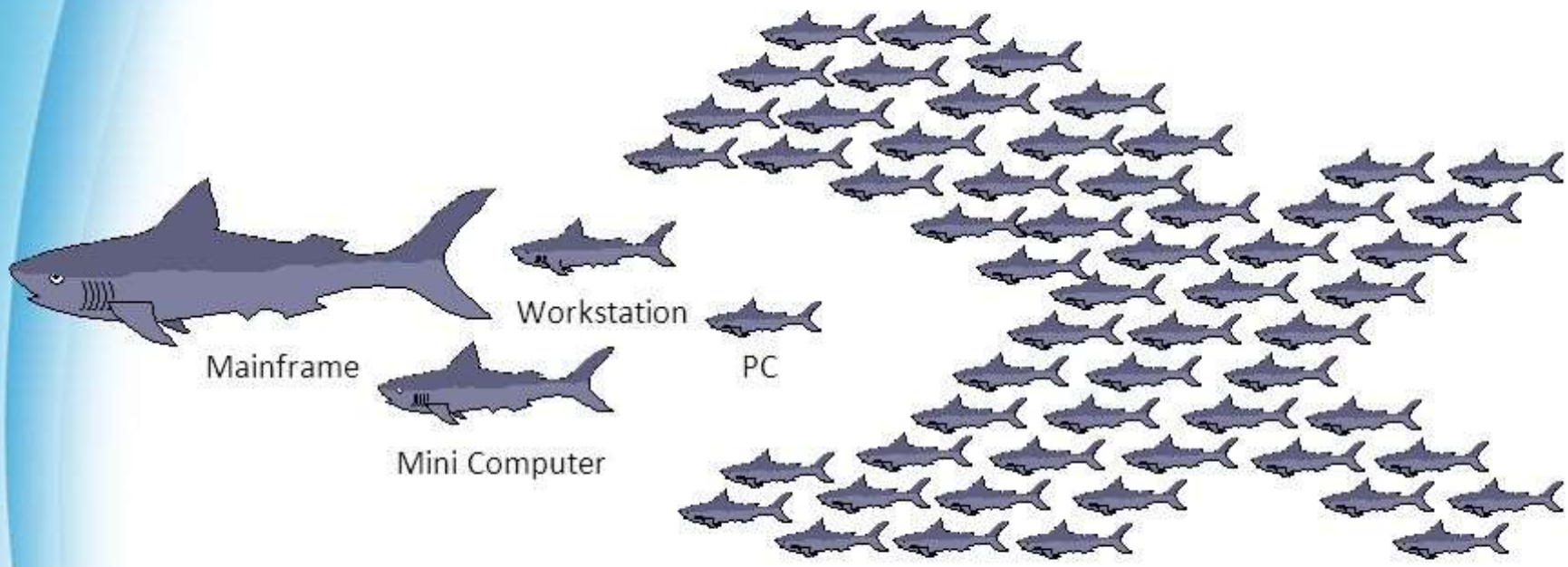
1997 Computer Food Chain



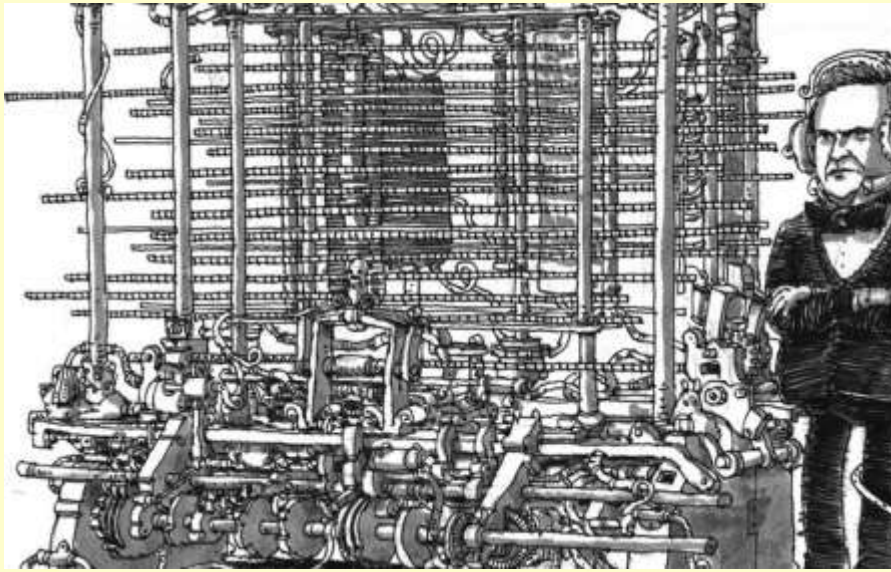
Computer Food Chain



Food Chain of Distributed Computing



2. SCURT ISTORIC AL CALCULATOARELOR



- abacul (antichitate)

  calculatoare mecanice – (??-1940)

- sec. 17 – Pascal –masina de calcul mecanica (+, -)
- sec. 17-18 – Leibnitz – (+,-,*,/)
- sec 19 - Ch. Babbage (Cambridge) – masina diferentiala si masina analitica (memorie, unitate de calcul, cititor de cartele si perforator de cartele)

  sec. XX

- Howard Aiken (Harvard 1937) – Mark I, II – calculatoare cu secventa de comanda automata (Babbage+IBM) (relee + comutatoare) >> inceputul noii ere a calculatoarelor

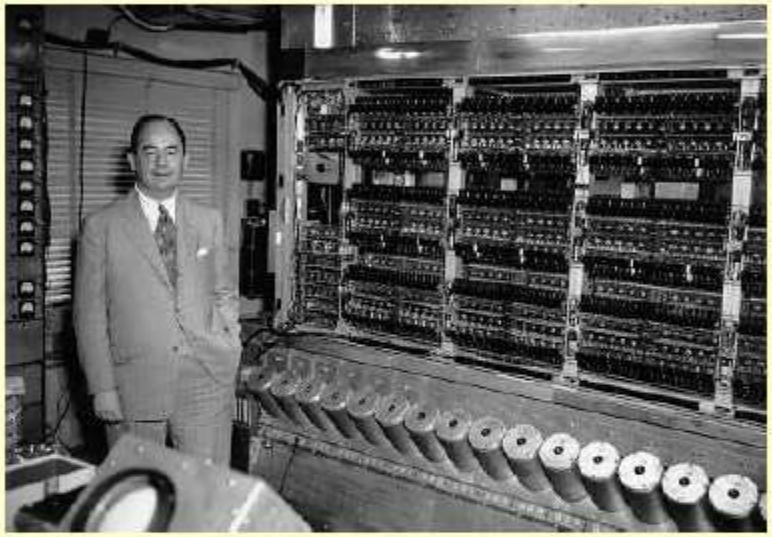
Prima generatie ~ 1943-55

***tehnologie*: tuburi electronice**

1943-46 – P. Eckert & J. Mauchley (Univ. Pensilvania- Aberdeen)
– ENIAC – primul calculator electronic (versiunea MARK I)
18000 tuburi, 1500 relee, 30 tone
- conceptele si ideile - John von Neumann – calculatorul cu program memorat

- alte variante: EDVAC, ILLIAC, MANIAC, Wirlwind, UNIVAC IBM 701,704,709 – primele calculatoare comerciale
DACICC, CIFA, MECIPT – variante romanesti

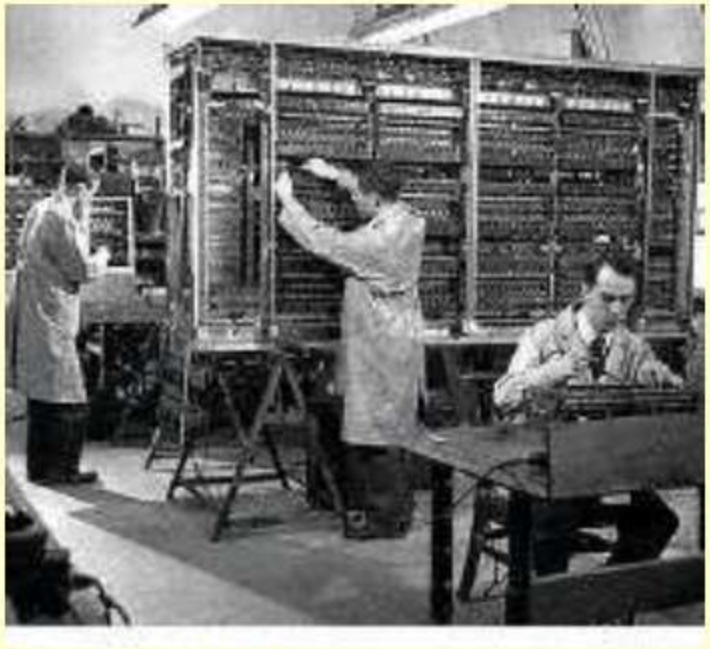
Eckart si Mauchley



John von Neumann

UNIVAC

ENIAC



ADVAC

IBM 701

Generatia a II-a ~ 1955-65

tehnologia: tranzistorul

Shockley, Brattain si Bradley – (Bell labs) - 1 Iulie 1947

- primul calculator tranzistorizat: TX-0
- BM 7090 – varianta tranzistorizata, IBM 1401
- Wirlwind – MIT
- PDP-1, PDP-8, firma DEC
- CDC 6600 – primul calculator paralel
- CETA – calc. romanesc

TX-0

PDP-1

Generatia a III-a ~ 1965-75

tehnologia: circuite integrate
Primul CI digital 12 sept. 1958 ? (Fairchild ?? Texas Instr.)

familii de calculatoare:
- mainframe: IBM 360, IBM 370
- mini: PDP 11

calculatoare romanesti:
- Felix C-256, C-512, C-32
- Independent, Coral – copiaza PDP-11

imbunatatiri:
- Viteza,fiabilitate, dimensiuni,capacitatea memoriei (256k-512k)
- Noi periferice: consola-display (PDP11)

Calculator HP

Apollo

HP (1972)

Generatia a IV-a 1975 -

tehnologia: VLSI >> µP

-aparitia primului microprocesor - Intel 4004 (1971)

- avantaje: viteza, grad ridicat de integrare, fiabilitate mare, cost redus, dimensiuni mici

- CI ROM, RAM, DRAM de capacitate mare (1-16ko)

- aparitia µcalculatoarelor – pe baza de microprocesor

- apar calculatoarele personale:

- home-computer: ZX81, Spectrum

- PC: IBM-PC, XT, AT, Apple, Machintosh

- calculatoare romanesti: seria M18, PRAE, aMIC, Felix PC, Telerom-PC

Apple I 1976

Sinclair ZX80 1980

IBM PC 1981

Atari 400 1979

Apple Mac 1984

14

Bill Gates

Steve Jobs si Steve Wozniak

Generatia a V-a ??? (1982-

-proiect japonez ambitios - esec

obiective: -viteze f.mari de calcul (mil.inferente/s)
- interfete om-calculator naturale (voce, imagine)
- aplicatii de inteligenta artificiala
- arhitecturi paralele de calcul

ce nu s-a prevazut:
- dezvoltarea sistemelor bazate pe microprocesoare
- dezvoltarea retelelor de calculatoare
-dezvoltarea sistemelor / aplicatiilor distribuite (Internet)

-http://en.wikipedia.org/wiki/Fifth_generation_computer

INFERÉNŢĂ= Operaţie logică de trecere de la un enunţ la altul şi în care ultimul enunţ este dedus din primul

Width	Processor	Application
4 bit	4004	Pocket calculators
8 bit	8080	Small CP/M based home computers
16 bit	8086, 8088, 80286	IBM-compatible PC's running MS-DOS
32 bit	80386 - Pentium 4	32 bit versions of Windows (Windows 95/98/2000/ XP)
64 bit	Athlon 64 Pentium 4 Itanium	Server software 64 bits versions of Windows, Linux etc.

GENERATII DE PC-uri

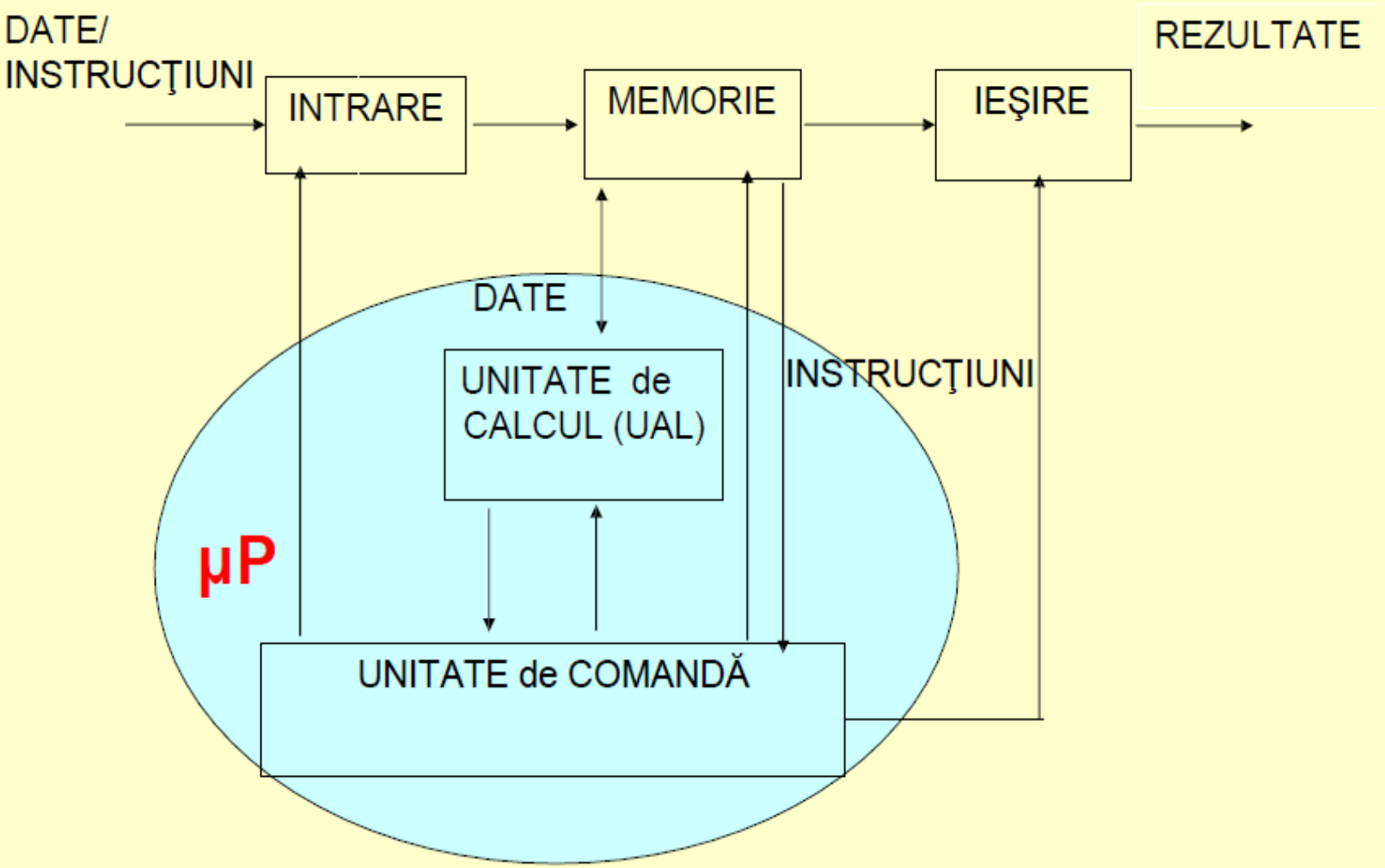
PC	CPUs	Year	Number of transistors
1st. Generation	8086 and 8088	1978-81	29,000
2nd. Generation	80286	1984	134,000
3rd. Generation	80386DX and 80386SX	1987-88	275,000
4th. Generation	80486SX, 80486DX, 80486DX2 and 80486DX4	1990-92	1,200,000
5th. Generation	Pentium Cyrix 6X86 AMD K5 IDT WinChip C6	1993-95 1996 1996 1997	3,100,000 -- -- 3,500,000
Improved 5th. Generation	Pentium MMX IBM/Cyrix 6x86MX IDT WinChip2 3D	1997 1997 1998	4,500,000 6,000,000 6,000,000
6th. Generation	Pentium Pro AMD K6 Pentium II AMD K6-2	1995 1997 1997 1998	5,500,000 8,800,000 7,500,000 9,300,000
Improved 6th. Generation	Mobile Pentium II Mobile Celeron Pentium III AMD K6-3 Pentium III CuMine	1999	27,400,000 18,900,000 9,300,000 ? 28,000,000
7th. Generation	AMD original Athlon AMD Athlon Thunderbird Pentium 4	1999 2000	22,000,000 37,000,000 42,000,000

Alte familii de microprocesoare:

- **Motorola: 6800 (8 biti), 68000 (16 biti), 68020, 68030 (32 biti), 68040**
- **Zilog: Z80, Z8000**
- **Texas Instruments: -DSP: TMS320c10/20/30/5x/6x; DSC**
- **Microchip: microcontrolere: PICxxx**
- **Atmel AT89Sxxx, AT90SXXX (AVR)**
- **MIPS, ARM etc.**

Codename	i7 x86 gen	Official Gen	Lead chip	Process	Intro	Graphics
Skylake	7th	6th	Core i7-6700K	14nm	2015	HD 530
Broadwell	6th	5th	Core i7-5775C	14nm	2015	Iris Pro 5200
Haswell	5th	4th	Core i7-4770K	22nm	2013	HD 4600
Ivy Bridge	4th	3rd	Core i7-3770K	22nm	2012	HD 4000
Sandy Bridge	3rd	2nd	Core i7-2600K	32nm	2011	HD 3000
Clarkdale	2nd	1st	Core i5-655K	32nm	2010	HD
Westmere	2nd		Core i7-980X	32nm	2010	None
Lynnfield	1st		Core i7-870	45nm	2009	None
Bloomfield	1st		Core i7-965XE	45nm	2008	None
Yorkfield			Core 2 Extreme QX6850	45nm	2007	None
Conroe			Core 2 X6800	65nm	2006	None

3. ARHITECTURI DE PRELUCRARE



Schema bloc a calculatorului cu program memorat

Un calculator cu program memorat trebuie să posede :

1. **Intrare pentru un număr nelimitat de date şi instrucţiuni**

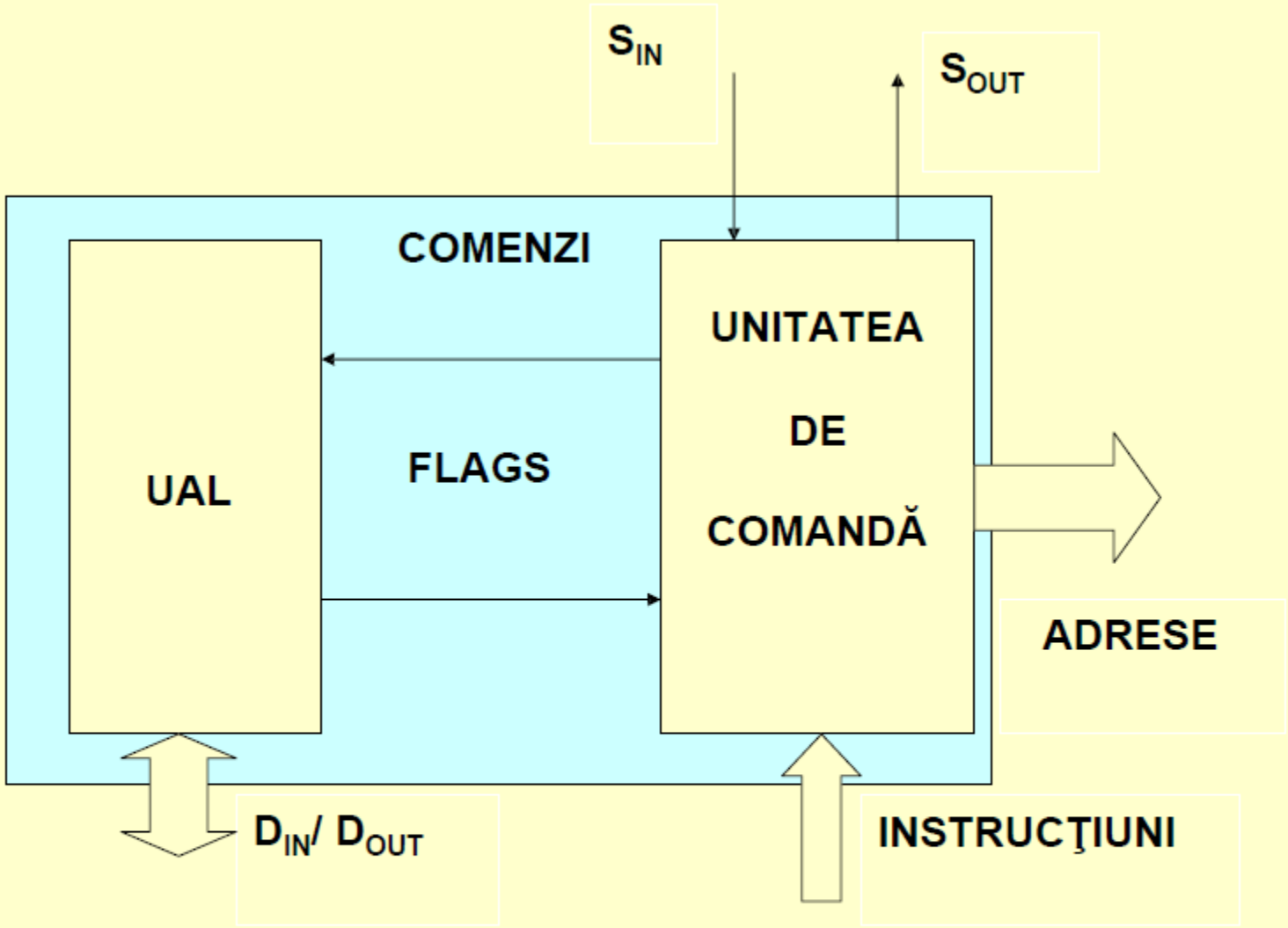
2. **Memorie din care se pot citi instrucţiuni şi operanzi şi se depun rezultate**

3. **Ieşire prin care să pună rezultatele la dispoziţia utilizatorului**

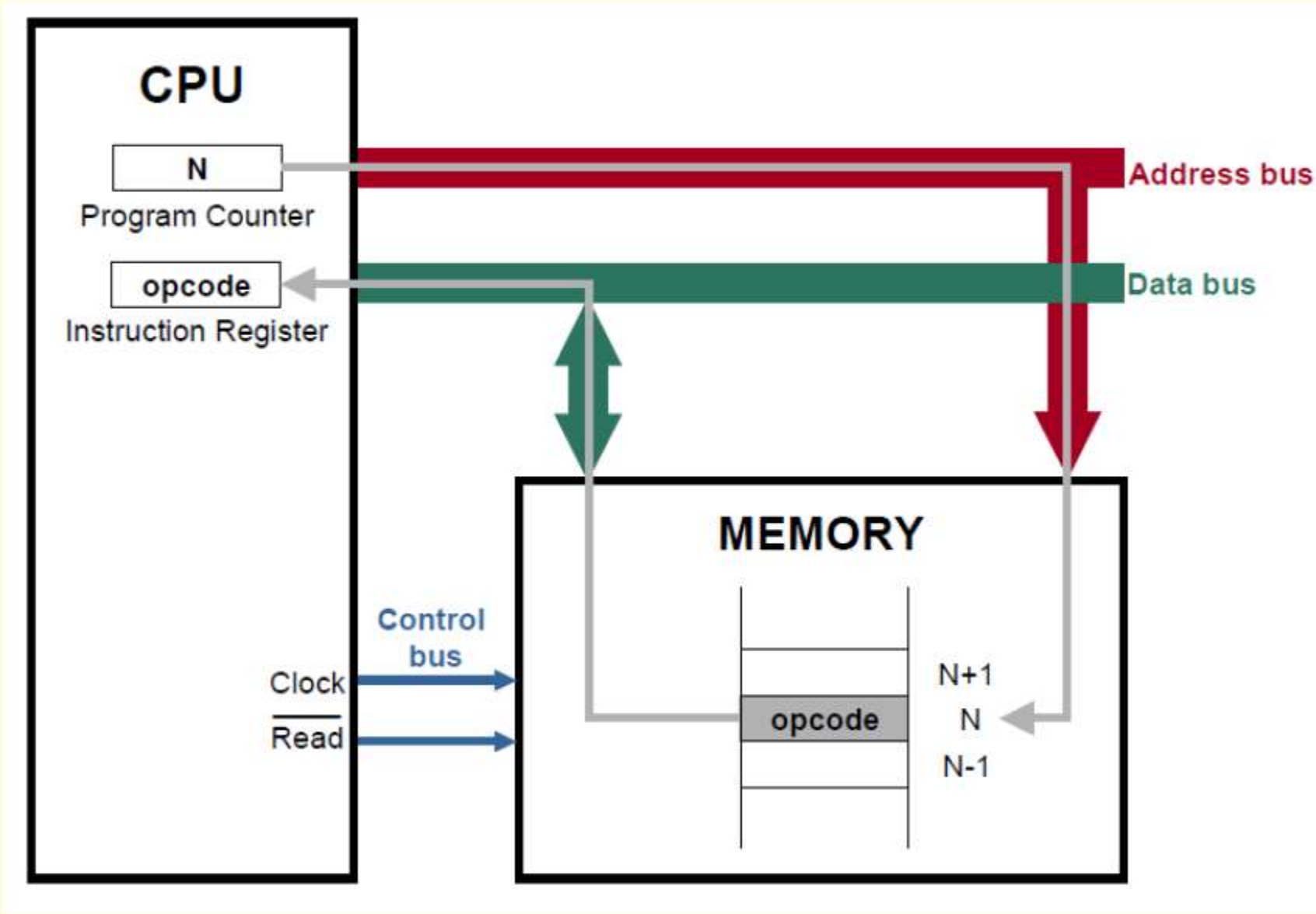
4. **Unitate de calcul (UAL –unitate aritmetică şi logică sau de execuţie) care să execute operaţii aritmetice şi logice asupra datelor din memorie**

5. **Unitate de comandă (control) care să interpreteze instrucţiunile extrase din memorie şi să aleagă diferite acţiuni pe baza rezultatelor calculelor**

MICROPROCESOR = Unitate de calcul + Unitate de comandă (4+5)
MICROCALCULATOR (single-chip) = 1 +...+ 5 (microcontroler)



SCHEMA BLOC A MICROPROCESORULUI

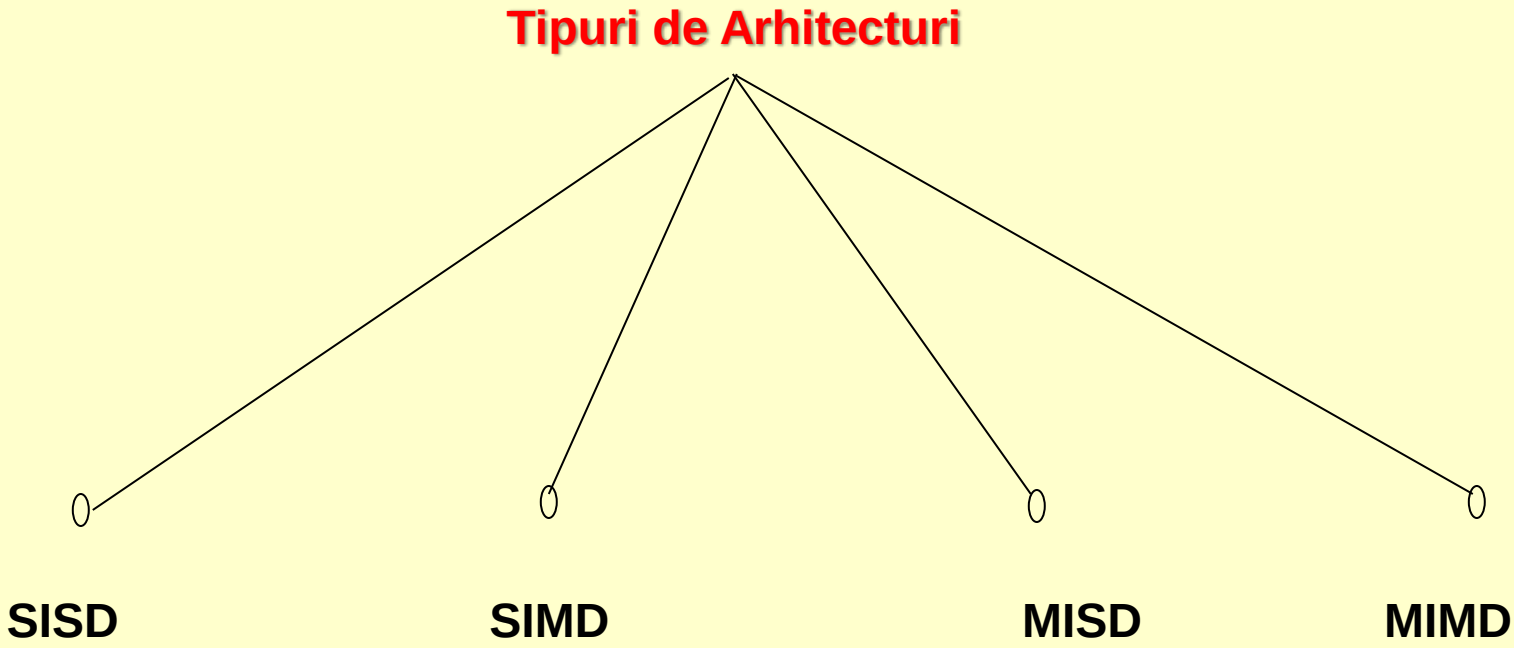

CPU
N
Program Counter
opcode
Instruction Register
Address bus
Data bus
MEMORY
Control bus
Clock
Read
N+1
N
opcode
N-1

Taxonomii ale arhitecturilor de prelucare

- Flynn [1966]
- Feng [1972]
- Händler [1977]
- Moderne (Sima, Fountain & Kacsuk)

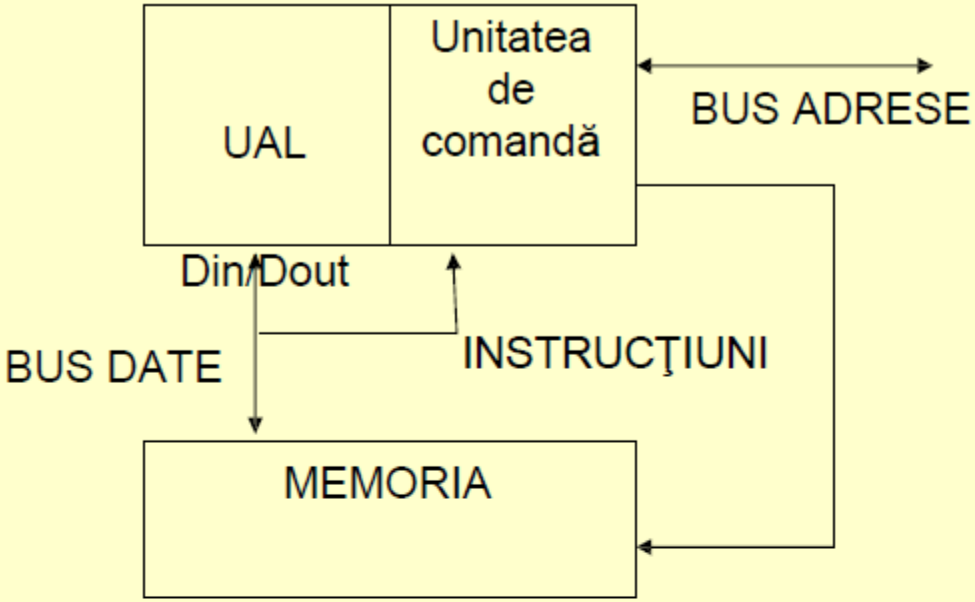
Clasificarea dupa Flynn

- Se bazeaza pe **multiplicitatea *sirului de date sau instructiuni primite*** de CPU pe parcursul executiei unui program



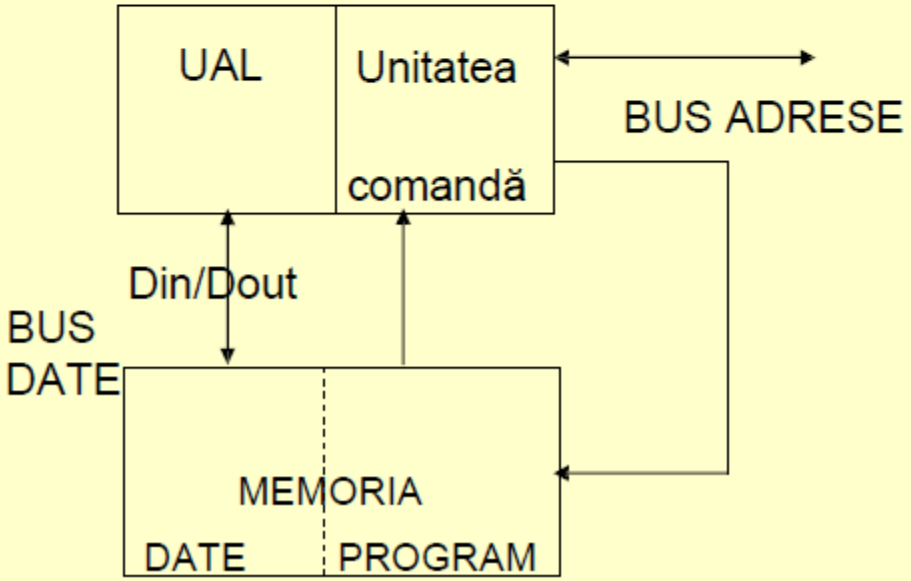
1) **Single Instruction and Single Data stream (SISD)**
2) **Single Instruction and multiple Data stream (SIMD)**
3) **Multiple Instruction and Single Data stream (MISD)**
4) **Multiple Instruction and Multiple Data stream (MIMD)**

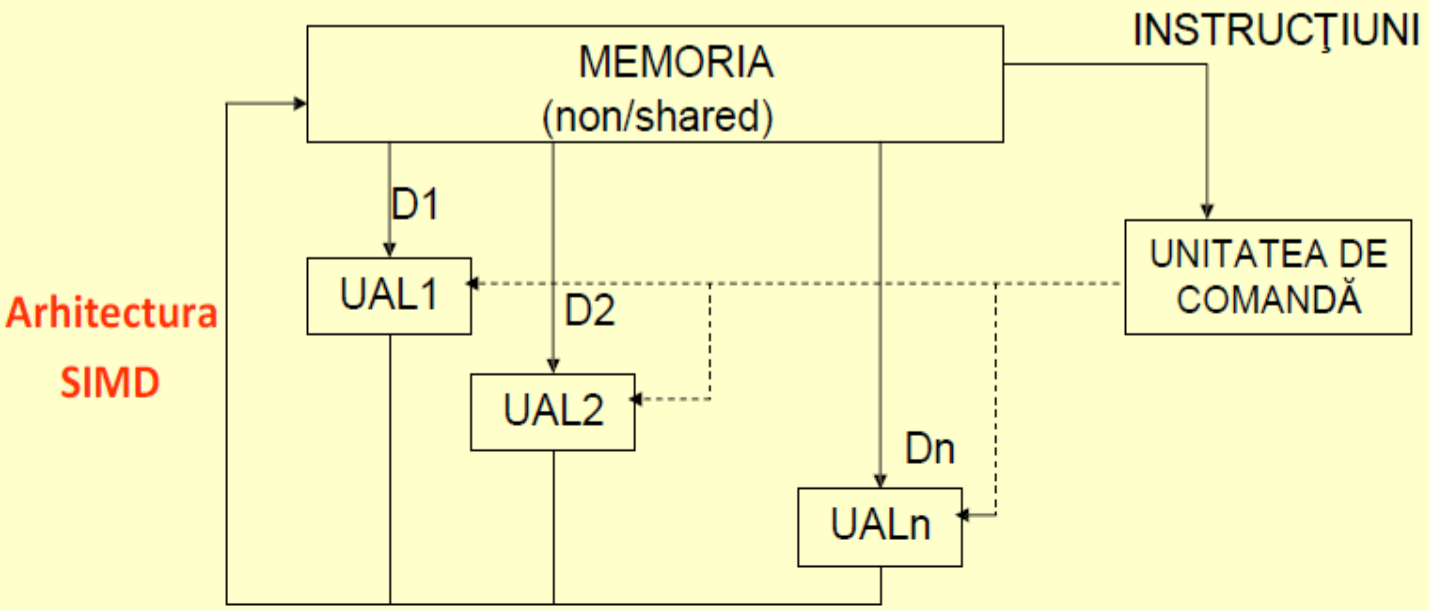
Clasificarea arhitecturilor de prelucrare - dupa Flynn

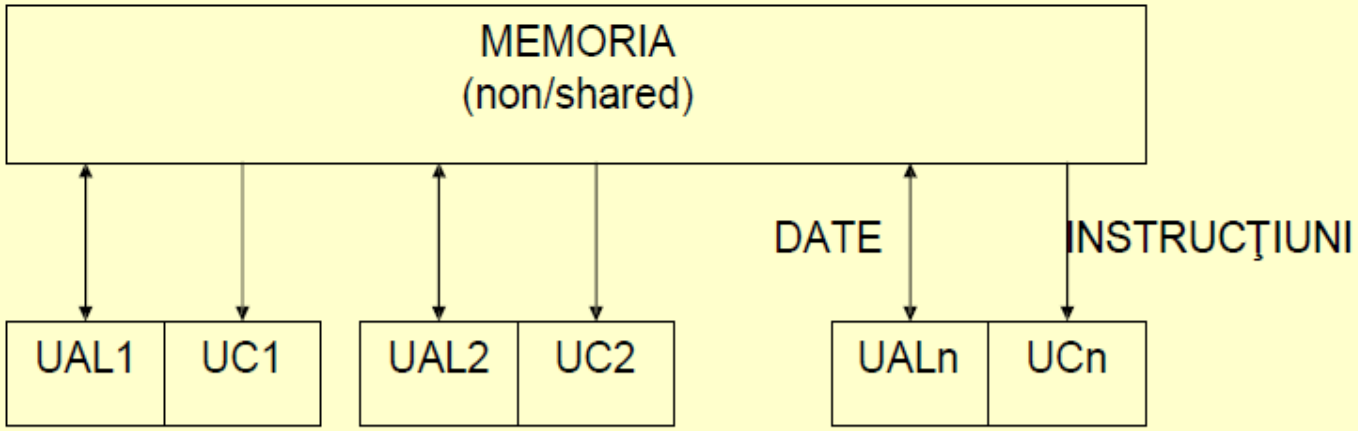


Arhitectura SISD (von Neumann)

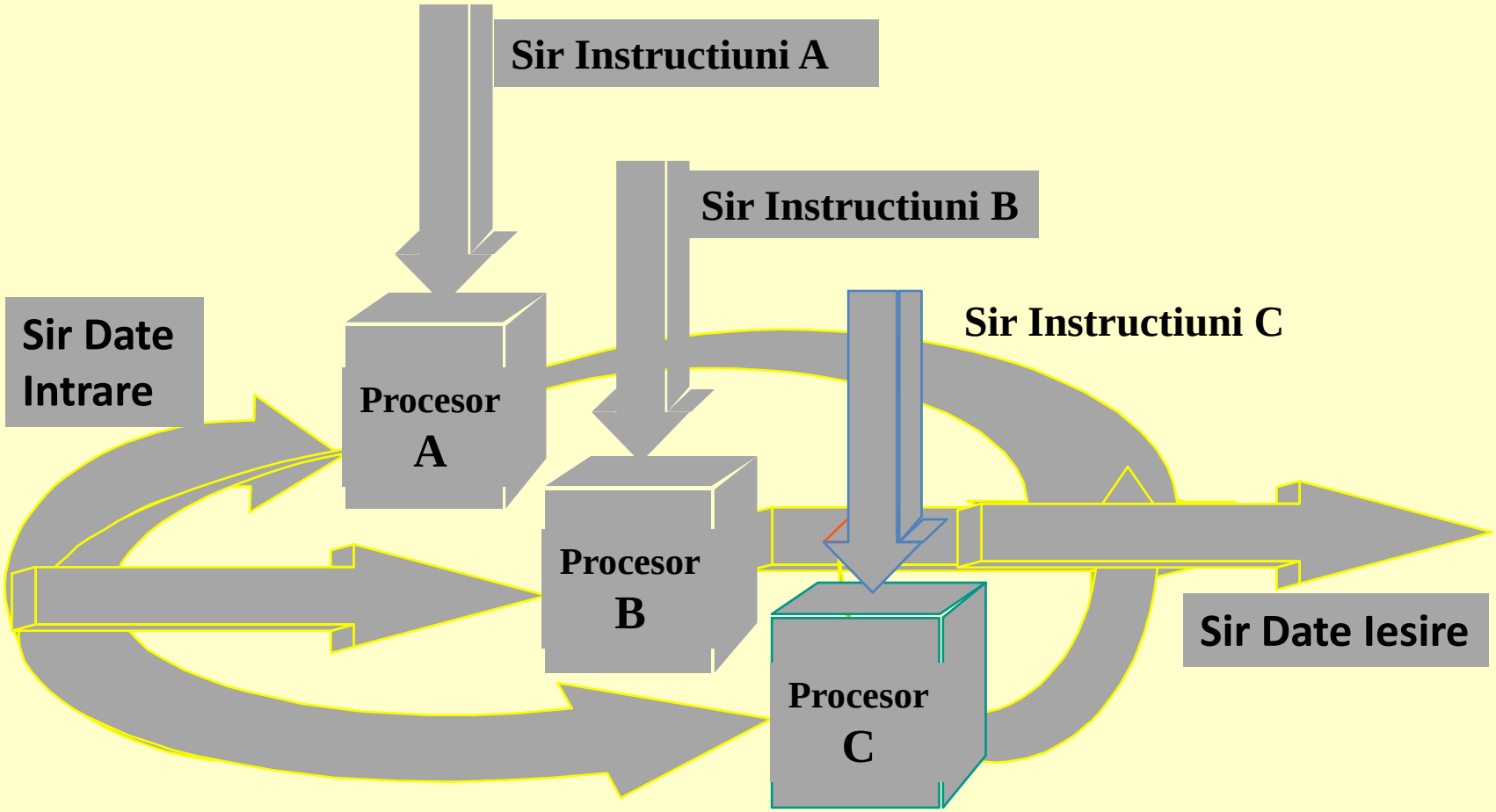
Arhitectura HARVARD







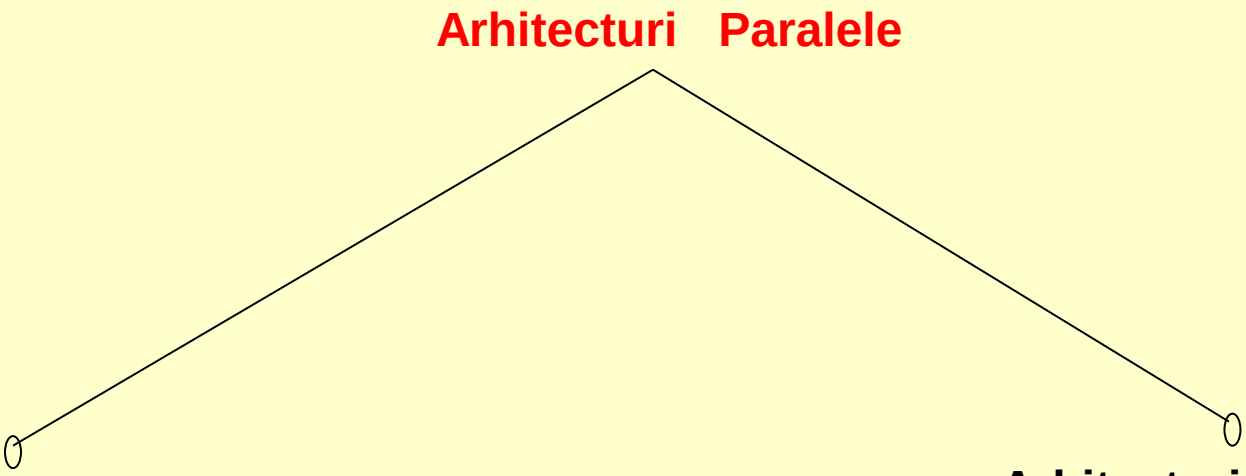
!!! TOP500 supercomputers are based on a MIMD architecture (2006).



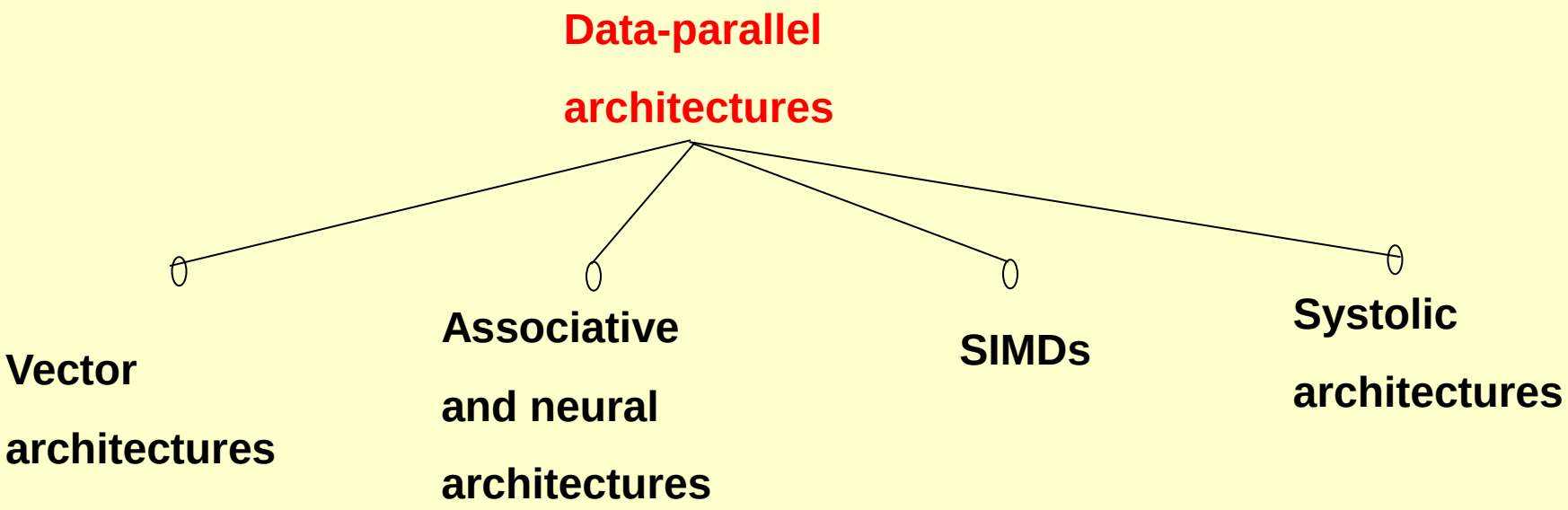
Arhitectura MISD

- Mai mult o configuratie teoretica decat una practica
- mașinile MISD pot fi aplicate la calculatoare de timp real tolerante la erori
- Foarte putine abordari, fara produse comerciale
- (Ex:C.mmp - Carnegie-Mellon University.)

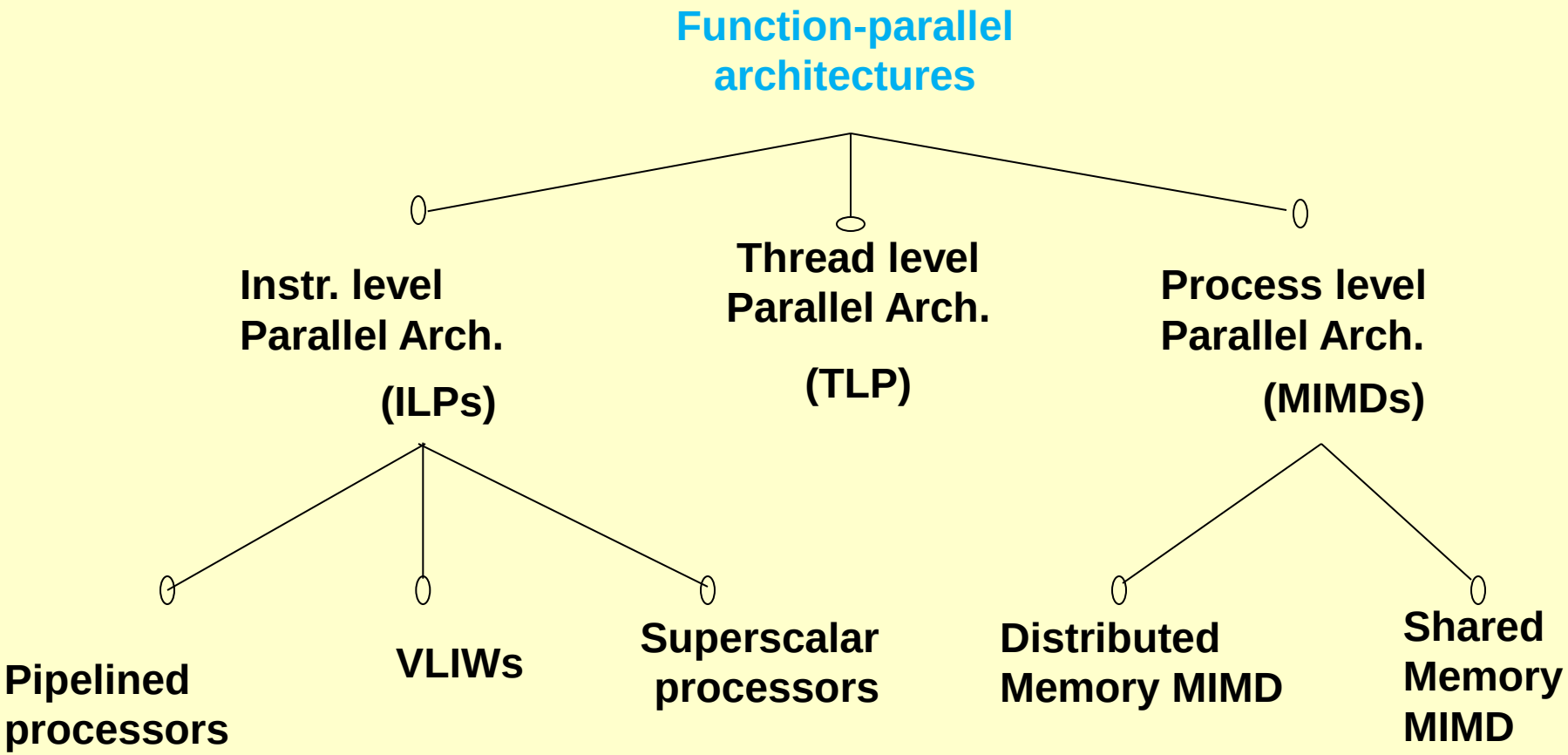
Clasificari Moderne



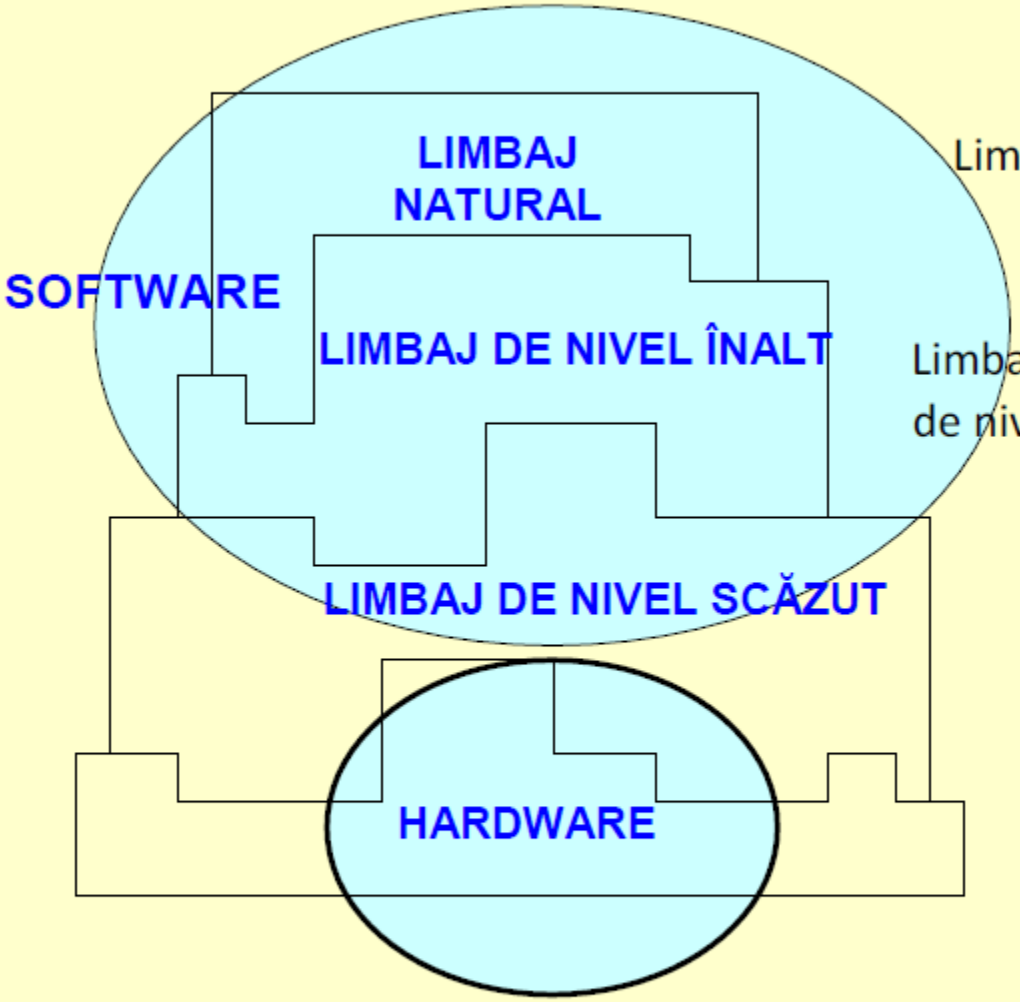
Arhitecturi de Date Paralele



Arhitecturi de Functii Paralele



4. LIMBAJUL DE ASAMBLARE

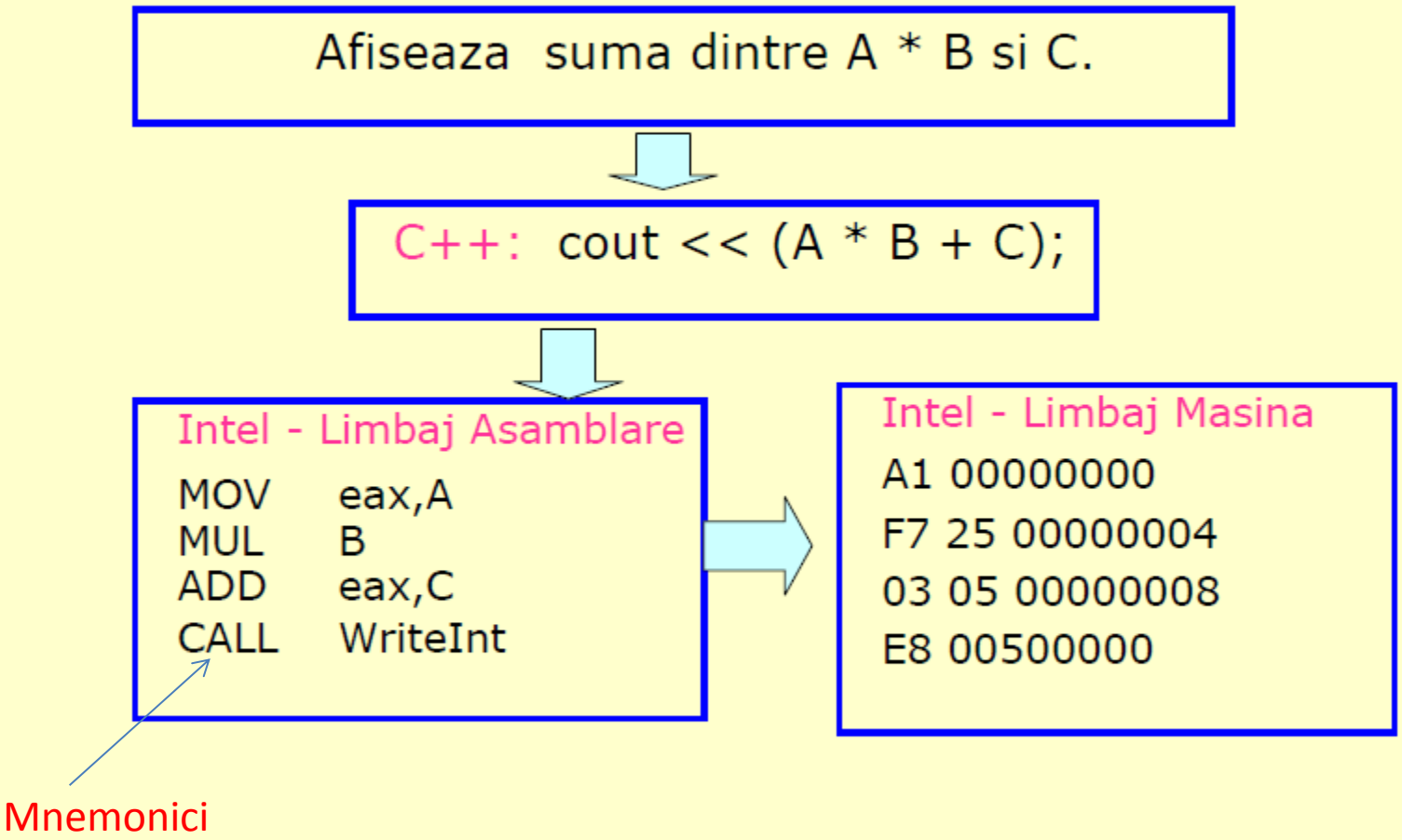


Limbajul uman

Limbaje de programare,
de nivel înalt - HLL

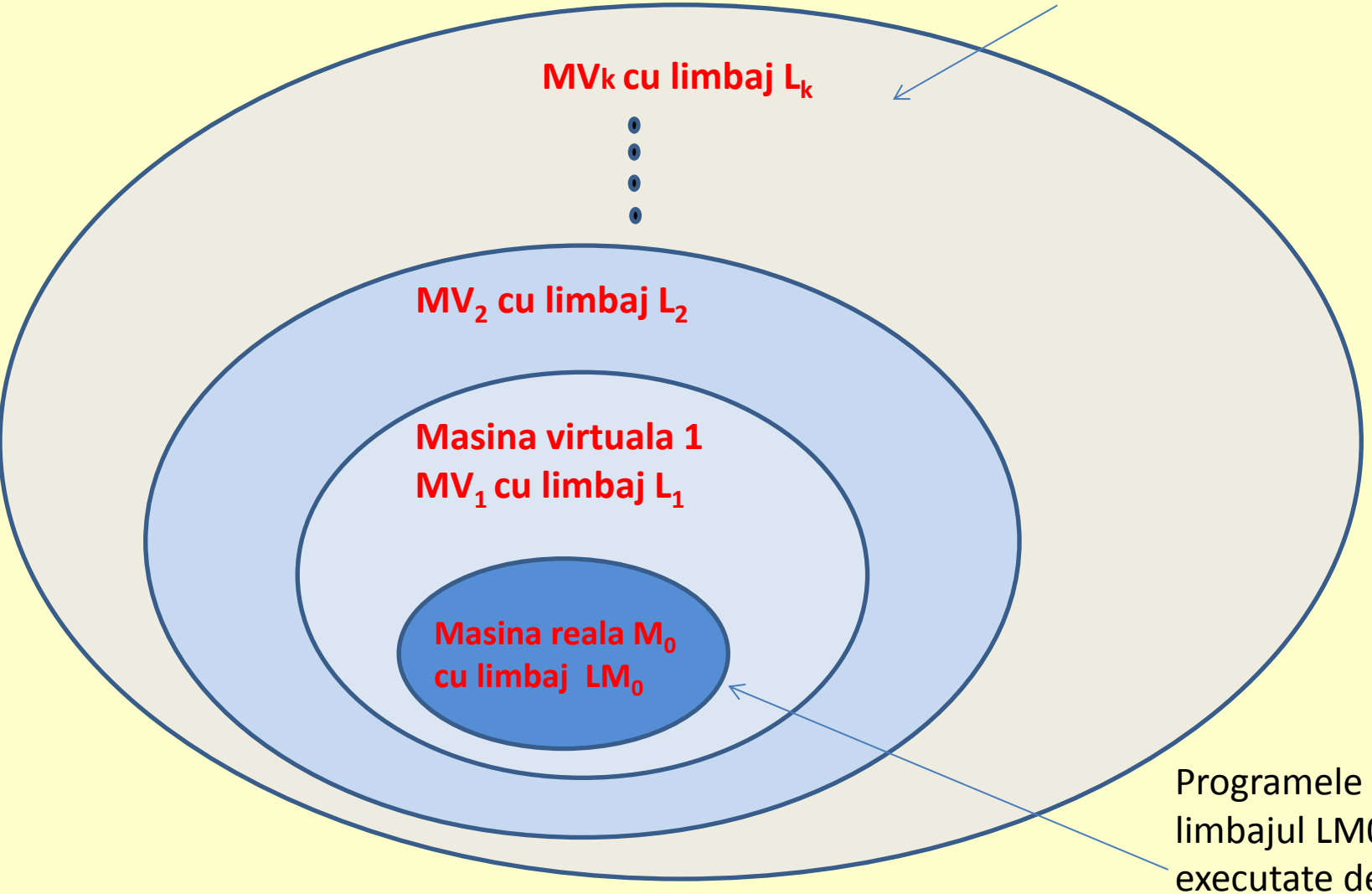
Limbaj de asamblare
(cod maşină)
limbaj "low-level"

Ierarhizarea limbajelor


Afiseaza suma dintre A * B si C.
C++: cout << (A * B + C);
Intel - Limbaj Asamblare
MOV eax,A
MUL B
ADD eax,C
CALL WriteInt
Intel - Limbaj Masina
A1 00000000
F7 25 00000004
03 05 00000008
E8 00500000
Mnemonici

- **Calculatorul (d.p.d.v software) poate fi considerat ca o succesiune de masini virtuale**

Nivel k : Programele scrise in Lk pot fi interpretate de un program interpretor, care ruleaza pe o MV de nivel inferior sau translatat in limbajul unei MV inferioare



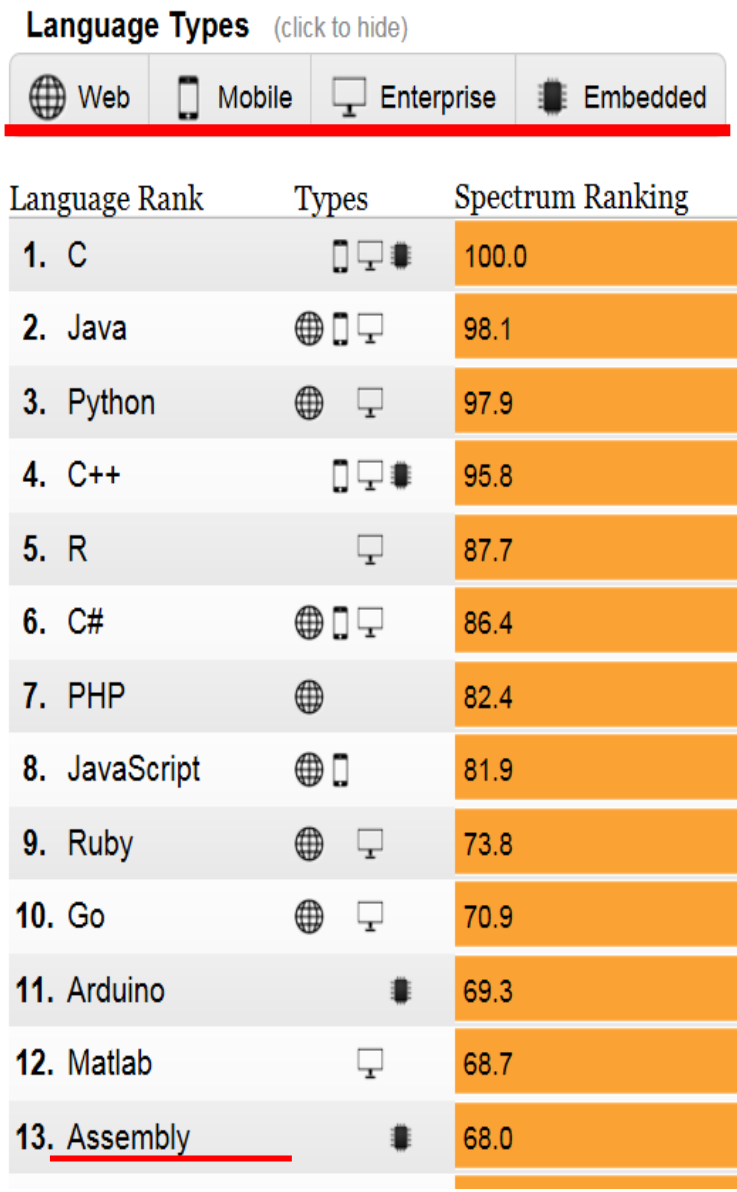
Programele scrise in limbajul LM0 pot fi executate de hardware

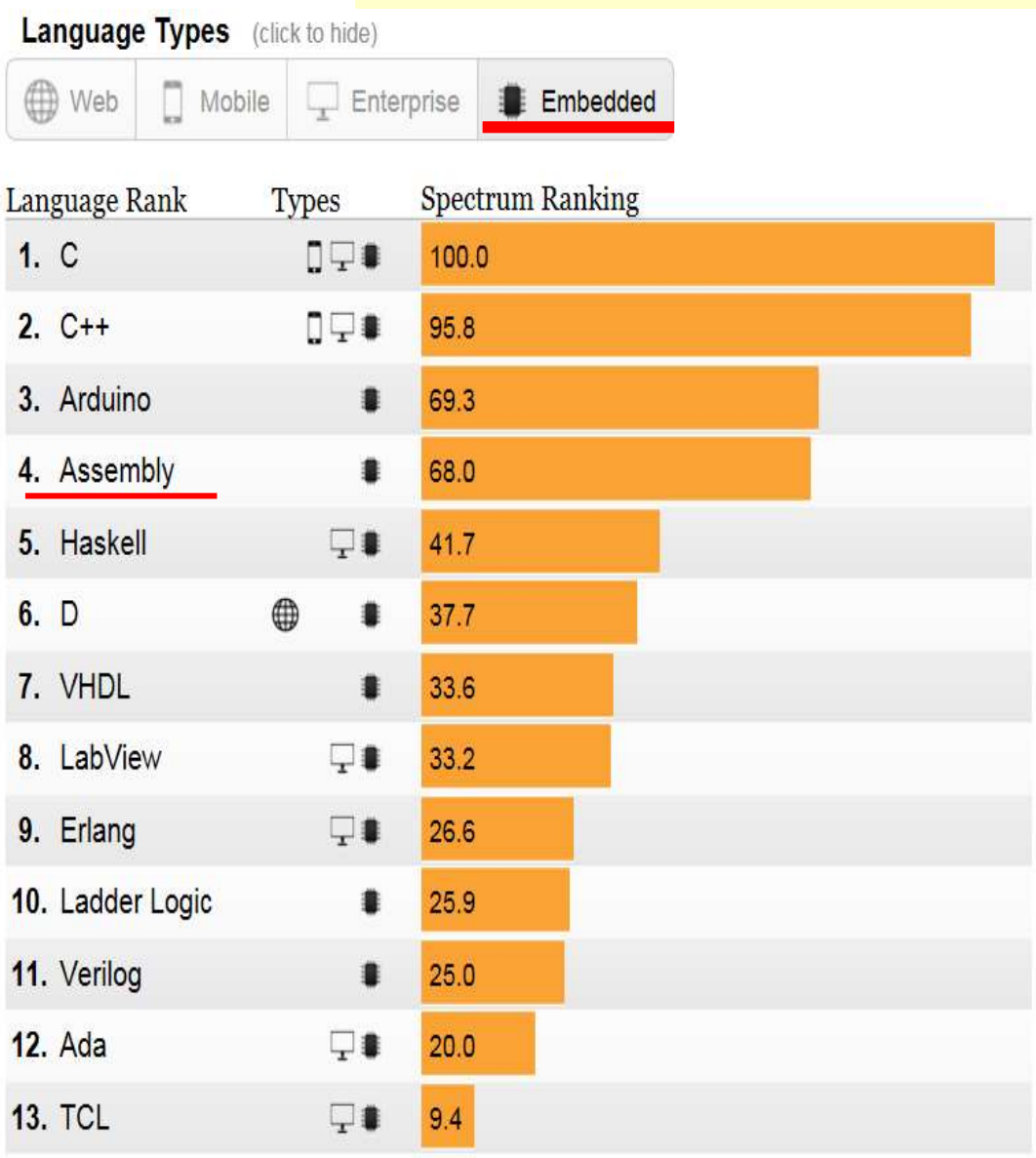
- Se poate spune că limbajul **L1,** corespunde unei maşini virtuale programabile, **MV1.** Acest limbaj simbolic de programare este **“limbajul de asamblare”,** iar aplicatia de translatare este numita ***“asamblor”***

- **Translatarea:** - programul scris în **L1** este convertit într-un program în LM0 (executabil), iar varianta in **L1** este abandonata.
  - programul în **LM0** este încărcat în memoria calculatorului şi executat
- Ex. **translator**: compilator, asamblor.

- **Interpretarea** – un program în **LM0** care rulează pe **M0** şi care citeste instrucţiunile programului în **L1** ca date de intrare
- Interpretorul citeşte şi decodifică instrucţiunea din **L1** şi apoi trece imediat la execuţia acesteia.
- La interpretare **nu se generează program executabil** ca la translatare
- Limbaje de programare mai apropiate de limbajul uman: L2, L3 (HLL) care ruleaza pe MV2, MV3.

O mașină virtuală este un software care emulează sarcinile unei platforme hardware cu toate componentele sale (procesor, memorie, hard disk, USB, unitate optică, adaptoare video și de rețea etc.). O mașină virtuală vă permite să instalați și să executați simultan mai multe sisteme de “guest” (OS, care rulează pe mașini virtuale) într-un singur sistem gazdă (OS instalat pe hardware). Lista sistemelor de operare care pot fi instalate pe mașinile virtuale variază foarte mult și depinde de sistemul de virtualizare particular.





The Top Programming Languages 2016

Courtesy of IEEE Spectrum

Language Types (click to hide)

Web | Mobile | Enterprise | Embedded

Language Rank	Types	Spectrum Ranking
1. Python		100.0
2. C		99.7
3. Java		99.4
4. C++		97.2
5. C#		88.6
6. R		88.2
7. JavaScript		85.4
8. PHP		81.1
9. Go		75.8
10. Swift		75.0
11. Arduino		72.4
12. Ruby		72.1
13. Assembly		71.8
14. Matlab		68.6

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5. Haskell		47.7
6. D		37.9
7. VHDL		35.1
8. LabView		32.2
9. Verilog		29.9
10. Erlang		27.4
11. Ada		25.5

LIMBAJUL DE ASAMBLARE

DEZAVANTAJE	AVANTAJE
• Assembly is hard to learn •Assembly is hard to read and understand • Assembly is hard to debug • Assembly is hard to maintain • Assembly is hard to write •Assembly language programming is time consuming •Improved compiler technology has eliminated the need for assembly language •Today, machines are so fast that we no longer need to use assembly •If you need more speed, you should use a better algorithm rather than switch to assembly language. •Machines have so much memory today, saving space using assembly is not important. •Assembly language is not portable.	•Speed. Assembly language programs are generally the fastest programs around. • Space. Assembly language programs are often the smallest. •Capability. You can do things in assembly which are difficult or impossible in HLLs. •Knowledge. Your knowledge of assembly language will help you write better programs, even when using HLLs.

5. TEME:

http://en.wikipedia.org/wiki/History_of_computing_hardware
http://www.karbosguide.com/
http://en.wikipedia.org/wiki/List_of_Intel_microprocessors
https://en.wikipedia.org/wiki/Template:CPU_technologies

CPU technologies

Architecture		ISA : CISC · EDGE · EPIC · MISC · OISC · RISC · VLIW · ZISC · Harvard architecture · von Neumann architecture · 4-bit · 8-bit · 12-bit · 16-bit · 18-bit · 24-bit · 31-bit · 32-bit · 36-bit · 48-bit · 64-bit · 128-bit
Parallelism	**Pipeline**	Instruction pipelining · In-order & out-of-order execution · Register renaming · Speculative execution · Hazards
	Level	Bit · Instruction · Superscalar · Data · Task
	Threads	Multithreading · Simultaneous multithreading · Hyperthreading · Superthreading
	Flynn's taxonomy	SISD · SIMD · MISD · MIMD
Types		Digital signal processor · Microcontroller · System-on-a-chip · Vector processor
Components		Arithmetic logic unit (ALU) · Barrel shifter · Floating-point unit (FPU) · Back-side bus · Multiplexer · Demultiplexer · Registers · Memory management unit (MMU) · Translation lookaside buffer (TLB) · Cache · register file · microcode · control unit · clock rate
Power management		APM · ACPI (states) · Dynamic frequency scaling · Dynamic voltage scaling · Clock gating