Arhitecturi Paralele
Introducere

Prof. Florin Pop
As. Drd. Ing. Cristian Chilipirea
cristian.chilipirea@cs.pub.ro

Elemente preluate din cursul Prof. Ciprian Dobre

Regulament

- Laboratoarele se rezolvă în laborator
- Temele se rezolvă individual și vor fi verificate anti-plagiat

Punctaje

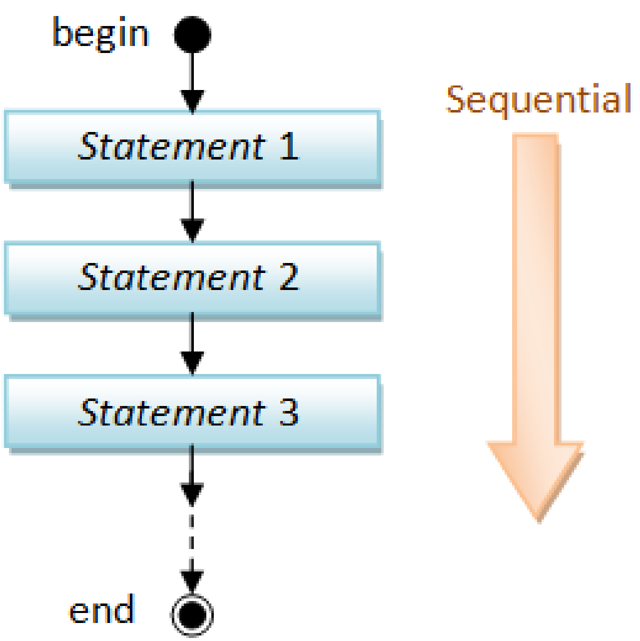
- 2p Laborator
- 4p Teme
  - Minim 3p pentru intrare în examen
- 4p Examen
  - Minim 2p

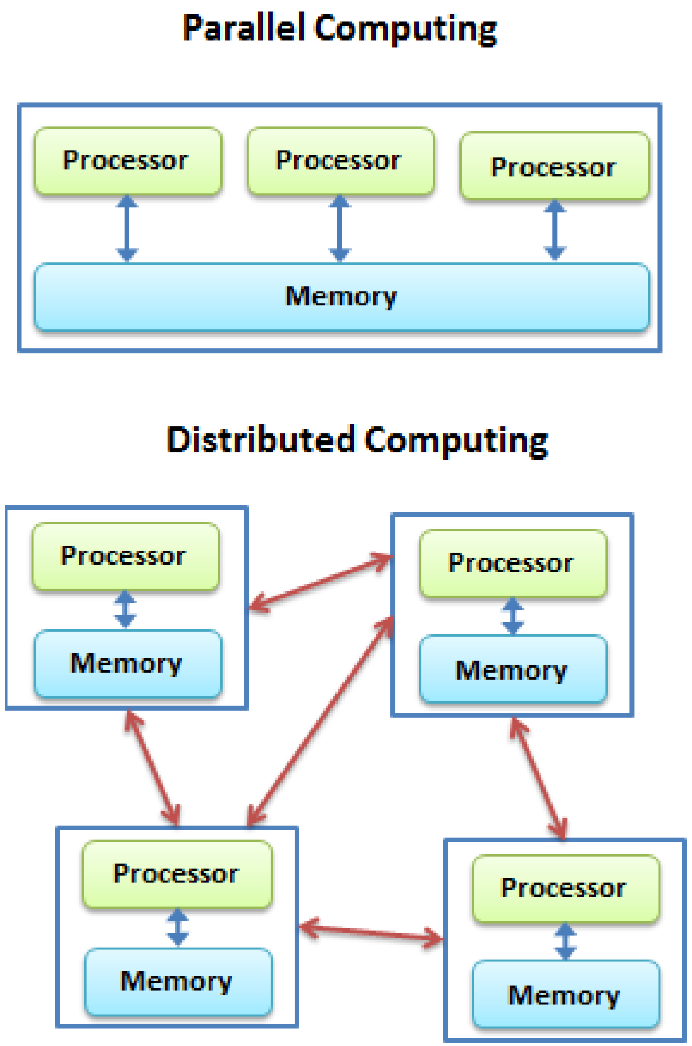
Obiective

Dezvoltarea abilităților pentru:

- Proiectarea și implementarea aplicațiilor multi-thread
- Proiectarea și implementarea aplicațiilor distribuite
- Depanarea unor aplicații multi-thread sau distribuite
- Demonstrarea corectitudinii și scalabilității unui program multi-threa sau distribuit
- Modelarea complexității unui algoritm multi-thread sau distribuit
- Recunoașterea soluțiilor clasice de tip multi-thread sau distribuite în probleme reale

Algoritmi Paraleli/Distribuiți vs Secvențiali





Resurse fizice

- Procesor – multi-core – 28 core-uri

- Cluster

- Grid/Cloud

Supercomputers

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	**Summit** - IBM Power System AC922, IBM POWER9 22C 3.07GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband , IBM DOE/SC/Oak Ridge National Laboratory United States	2,282,544	122,300.0	187,659.3	8,806
2	**Sunway TaihuLight** - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway , NRCPC National Supercomputing Center in Wuxi China	10,649,600	93,014.6	125,435.9	15,371
3	**Sierra** - IBM Power System S922LC, IBM POWER9 22C 3.1GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband , IBM DOE/NNSA/LLNL United States	1,572,480	71,610.0	119,193.6	
4	**Tianhe-2A** - TH-IVB-FEP Cluster, Intel Xeon E5-2692v2 12C 2.2GHz, TH Express-2, Matrix-2000 , NUDT National Super Computer Center in Guangzhou China	4,981,760	61,444.5	100,678.7	18,482
5	**AI Bridging Cloud Infrastructure (ABCI)** - PRIMERGY CX2550 M4, Xeon Gold 6148 20C 2.4GHz, NVIDIA Tesla V100 SXM2, Infiniband EDR , Fujitsu National Institute of Advanced Industrial Science and Technology (AIST) Japan	391,680	19,880.0	32,576.6	1,649

Summit

Sunway TaihuLight

Sierra

Piz Daint

De ce calcul paralel și distribuit?

- Timp de execuție mai scurt
- Permite abordarea problemelor de dimensiuni mari
- Accesul resurselor aflate la distanță
- Reducerea costurilor
- Toleranța la defecte
- Ascunderea timpilor de așteptare
- Redundanța
- Scalabilitatea
- Scăderea timpului de răspuns
- Securitate

Limitele programării secvențiale?

Cramming More Components onto Integrated Circuits

GORDON E. MOORE, LIFE FELLOW, IEEE

With unit cost falling as the number of components per circuit rises, by 1975 economics may dictate squeezing as many as 65 000 components on a single silicon chip.

The future of integrated electronics is the future of electronics itself. The advantages of integration will bring about a proliferation of electronics, pushing this science into many new areas.

Integrated circuits will lead to such wonders as home computers—or at least terminals connected to a central computer—automatic controls for automobiles, and personal portable communications equipment. The electronic wristwatch needs only a display to be feasible today.

But the biggest potential lies in the production of large systems. In telephone communications, integrated circuits

Each approach
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various approach
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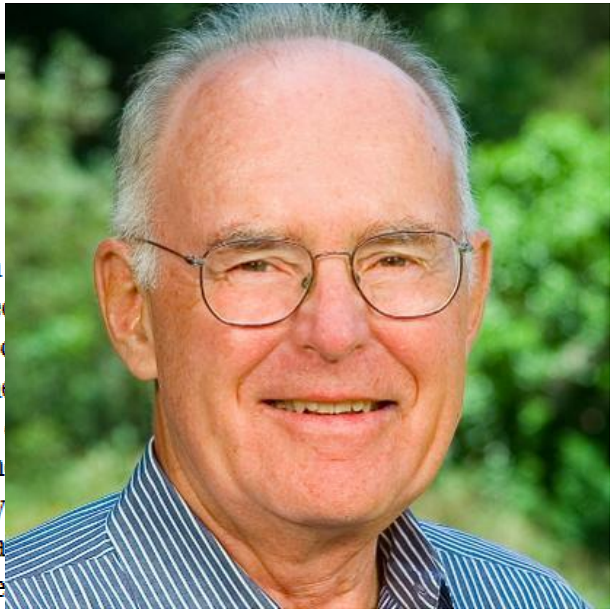
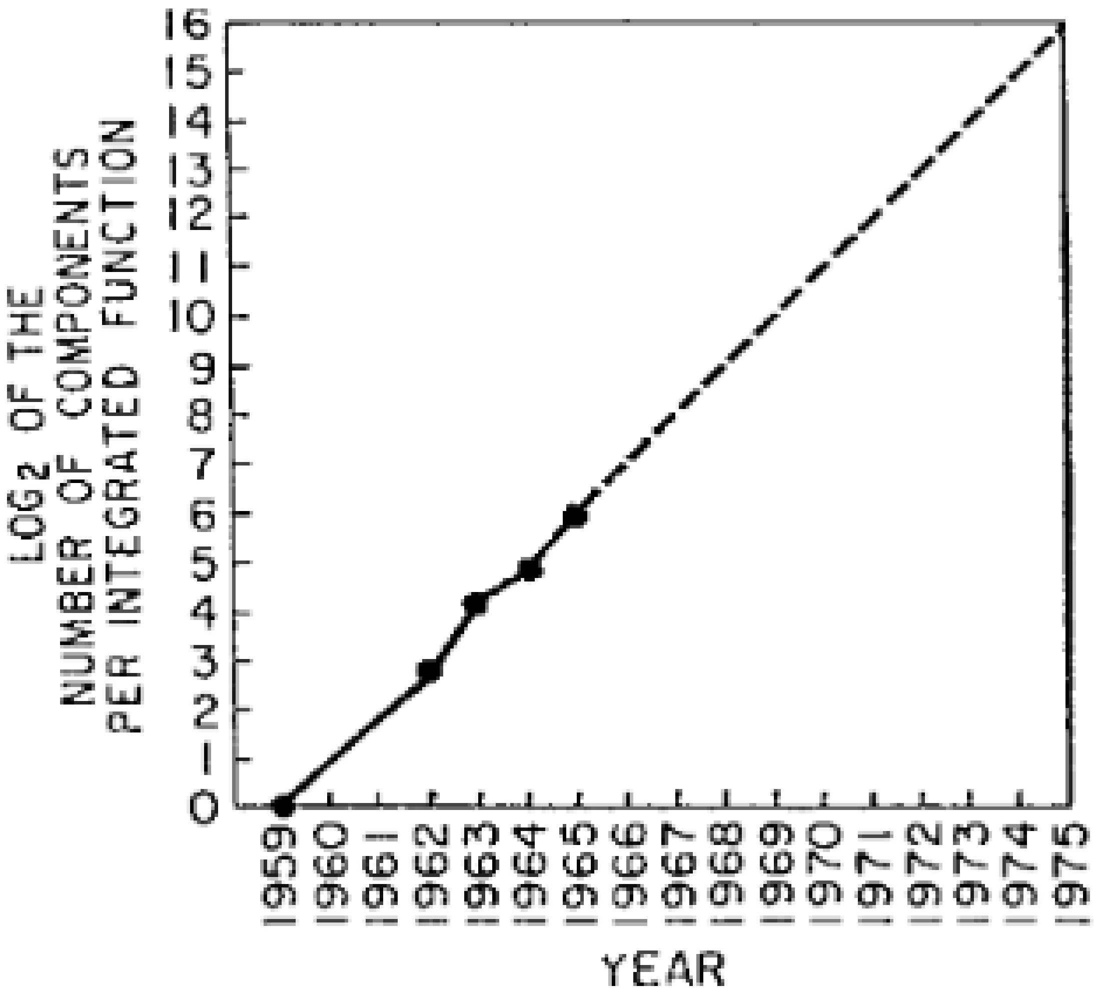
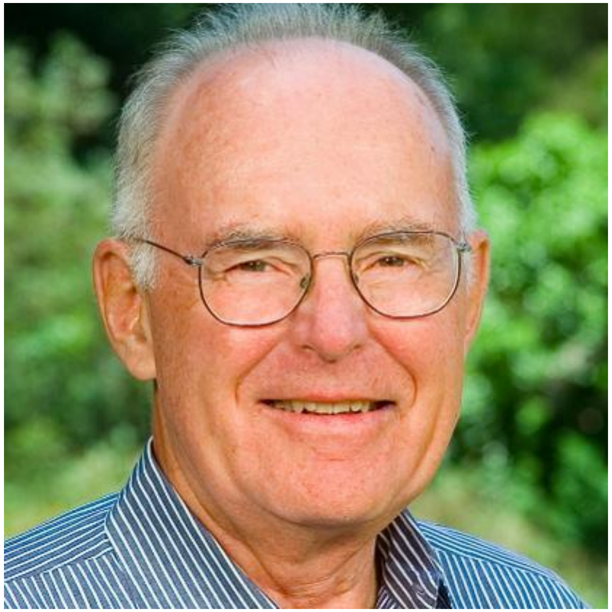
already using th
resistors by apply
conductor substra
upon films are de
attachment of active semiconductor devices to the passive film arrays.

Both approaches have worked well and are being used in equipment today.



Limitele programării secvențiale?





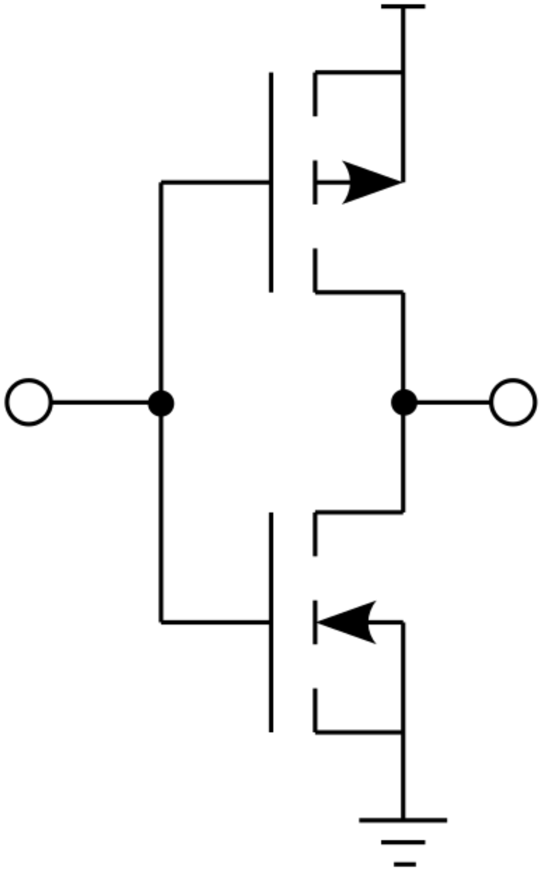
cofounded Intel

Limitele programării secvențiale

- Viteza de transmisie
  – Maxim c – viteza luminii
- Miniaturizare
  – Tranzistor de mărimea unui atom
- Economic
  – Costuri enorme pentru cercetare și proiectarea unui nou timp de procesor

Limitele programării secvențiale

- CMOS



Importanța cursului

- Apar tot mai multe tehnologii distribuite
  - Blockchain; Peer-to-Peer
- Chiar și un procesor de ceas are mai multe core-uri
  - LG Watch Sport - MSM8909w Processor
    - Quad-Core

- Suport în noile IDE-uri
  - Eclipse; Visual Studio
- Număr mare de aplicații distribuite
  - Dropbox; Spark; Boinc

Computing power

24-hour average: 28.019 PetaFLOPS.

Active: 156,141 volunteers, 648,324 computers.

Importanța cursului

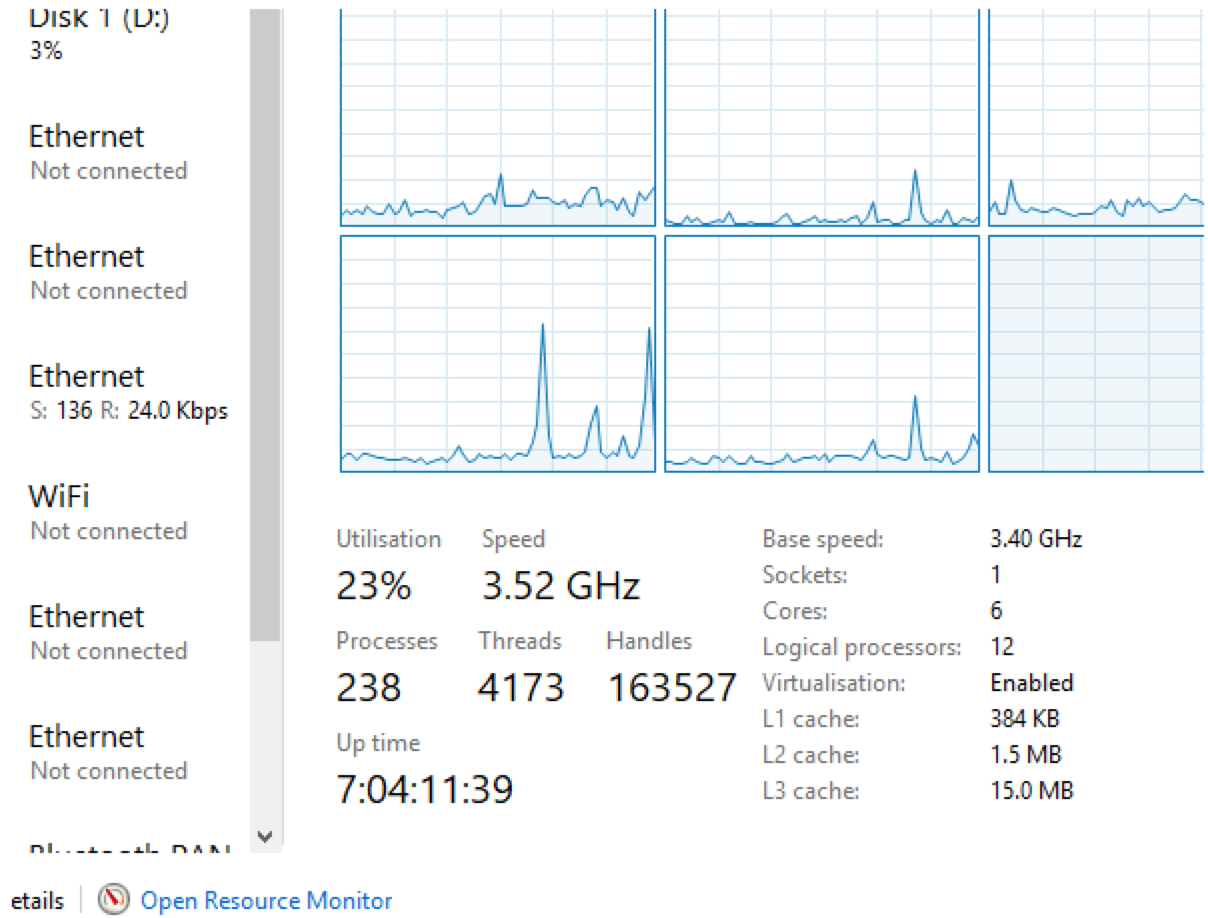
Europeans Budget 1.4 Billion Euros to Build Next-Generation Supercomputers

Michael Feldman | October 1, 2018 17:32 CEST

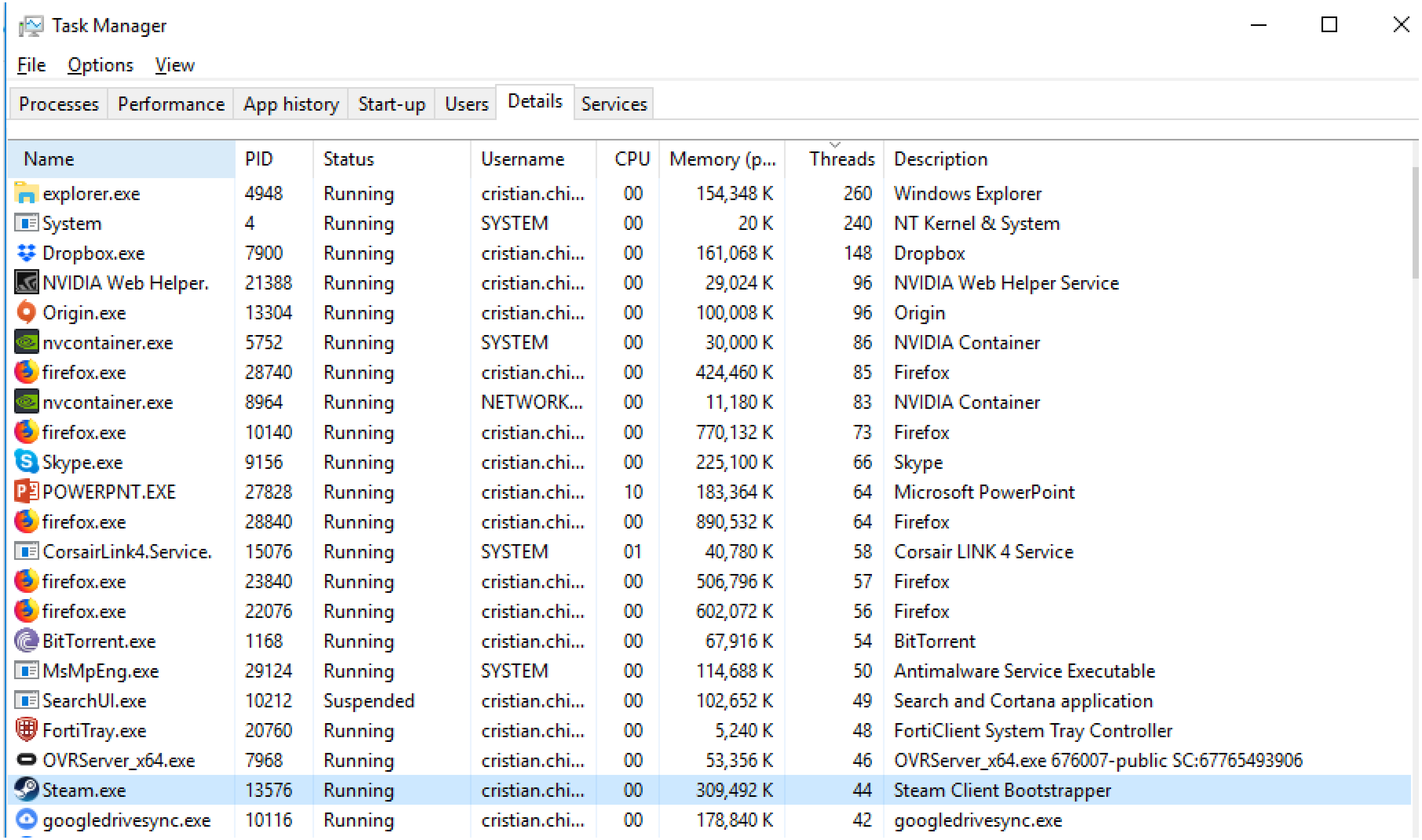
Funding for the European High Performance Computing (EuroHPC) Joint Undertaking has been allocated to deploy the region's initial batch of pre-exascale supercomputers, as well as drive development of an indigenous ecosystem for high performance computing.

Importanța cursului

- Aproape toate aplicațiile au mai multe thread-uri



Importanța cursului



Task Manager

File Options View

Processes | Performance | App history | Start-up | Users | Details | Services

Name	PID	Status	Username	CPU	Memory (p...	Threads	Description
explorer.exe	4948	Running	cristian.chi...	00	154,348 K	260	Windows Explorer
System	4	Running	SYSTEM	00	20 K	240	NT Kernel & System
Dropbox.exe	7900	Running	cristian.chi...	00	161,068 K	148	Dropbox
NVIDIA Web Helper.	21388	Running	cristian.chi...	00	29,024 K	96	NVIDIA Web Helper Service
Origin.exe	13304	Running	cristian.chi...	00	100,008 K	96	Origin
nvcontainer.exe	5752	Running	SYSTEM	00	30,000 K	86	NVIDIA Container
firefox.exe	28740	Running	cristian.chi...	00	424,460 K	85	Firefox
nvcontainer.exe	8964	Running	NETWORK...	00	11,180 K	83	NVIDIA Container
firefox.exe	10140	Running	cristian.chi...	00	770,132 K	73	Firefox
Skype.exe	9156	Running	cristian.chi...	00	225,100 K	66	Skype
POWERPNT.EXE	27828	Running	cristian.chi...	10	183,364 K	64	Microsoft PowerPoint
firefox.exe	28840	Running	cristian.chi...	00	890,532 K	64	Firefox
CorsairLink4.Service.	15076	Running	SYSTEM	01	40,780 K	58	Corsair LINK 4 Service
firefox.exe	23840	Running	cristian.chi...	00	506,796 K	57	Firefox
firefox.exe	22076	Running	cristian.chi...	00	602,072 K	56	Firefox
BitTorrent.exe	1168	Running	cristian.chi...	00	67,916 K	54	BitTorrent
MsMpEng.exe	29124	Running	SYSTEM	00	114,688 K	50	Antimalware Service Executable
SearchUI.exe	10212	Suspended	cristian.chi...	00	102,652 K	49	Search and Cortana application
FortiTray.exe	20760	Running	cristian.chi...	00	5,240 K	48	FortiClient System Tray Controller
OVRServer_x64.exe	7968	Running	cristian.chi...	00	53,356 K	46	OVRServer_x64.exe 676007-public SC:67765493906
Steam.exe	13576	Running	cristian.chi...	00	309,492 K	44	Steam Client Bootstrapper
googledrivesync.exe	10116	Running	cristian.chi...	00	178,840 K	42	googledrivesync.exe

Taxonomia Flynn

Some Computer Organizations and Their Effectiveness

MICHAEL J. FLYNN, MEMBER, IEEE

Abstract—A hierarchical model of computer organizations is developed, based on a tree model using request/service type resources as nodes. Two aspects of the model are distinguished: logical and physical.

General parallel- or multiple-stream organizations are examined as to type and effectiveness—especially regarding intrinsic logical difficulties.

The overlapped simplex processor (SISD) is limited by data dependencies. Branching has a particularly degenerative effect.

The parallel processors [single-instruction stream–multiple-data stream (SIMD)] are analyzed. In particular, a nesting type explanation is offered for Minsky's conjecture—the performance of a parallel processor increases as log M instead of M (the number of data stream processors).

Multiprocessors (MIMD) are subjected to a saturation syndrome based on general communications lockout. Simplified queuing models indicate that saturation develops when the fraction of task time spent locked out (L/E) approaches $1/n$, where n is the number of processors. Resources sharing in multiprocessors can be used to avoid

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more signific
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sets. It is ass
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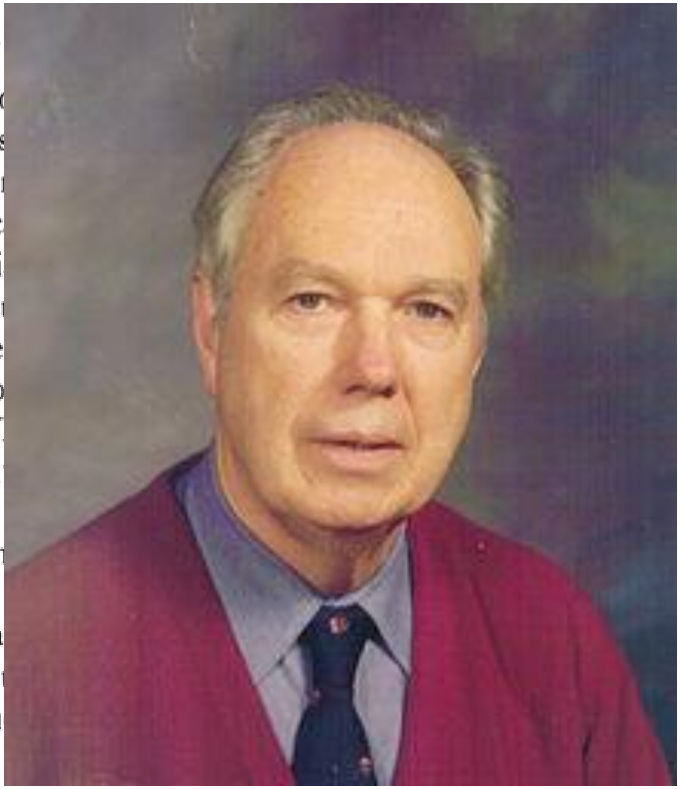
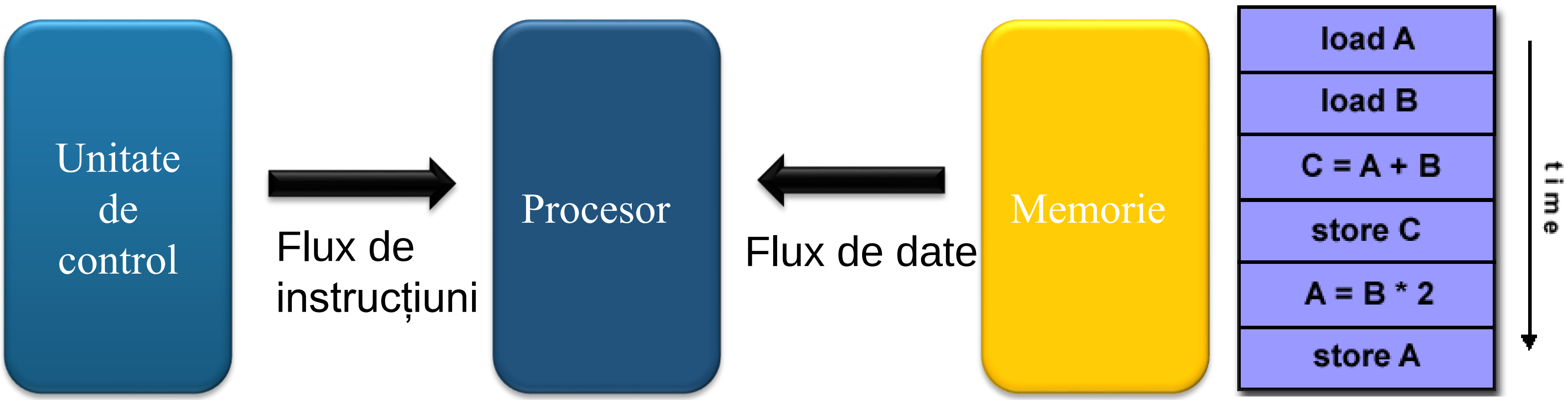


Taxonomia Flynn

- SISD
  - Single Instruction Stream, Single Data Stream
  - Calculatorul Clasic one-core
- SIMD
  - Single Instruction Stream, Multiple Data Streams
  - Suportul SSE; procesoare GPU
- MISD
  - Multiple Instruction Streams, Multiple Data Streams
  - Sisteme specializate
- MIMD
  - Multiple Instruction Streams, Multiple Data Streams
  - Procesoare actuale (ce aveți acasă și în buzunar)

SISD

- Model clasic Arhitectura *von Neumann*



SISD

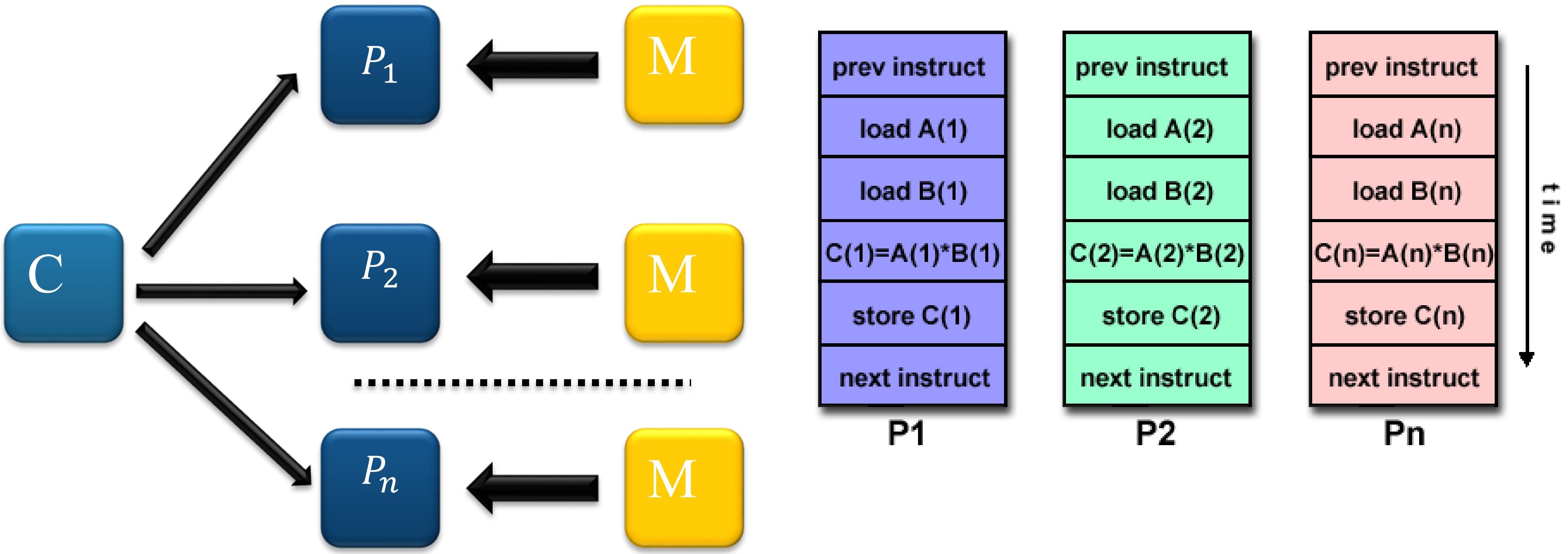
- Model clasic Arhitectura *von Neumann*

First Draft of a Report
on the EDVAC

by

John von Neumann

SIMD



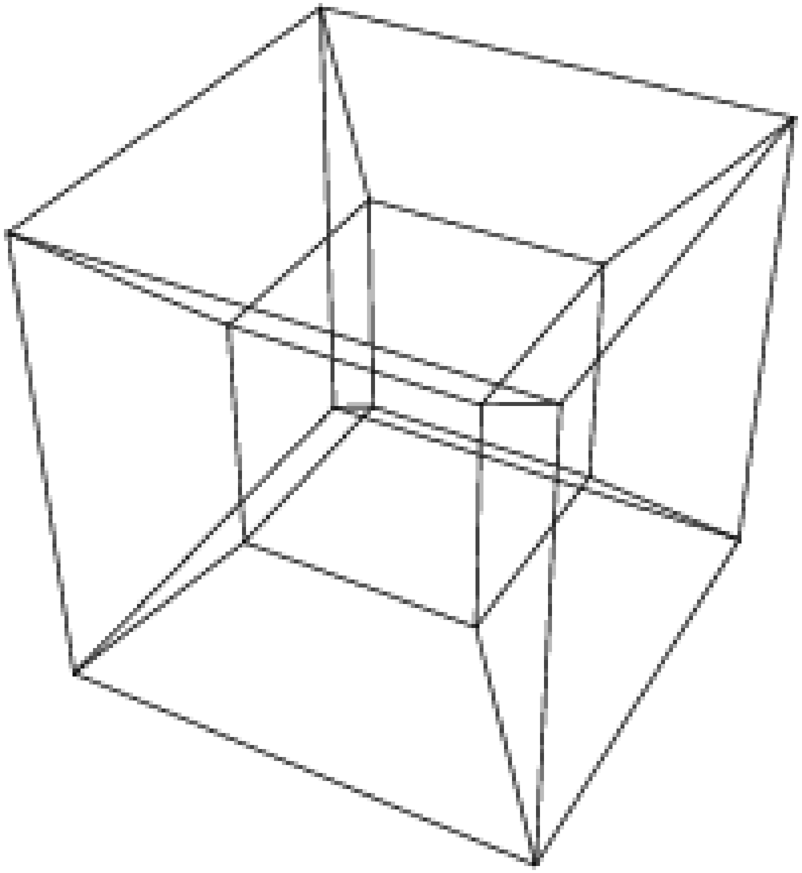
C
P_1
P_2
P_n
M
M
M
prev instruct
load A(1)
load B(1)
C(1)=A(1)*B(1)
store C(1)
next instruct
P1
prev instruct
load A(2)
load B(2)
C(2)=A(2)*B(2)
store C(2)
next instruct
P2
prev instruct
load A(n)
load B(n)
C(n)=A(n)*B(n)
store C(n)
next instruct
Pn
time

SIMD – Memorie Partajată

- Shared memory
  - Parallel Random Access Memory
  - **PRAM**
  - **EREW** – Exclusive Read Exclusive Write
  - **CREW** – **Concurrent Read Exclusive Write --** cel mai des întâlnit
  - **ERCW** – Exclusive Read Concurrent Write
  - **CRCW** – Concurrent Read Concurrent Write
  - O variabilă poate fi citiă într-un pas în model **CR** dar în log(N) în model **ER.**

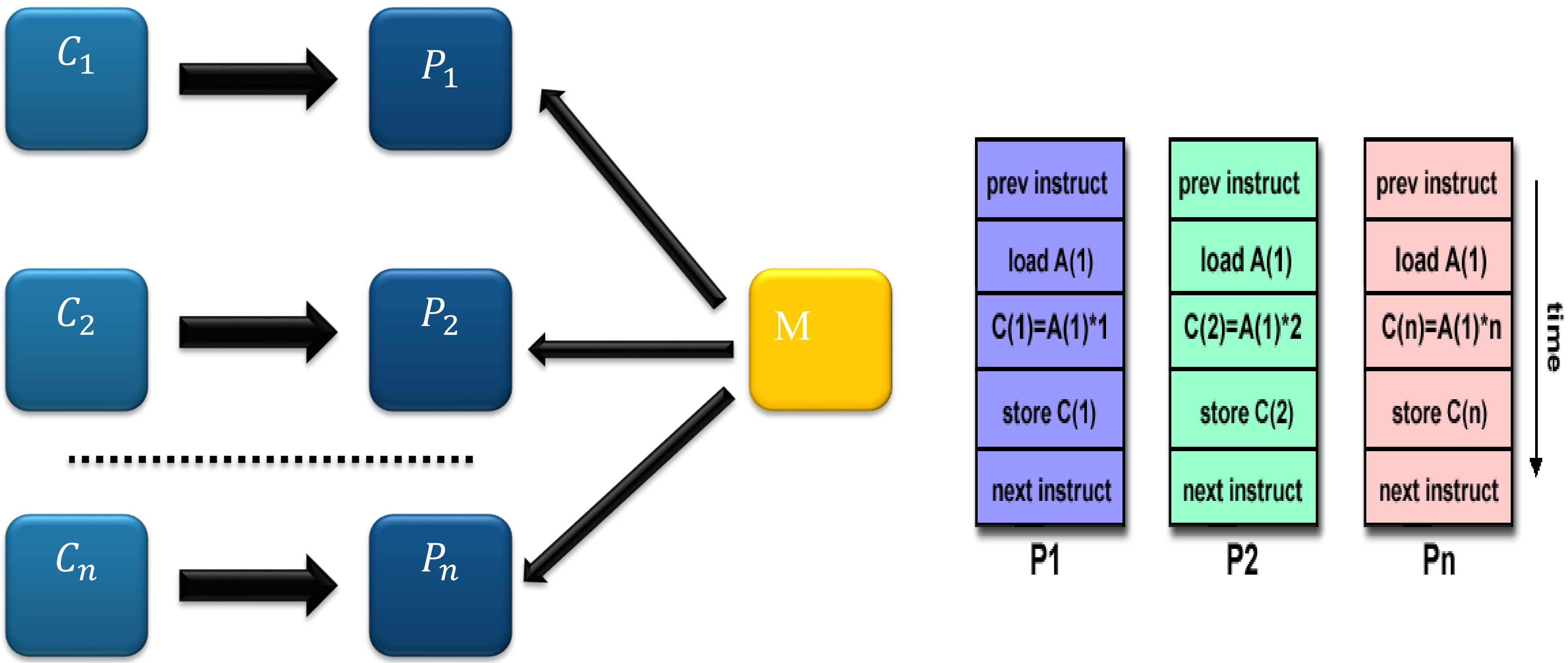
Rețele de configurare

- Topologii
  - Tablou
  - Arbore
  - Cub
  - Hipercub

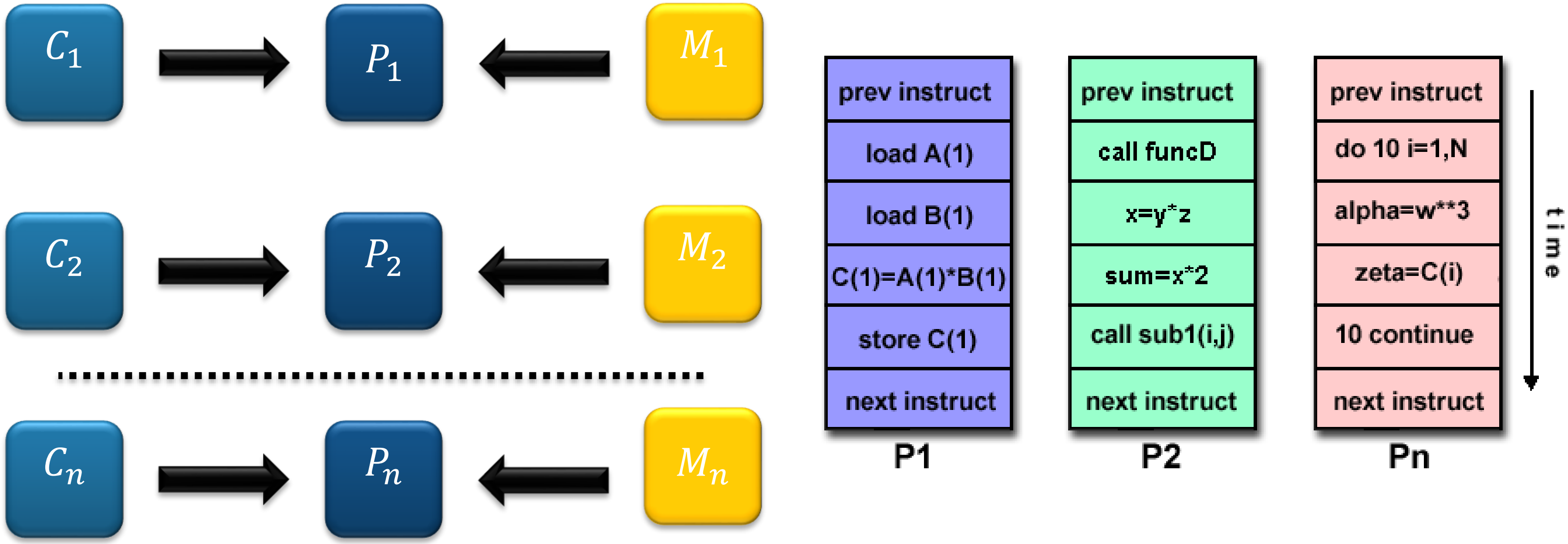


- Depinde de
  - Aplicație
  - Performanțe dorite
  - Număr procesoare disponibile
- Exemple: IBM 9000, Cray C90, Fujitsu VP

MISD


C_1
P_1
C_2
P_2
M
C_n
P_n
prev instruct
load A(1)
C(1)=A(1)*1
store C(1)
next instruct
P1
prev instruct
load A(1)
C(2)=A(1)*2
store C(2)
next instruct
P2
prev instruct
load A(1)
C(n)=A(1)*n
store C(n)
next instruct
Pn
time

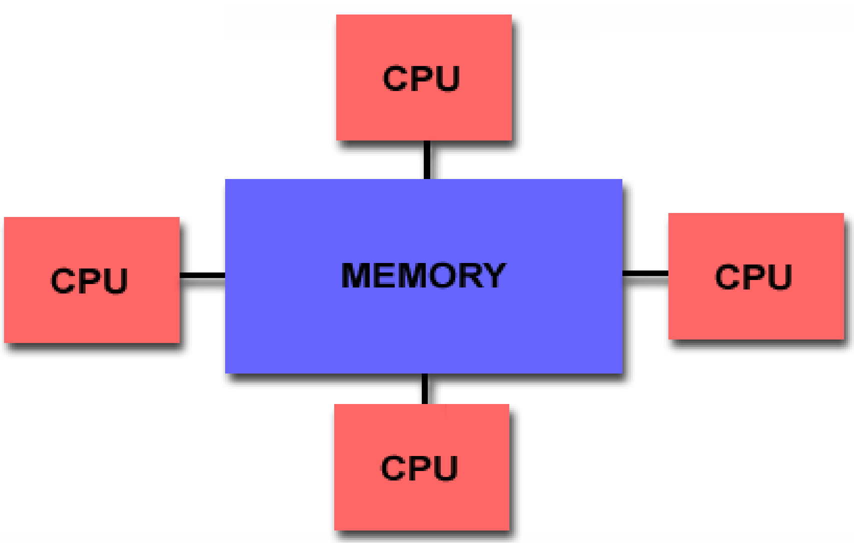
MIMD



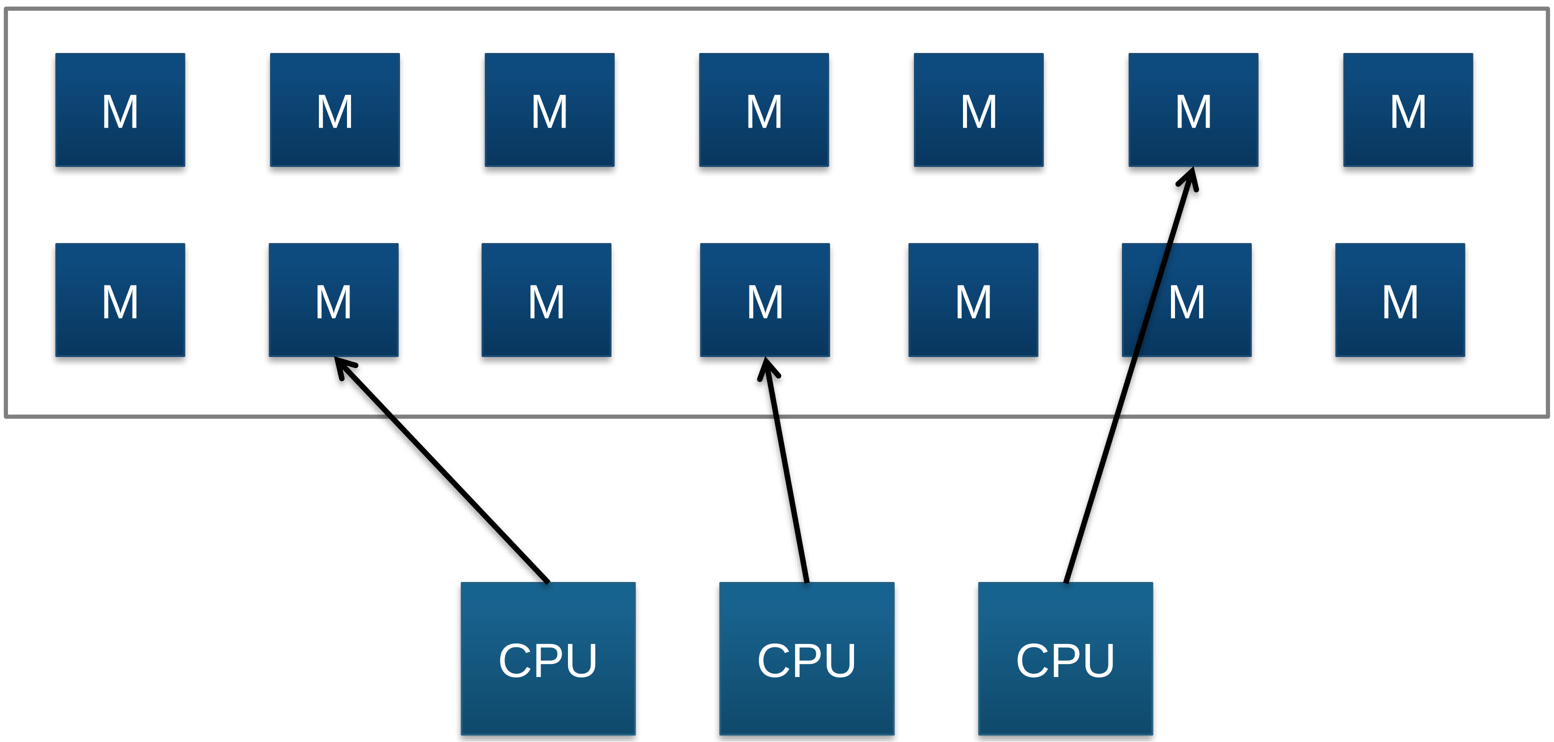
C_1
P_1
M_1
C_2
P_2
M_2
C_n
P_n
M_n
prev instruct
load A(1)
load B(1)
C(1)=A(1)*B(1)
store C(1)
next instruct
P1
prev instruct
call funcD
x=y*z
sum=x*2
call sub1(i,j)
next instruct
P2
prev instruct
do 10 i=1,N
alpha=w**3
zeta=C(i)
10 continue
next instruct
Pn
time

Memorie Partajată

- Uniform Memory Access
  - **UMA**

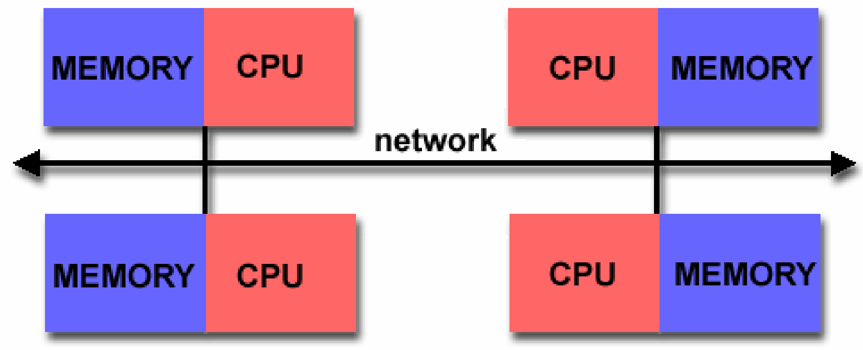


Memorie Partajată - Acces

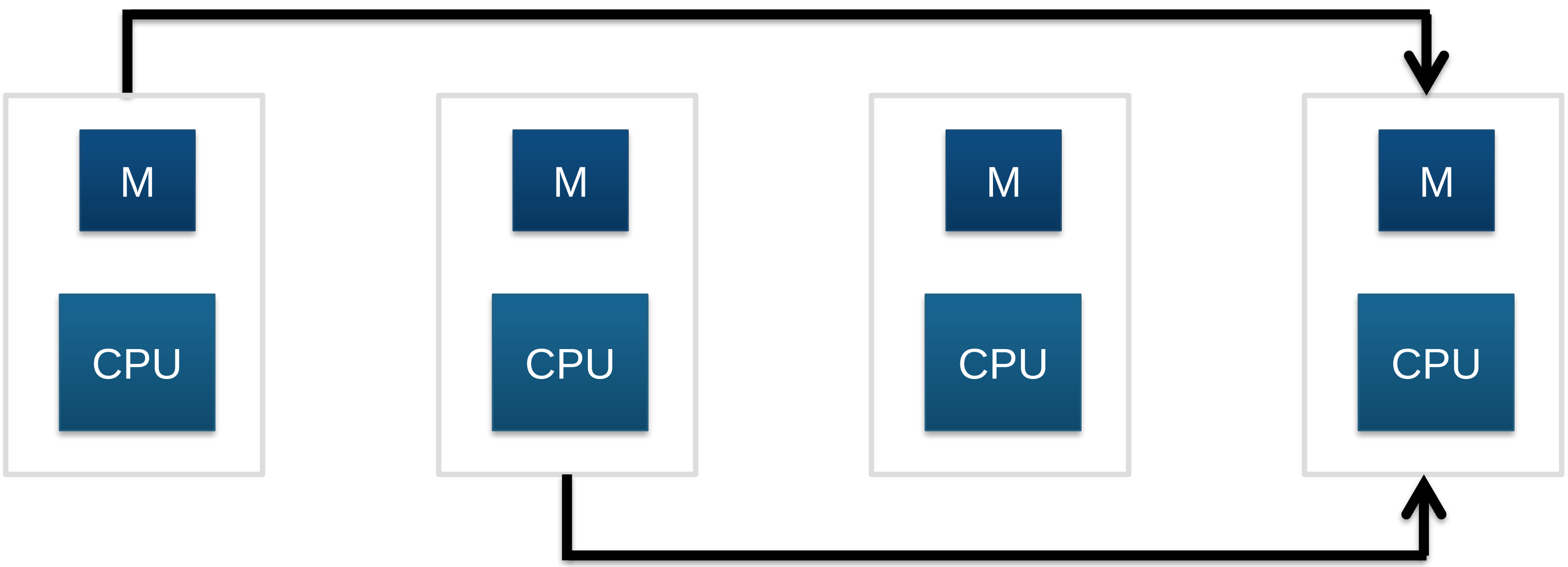


Memorie Distribuită

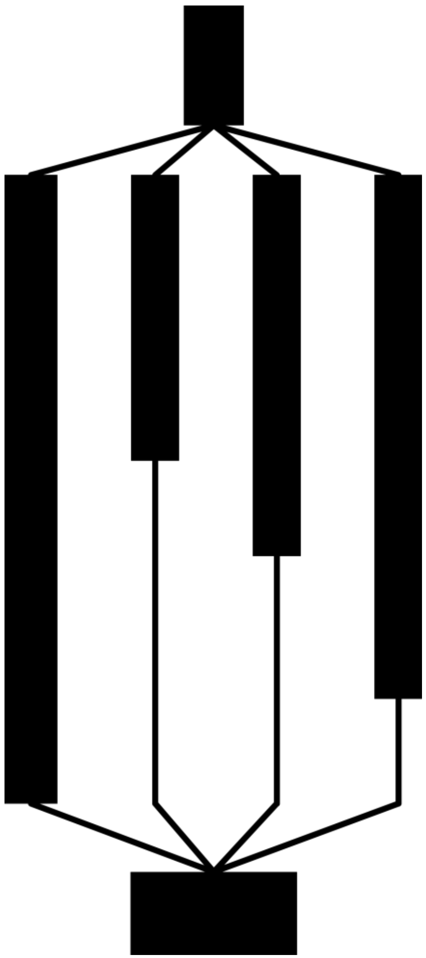
- Massively Parallel Processors
- Network of workstations
- Non-Uniform Memory Access
  - **NUMA**

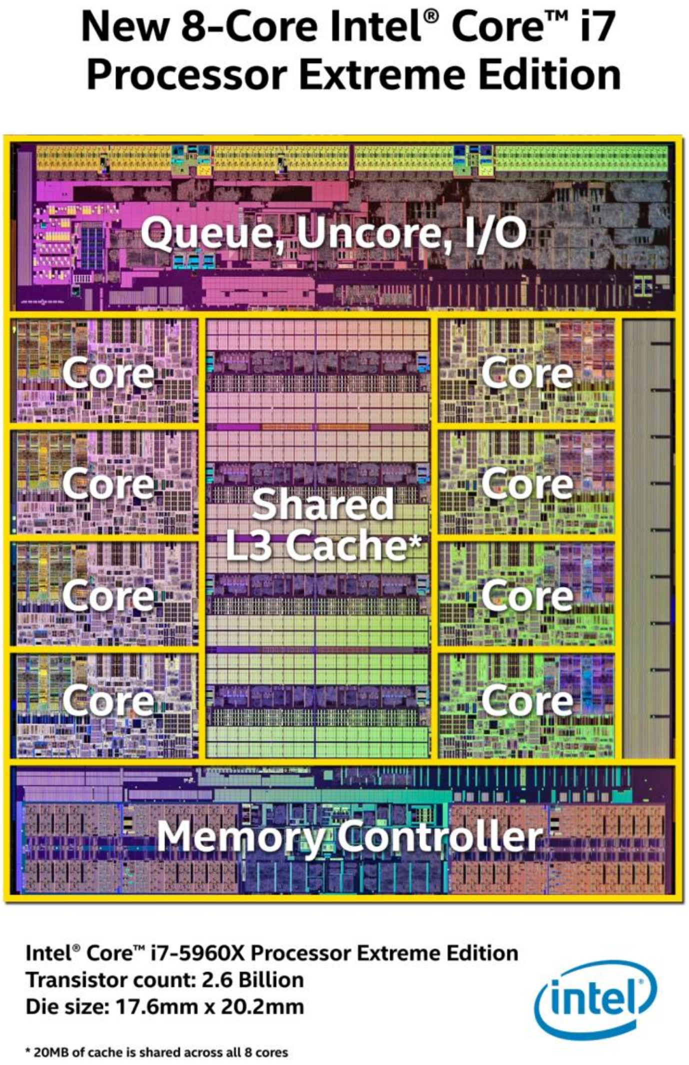


Memorie Distribuită - Acces



Threads vs cores

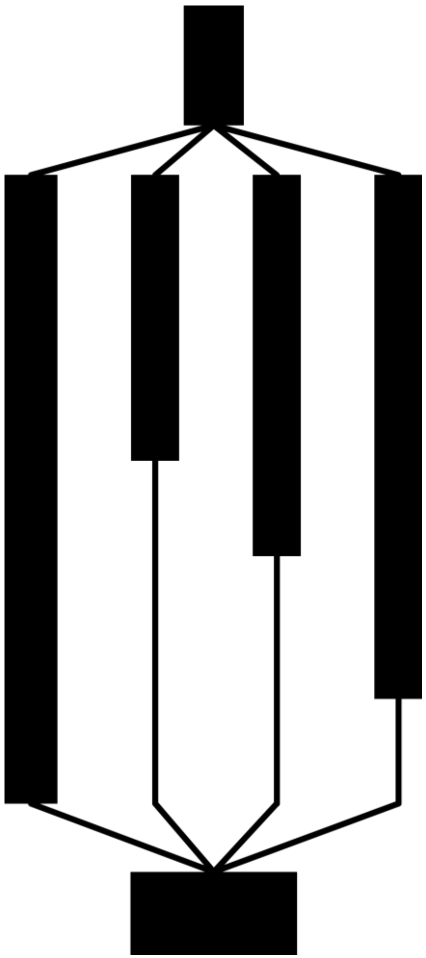


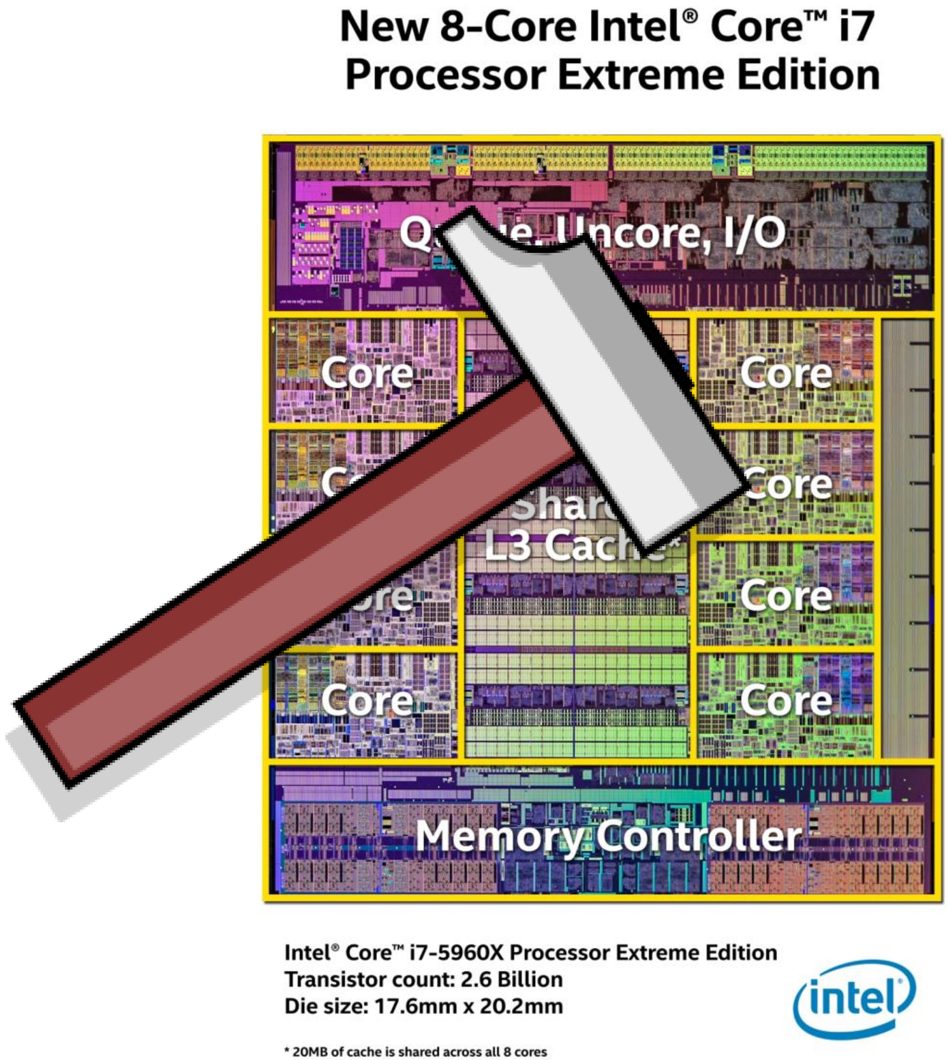


Hyperthreading – the confusion

Thank you intel

Hyperthreading – the confusion





Multi-tasking vs Multi-threading

Multi-tasking

Task 1

Task 2

Multi-tasking

Task 2

Task 1

Multi-tasking

Task 1

Task 2

Multi-tasking

Task 2

Task 1

Multi-threading

Thread 2

Thread 3

Thread 4

Thread 1

Multi-threading

Thread 1

Thread 2

Thread 4

Thread 3

Multi-threading

Thread 1

Thread 2

Thread 4 **Thread 3**

Multi-threading

Thread 2

Thread 3

Thread 4

Thread 1

Multi-threading

Thread 1

Thread 4

Thread 2 Thread 3

Multi-tasking vs Multi-threading

Not really any big difference!

Multi-tasking vs Multi-threading

Deci care sunt diferențele?

Un proces are mai multe thread-uri

Thread-urile unui proces împart memoria

Multi-tasking vs Multi-threading

Poți avea multi-tasking pe mai multe core-uri?

Poți avea multi-thread-ing pe un singur core?

Multi-tasking vs Multi-threading

Poți avea multi-tasking pe mai multe core-uri? **DA**

Poți avea multi-thread-ing pe un singur core? **DA**