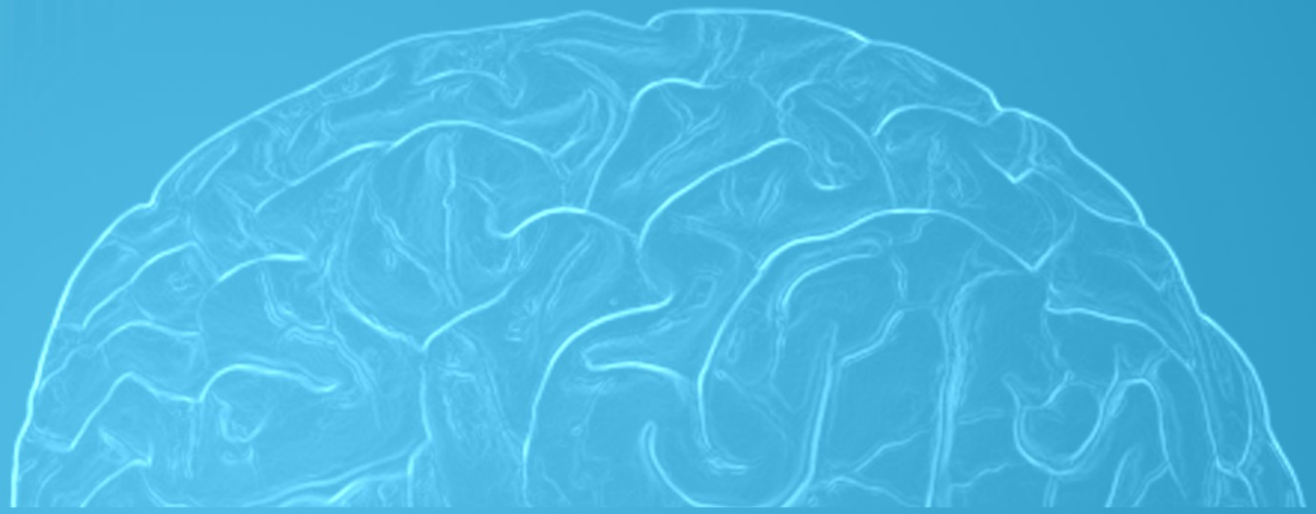
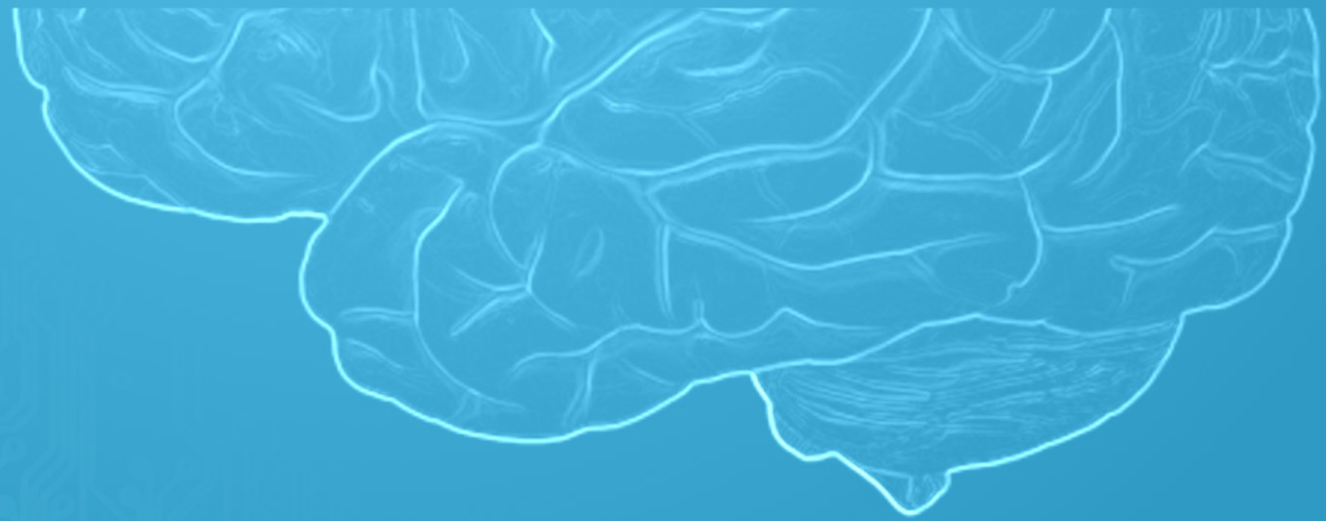



# Sisteme Tolerante la Defecte
# Introducere Cloud Computing

Lect. Dr. Ing. Cristian Chilipirea – cristian.chilipirea@mta.ro



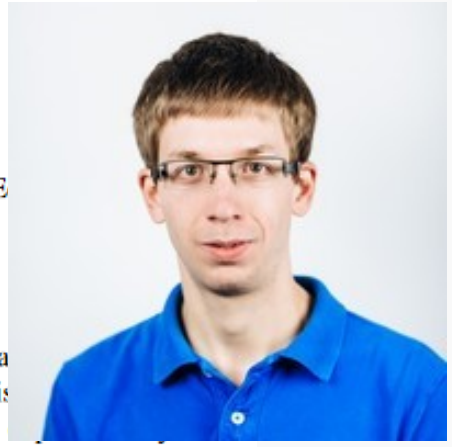
# Articol științific principal despre Cloud

## Above the Clouds: A Berkeley View of Cloud Computing

Michael Armbrust, Armando Fox, Rean Griffith, Anthony D. Joseph, Randy Katz,
Andy Konwinski, Gunho Lee, David Patterson, Ariel Rabkin, Ion Stoica, and Matei Zaharia
*(Comments should be addressed to abovetheclouds@cs.berkeley.edu)*

UC Berkeley Reliable Adaptive Distributed Systems Laboratory *
http://radlab.cs.berkeley.edu/

February 10, 2009



KEYWORDS: Cloud Computing, Utility Computing, I… System E…

1

Clou… of computing as a …sform a la…
IT i… attractive as a ser… ardware is…
purc… ideas for new Inter… the large…
in ha… he human expense… e concerned about over-
prov… ity does not meet t… stly resources, or under-
prov… popular, thus missin… ue. Moreover, companies
with… sults as quickly as t… sing 1000 servers for one
hour… for 1000 hours. Th… ut paying a premium for
large… y of IT.

# Cloud-ul este despre Cost $$$$

- **Economie de scală** (cumpără angro, în bulk).
  - Cumpăra hardware la un preț mai mic decât ar face asta chiar unele companii mari.
- **Pay-as-you-go** (efectiv resursele se închiriază).
  - Noutatea cloud-ului e că acest lucru se întâmplă automat.
  - Majoritatea se plătesc la nivel de ore
- **People are expensive**
  - Un cluster necesită o echipă 24/7
  - Echipa trebuie să aibă oameni cu specializări diverse (hardware, security, networking, etc.)
- Ideal pentru **start-up**-uri, echipe **mici**, proiecte **scurte**
  - Cost o lună resurse puține cloud << cost cluster

# Când NU cloud?

# Când NU cloud?

- Date **sensibile**
  - Poate fi chiar ilegal să pui anumite date (medicale) pe Cloud public
- Proiect foarte **mare** cu **durată mare**.
  - cost cluster < cost multe resurse cloud * periodă timp
- **Nevoi** de bandwidth/latență mari
  - Cloud-ul public este peste internet.
- **Control**
  - Serviciile și garanțiile se pot schimba în timp

# Elasticitate

**Elasticity in Cloud Computing: What It Is, and What It Is Not**

Nikolas Roman Herbst, Samuel Kounev, Ralf Reussner
*Institute for Program Structures and Data Organisation*
*Karlsruhe Institute of Technology*
*Karlsruhe, Germany*
{herbst, kounev, reussner}@kit.edu

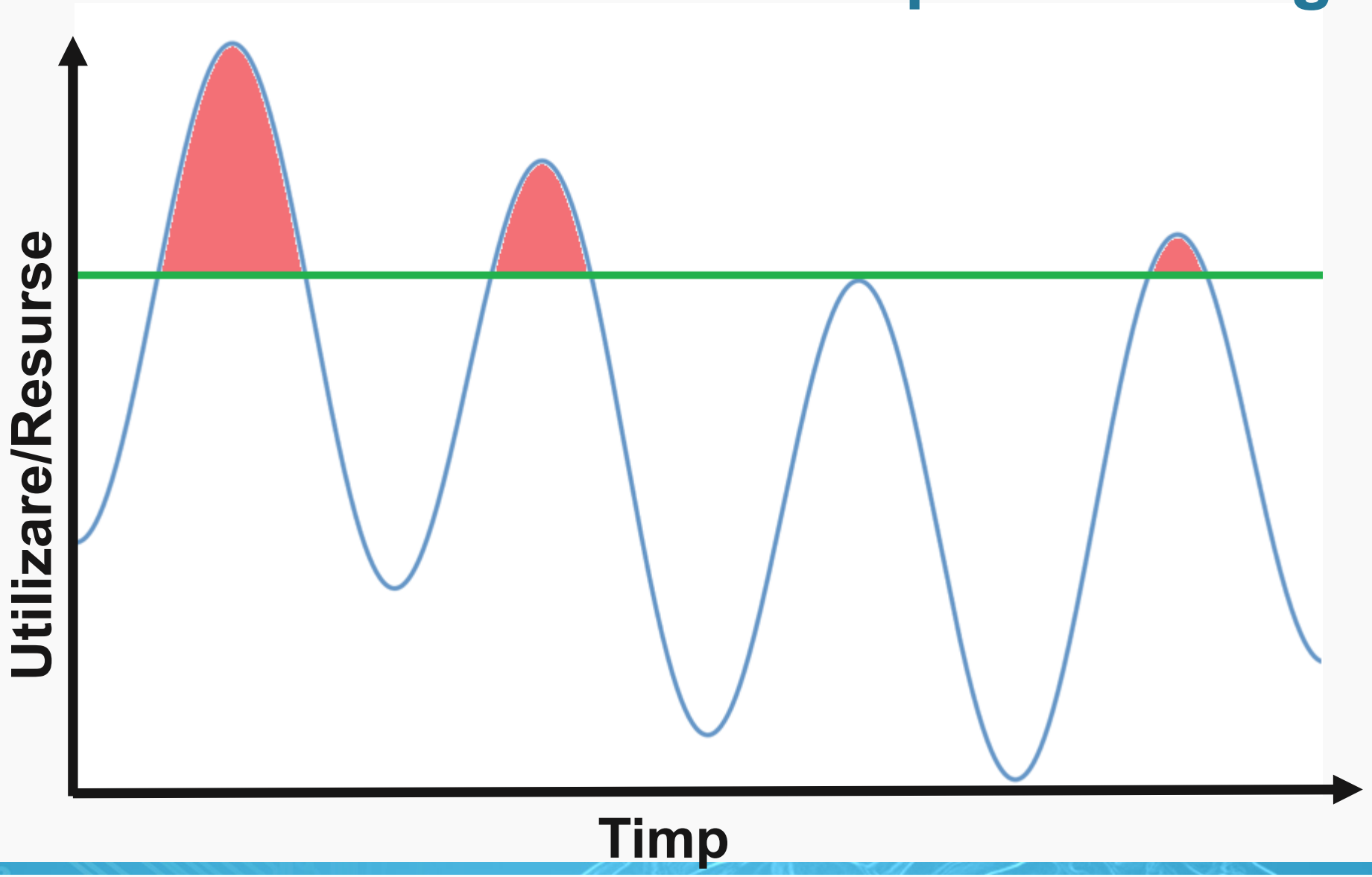
**Abstract**

Originating fro
term elasticity
of cloud compu

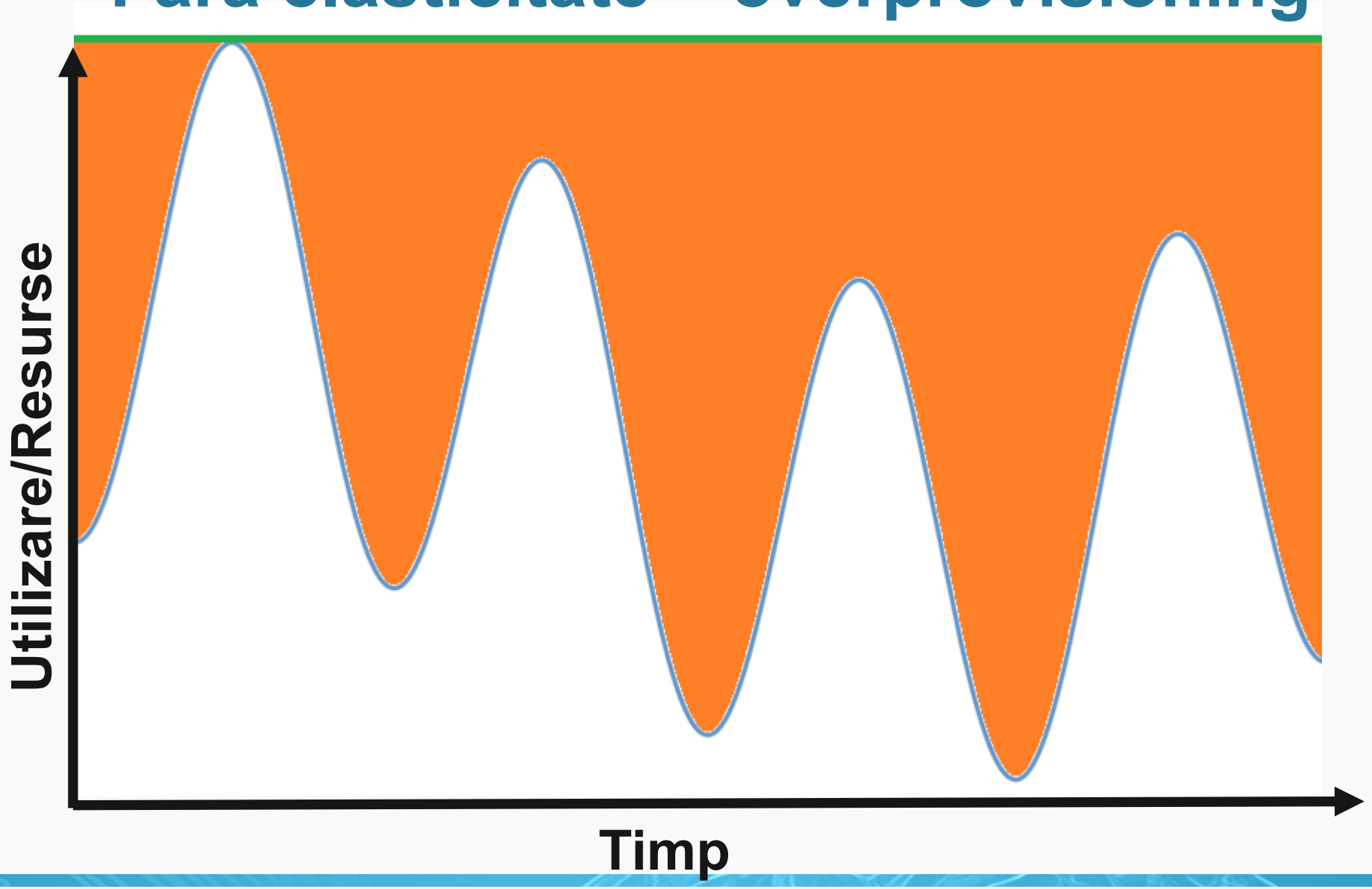
even in the naming of specific products or services. Even

**Elasticity** is the degree to which a system is able to adapt to workload changes by provisioning and de-provisioning resources in an autonomic manner, such that at each point in time the available resources *match* the current demand as closely as possible.

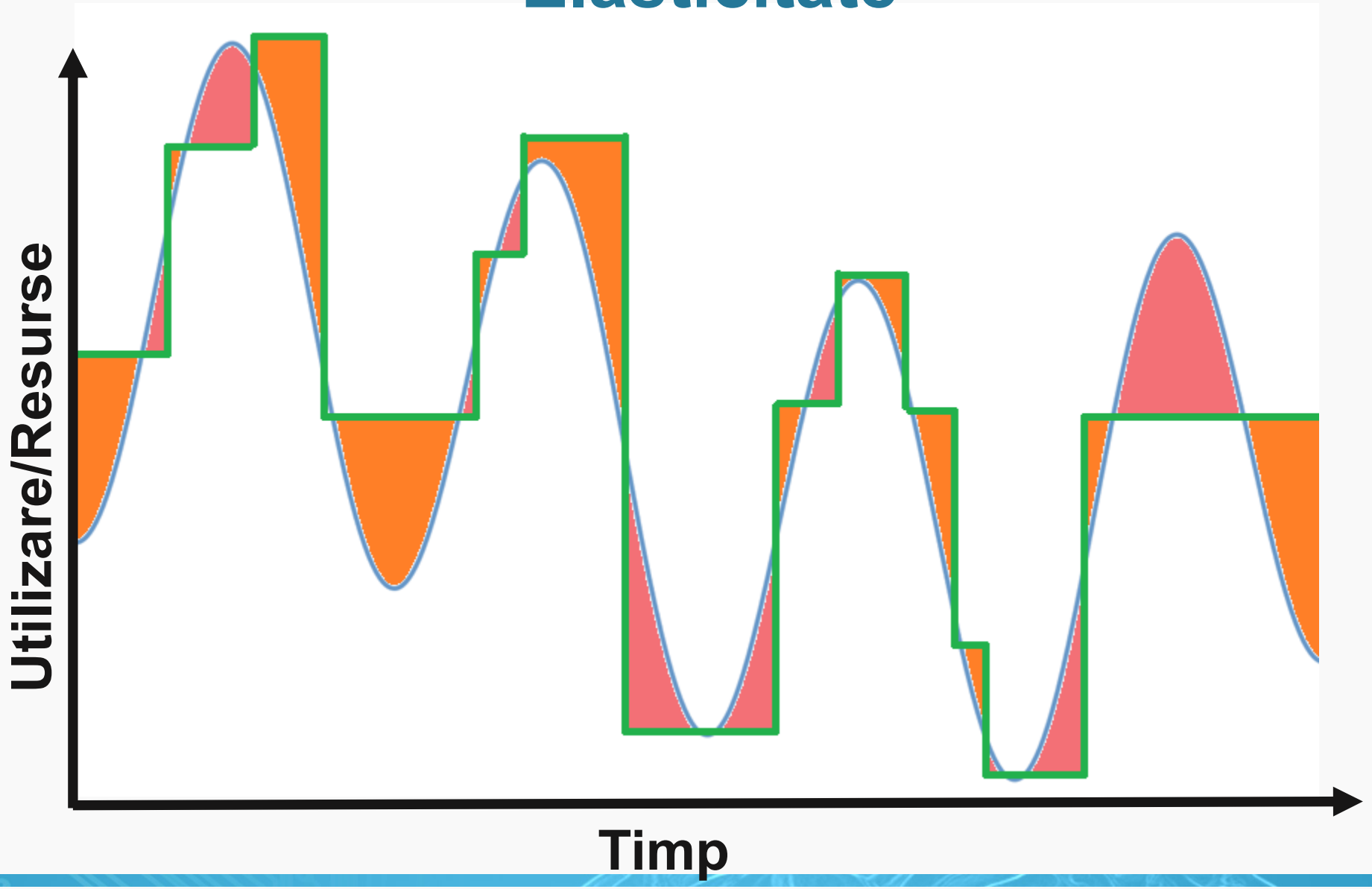
# Fără elasticitate – underprovisioning



# Fără elasticitate – overprovisioning



# Elasticitate



# Privat vs Public vs Hibrid

Cloud ținut în interiorul unei instituții. Menit pentru a oferi resurse diferitelor grupuri din instituție. Necesită menținerea unui singur grup de administrare cluster.



Google Cloud

Și **mulți** alții.....

Și privat și public. Când resursele private sunt epuizate se pot extinde cu cele publice. Posibil doar temporar.

# SLA/QoS

- Five nines
  - Se dorește 99.999% disponibilitate (5 minute pe an down-time)
  - Se obține prin securitate crescută
  - Se obține prin hardware de înaltă performanță
  - Se obține prin redundanță și back-up
  - Se obține prin mecanisme de toleranță la defecte

# X as a Service

| X | Exemplu Efectiv |
|---|---|
| **Software** as a Service | Dropbox, Slack |
| **Platform** as a Service | Baze de date |
| **Infrastructure** as a Service | Mașini virtuale |
| **Metal** as a Service | Mașini fizice |
| ... as a Service | |

# Metal as a Service

- Folosim direct mașinile.
- Sunt necesare servere specializate
  - Suport **Intelligent Platform Management Interface** (**IPMI**)
  - Suport **Baseboard management controller**
  - Suport **Preboot eXecution Environment** (**PXE)**

Combinate acestea oferă metode de power on/off, , monitorizare, remote-control, instalare OS.

Toate de la distanță

# Infrastructure as a Service – mașini virtuale



Hipervizoare:




# Avantaje mașini virtuale?

# Avantaje mașini virtuale?

- Development în sistem de operare diferit
- Deployment mai ușor
- Dependințe mai ușor de controlat
- Scalabilitate mai ușoară (copiezi mașina virtuală)

# Emulare vs virtualizare

- Simulează sistemul în software
- Fiecare instrucțiune e citită de software și interpretată

- Majoritatea instrucțiunilor sunt rulate **DIRECT** de procesor

- Ex: Simulator NES (Warning multiple hours of intense fun)

- **De citit** Capitol 7 – Modern Operating Systems (4th ed) Andrew Tanenbaum

# Reminder multi-tasking

## Assembly vs. machine code

| Machine code bytes | Assembly language statements |
|---|---|
| | foo: |
| B8 22 11 00 FF | movl $0xFF001122, %eax |
| 01 CA | addl %ecx, %edx |
| 31 F6 | xorl %esi, %esi |
| 53 | pushl %ebx |
| 8B 5C 24 04 | movl 4(%esp), %ebx |
| 8D 34 48 | leal (%eax,%ecx,2), %esi |
| 39 C3 | cmpl %eax, %ebx |
| 72 EB | jnae foo |
| C3 | retl |

Instruction stream

```
B8 22 11 00 FF 01 CA 31 F6 53 8B 5C 24
04 8D 34 48 39 C3 72 EB C3
```

Codul de rulat

**Loader** (Kernel Sistemul de operare)

# Reminder multi-tasking

Program counter

```
movl $0xFF001122, %eax
addl %ecx, %edx
xorl %esi, %esi
pushl %ebx
movl 4(%esp), %ebx
leal (%eax,%ecx,2), %esi
cmpl %eax, %ebx
jnae foo
retl
```


# Reminder multi-tasking

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# Reminder multi-tasking

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cmpl %eax, %ebx
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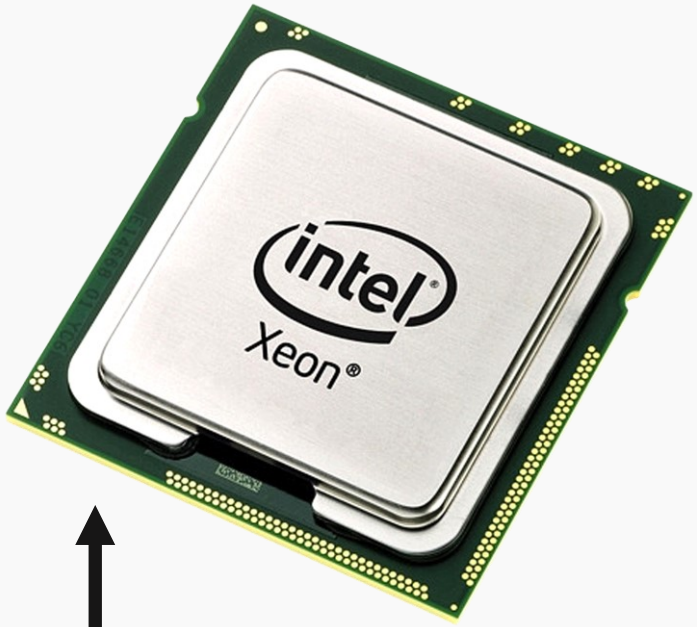
```



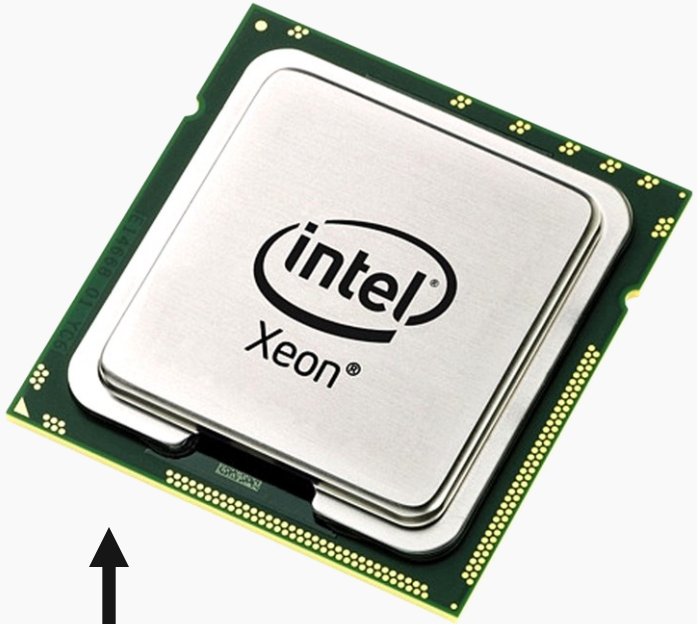


Timer Interrupt

# Reminder multi-tasking

Program counter

```
movl $0xFF001122, %eax
addl %ecx, %edx
xorl %esi, %esi
pushl %ebx
movl 4(%esp), %ebx
leal (%eax,%ecx,2), %esi
cmpl %eax, %ebx
jnae foo
retl
```


Pornește **scheduler**
(posibil read din RAM
pentru cod de scheduler)

Timer Interrupt

# Reminder multi-tasking

Program counter

```
movl $0xFF001122, %eax
addl %ecx, %edx
xorl %esi, %esi
pushl %ebx
movl 4(%esp), %ebx
leal (%eax,%ecx,2), %esi
cmpl %eax, %ebx
jnae foo
retl
```



**Scheduler – kernel OS**

# Reminder multi-tasking

Program counter
State
Registers
Codul e deja acolo



**Scheduler – kernel OS**

# Reminder multi-tasking

```
mov     eax, [ebp+0Ch]
mov     ecx, [eax+4]
push    ecx
call    dword ptr ds:__imp__atoi
add     esp, 4
mov     [ebp-4], eax
mov     edx, [ebp-4]
```



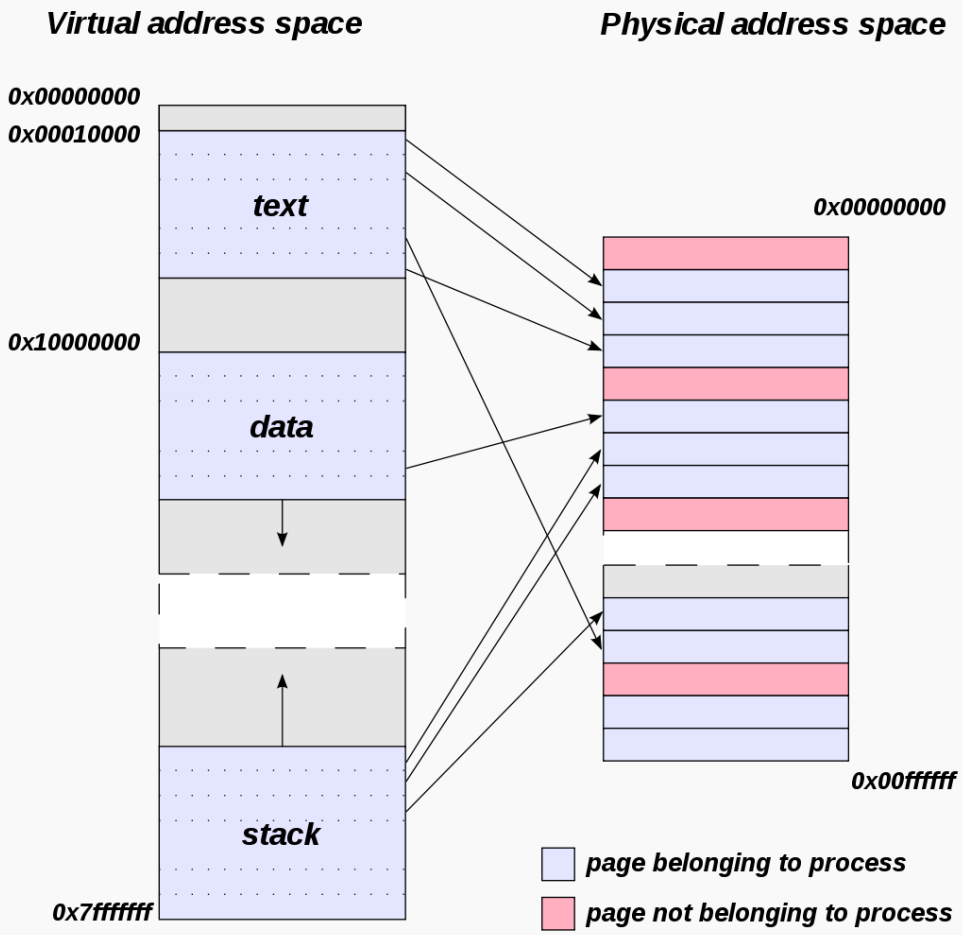
**Scheduler – kernel OS**

# Reminder multi-tasking

```
mov     eax, [ebp+0Ch]
mov     ecx, [eax+4]
push    ecx
call    dword ptr ds:__imp__atoi
add     esp, 4
mov     [ebp-4], eax
mov     edx, [ebp-4]
```


# Reminder multi-tasking

- Toate programele cred că au acces la tot RAM-ul fără spațiu alocat kernel
- Soluția este paginarea (bucăți de RAM virtual mapate pe cel real)
- Kernel-ul și CPU (prin MMU - memory management unit și TLB - translation lookaside buffer) controlează RAM-ul prin loader, malloc, free și tabelele de pagini



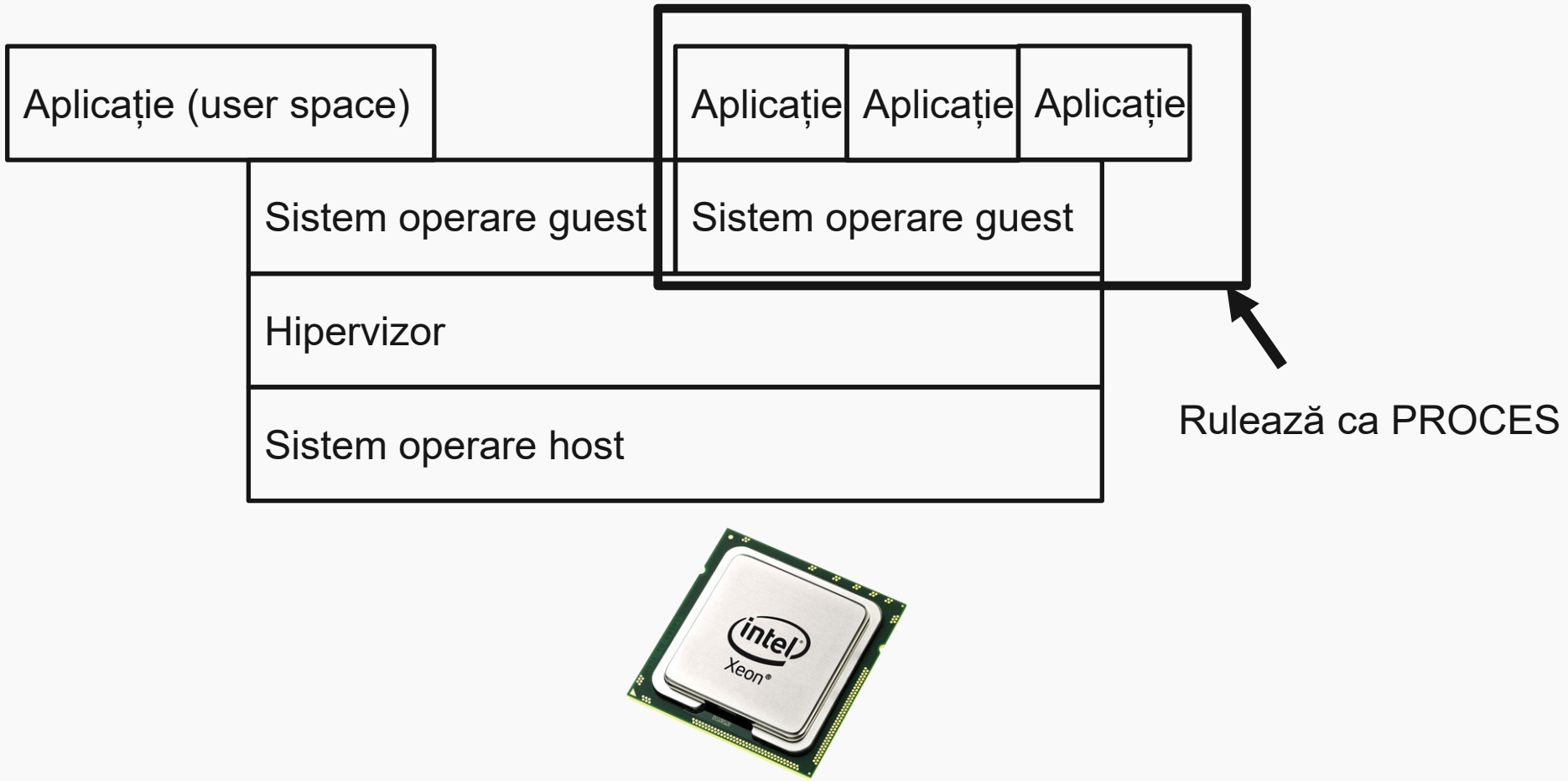
# Emulare CPU-RAM


Trebuie reținută starea (un set de variabile)
Trebuie reținuți regiștrii (un vector)
Majoritatea instrucțiunilor modifică starea sau regiștrii
Restul instrucțiunilor sunt citiri/scrieri RAM sau periferice

Codul de rulat

Un malloc mare

# Virtualizare CPU



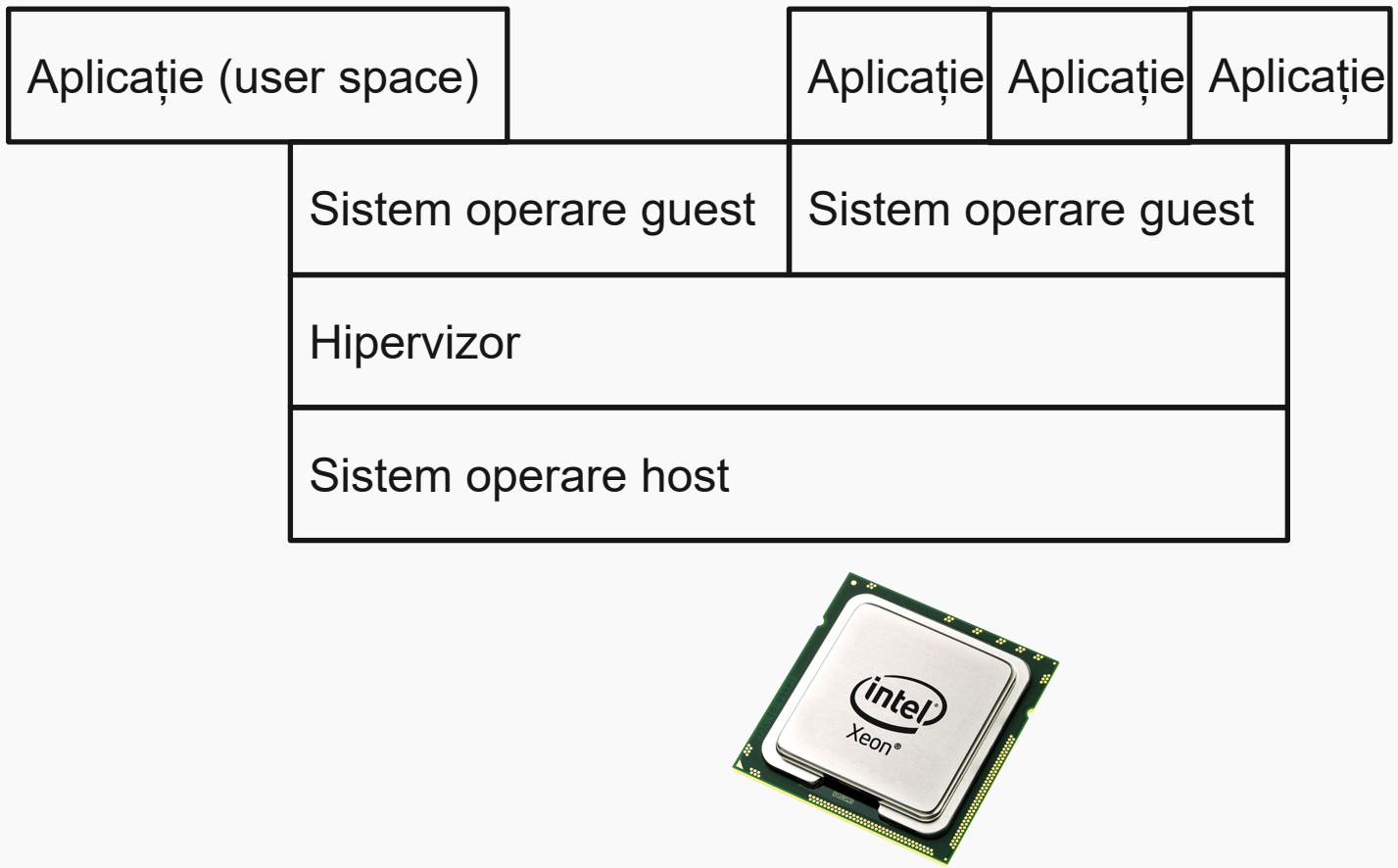
# Virtualizare CPU

## Formal Requirements for Virtualizable Third Generation Architectures

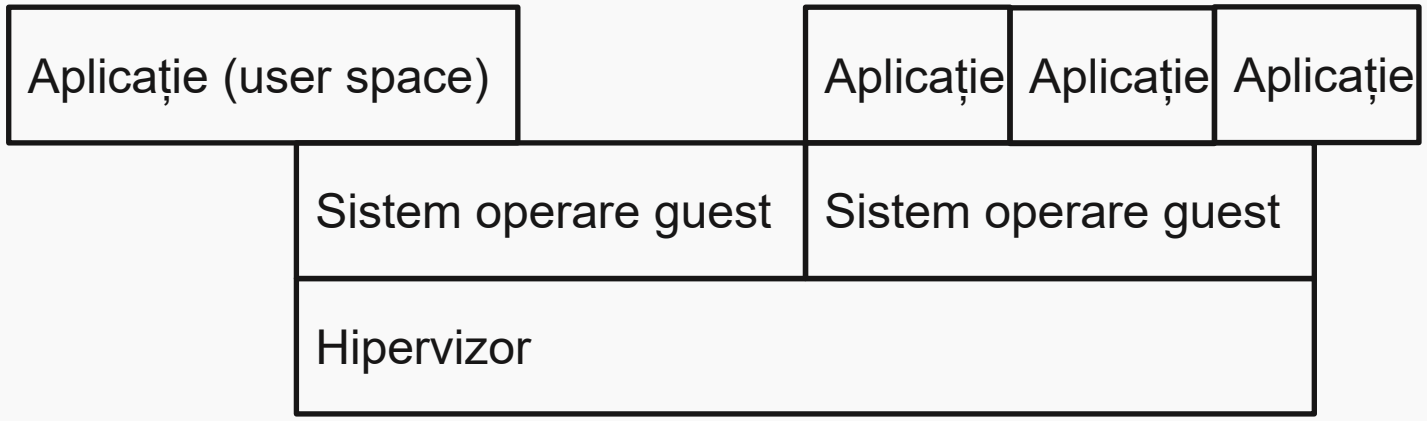
Gerald J. Popek
University of California, Los Angeles
and
Robert P. Goldberg
Honeywell Information Systems and
Harvard University

**Virtual machine systems have been implemented on a limited number of third generation computer systems, e.g. CP-67 on the IBM 360/67. From previous empirical studies, it is known that certain third generation computer systems, e.g. the DEC PDP-10, cannot support a virtual machine system. In this paper, model of a third-generation-like computer system is developed. Formal techniques are used to derive precise sufficient conditions to test whether such an architecture can support virtual machines.**

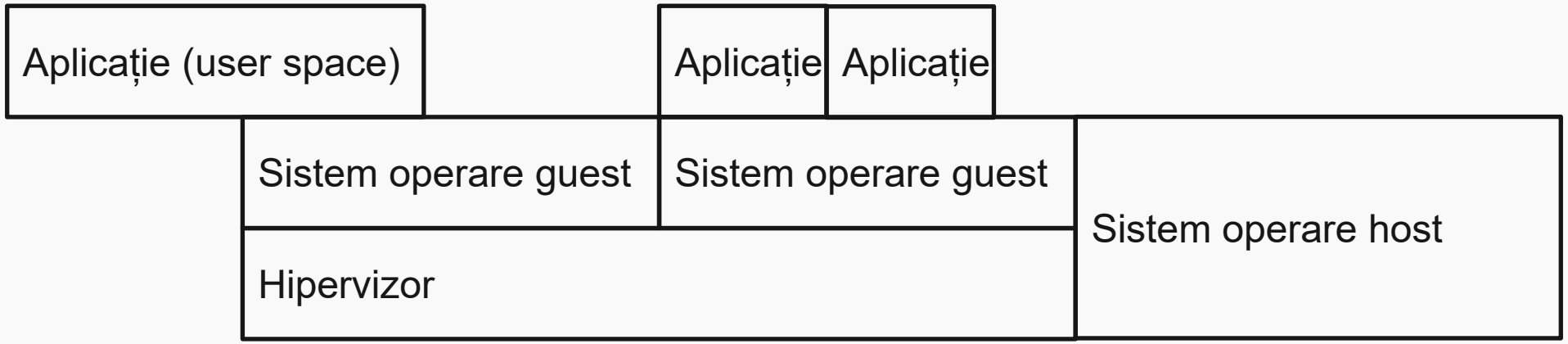
# Virtualizare CPU – Type 1



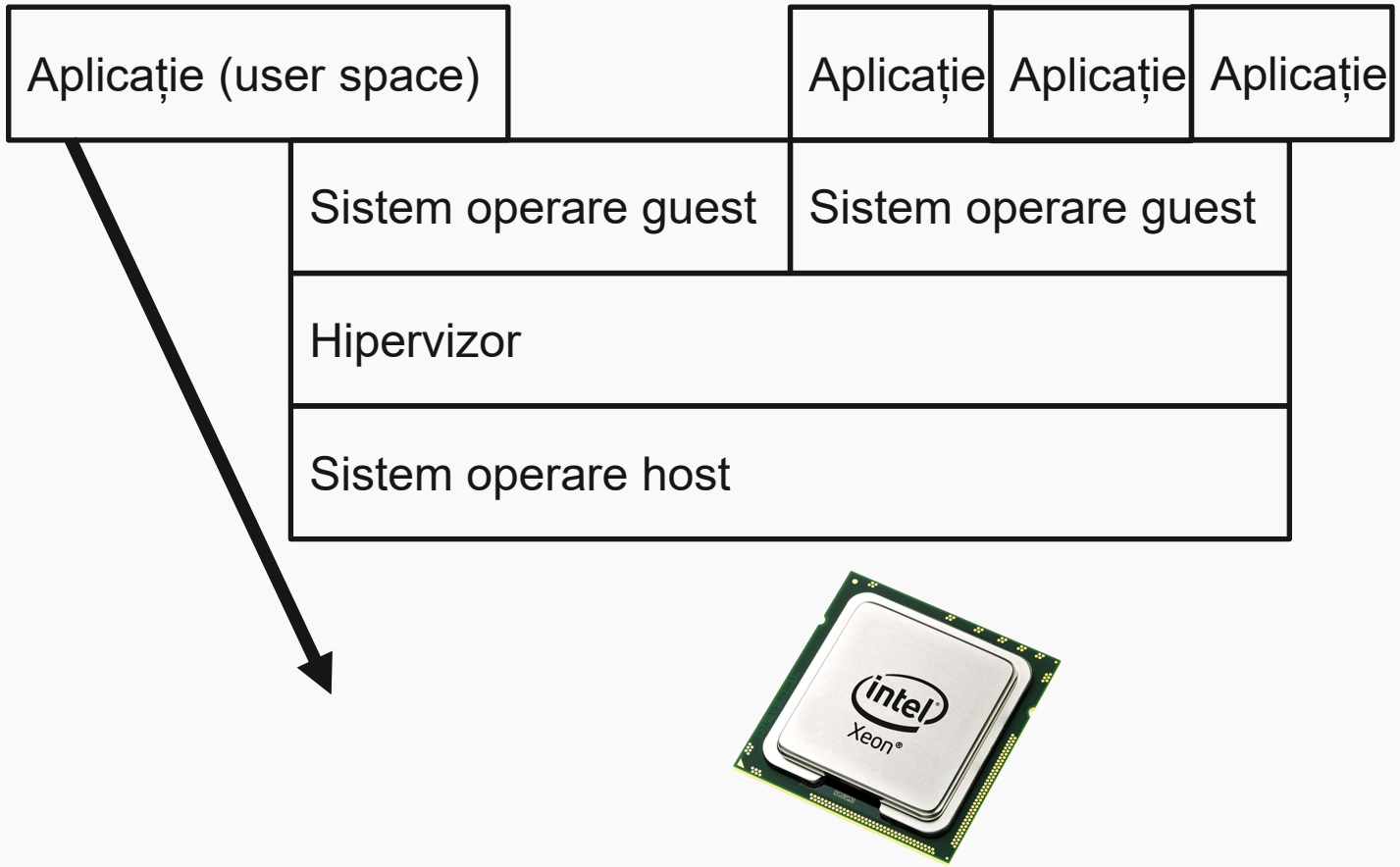
# Virtualizare CPU – Type 2




# Virtualizare CPU – Paravirtualizare

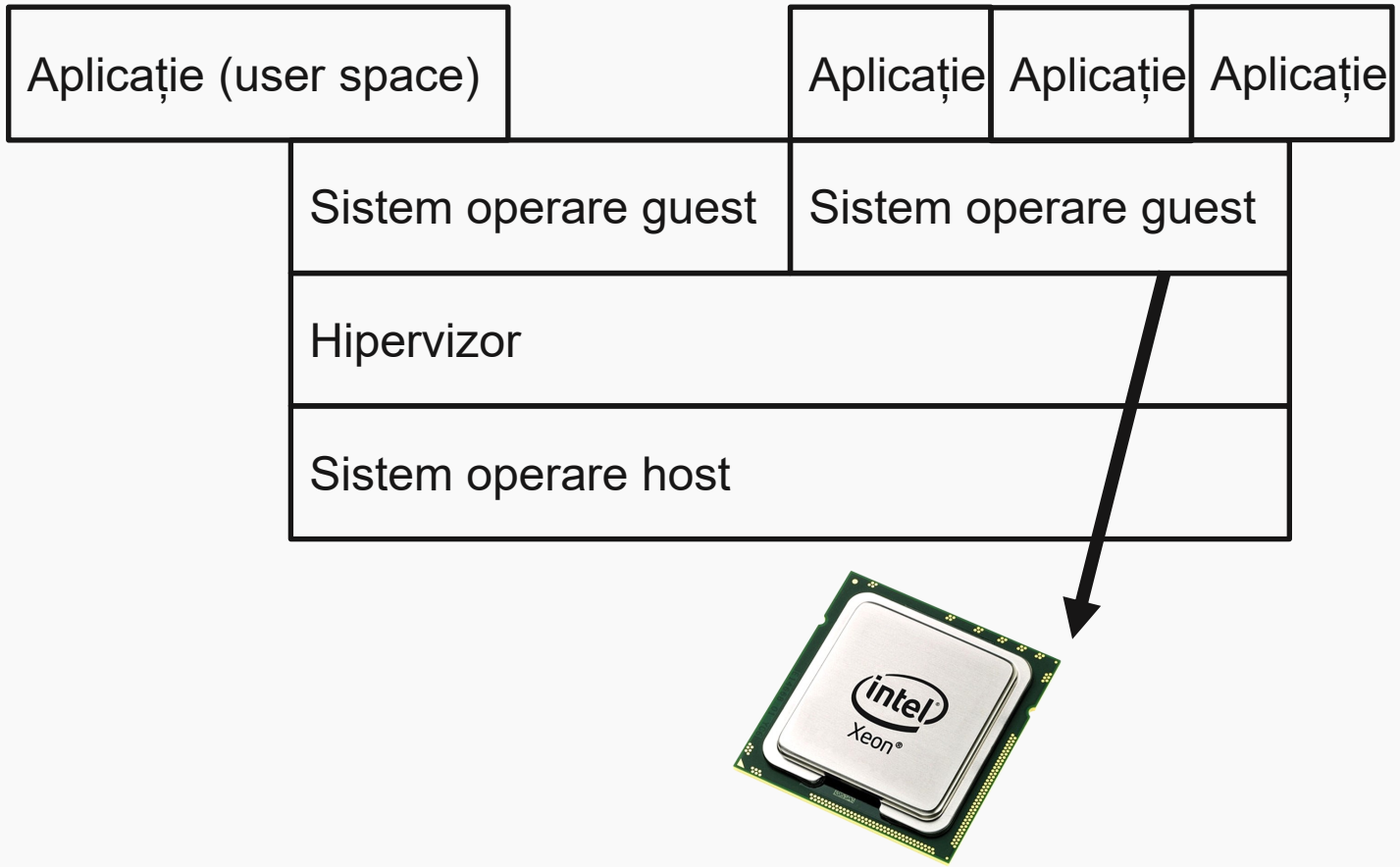



# Virtualizare CPU
# Instrucțiuni simple (ex. add, mov din memoria sa)



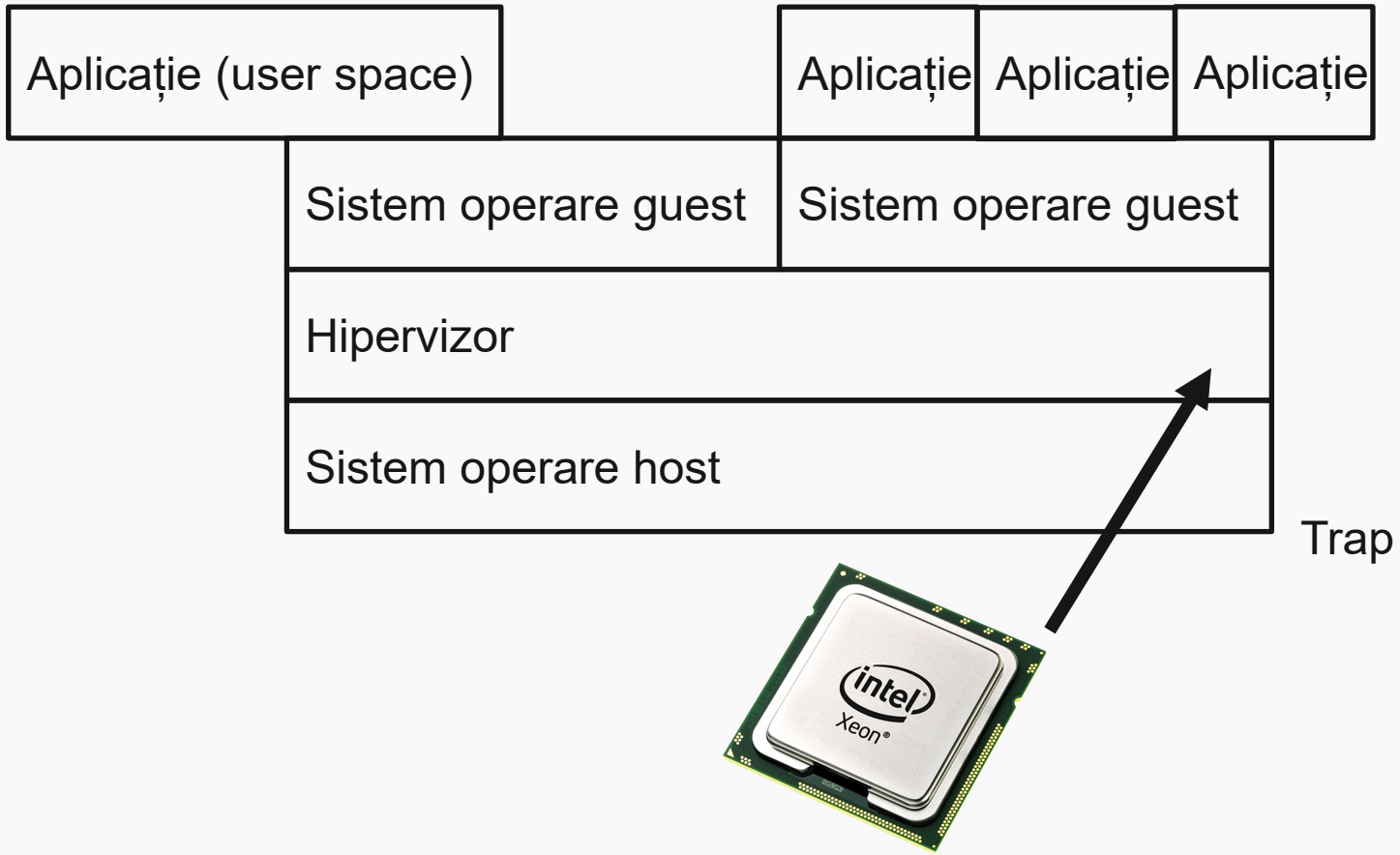
# Virtualizare CPU – trap and execute

## Instrucțiuni kernel (ex. umblat cu I/O, sist întreruperi)



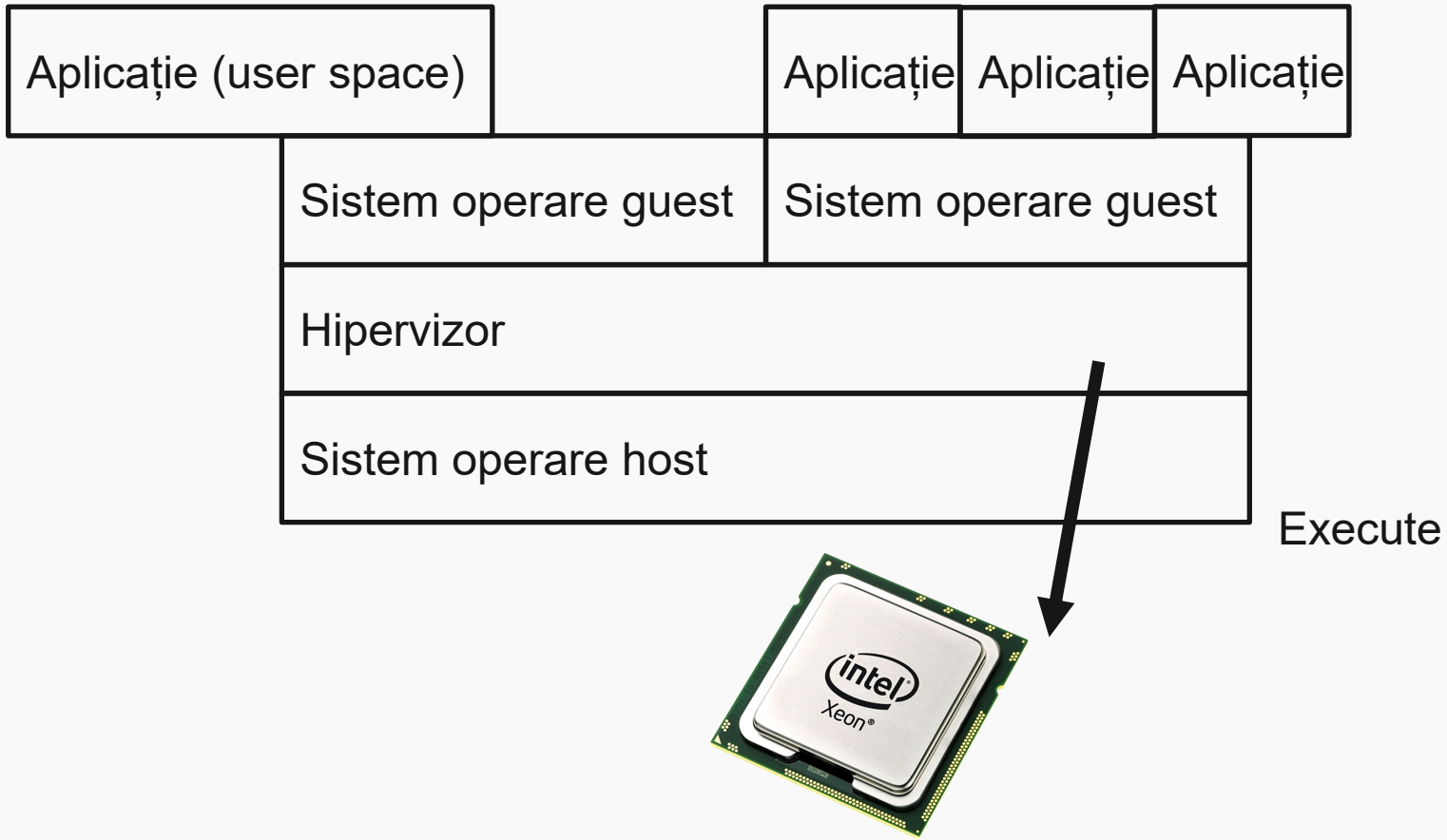
# Virtualizare CPU – trap and execute

## Instrucțiuni kernel (ex. umblat cu I/O, sist întreruperi)

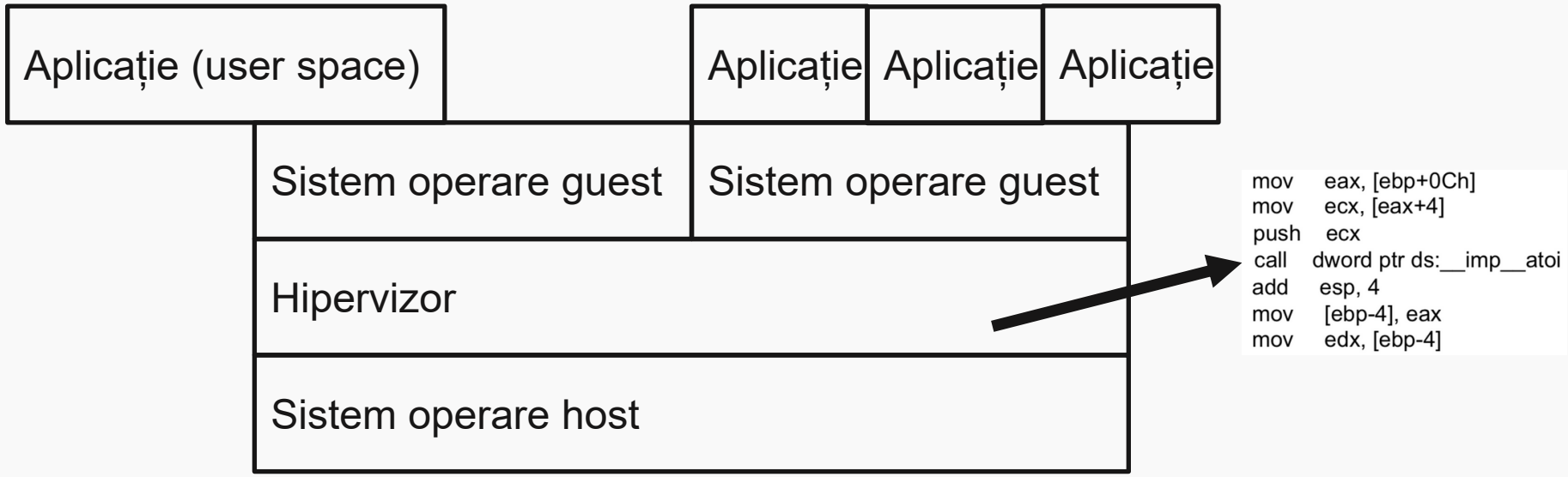


# Virtualizare CPU – trap and execute

## Instrucțiuni kernel (ex. umblat cu I/O, sist întreruperi)



# Virtualizare CPU – rescriere instrucțiuni (emulare)
# Instrucțiuni kernel (ex. umblat cu I/O, sist întreruperi)

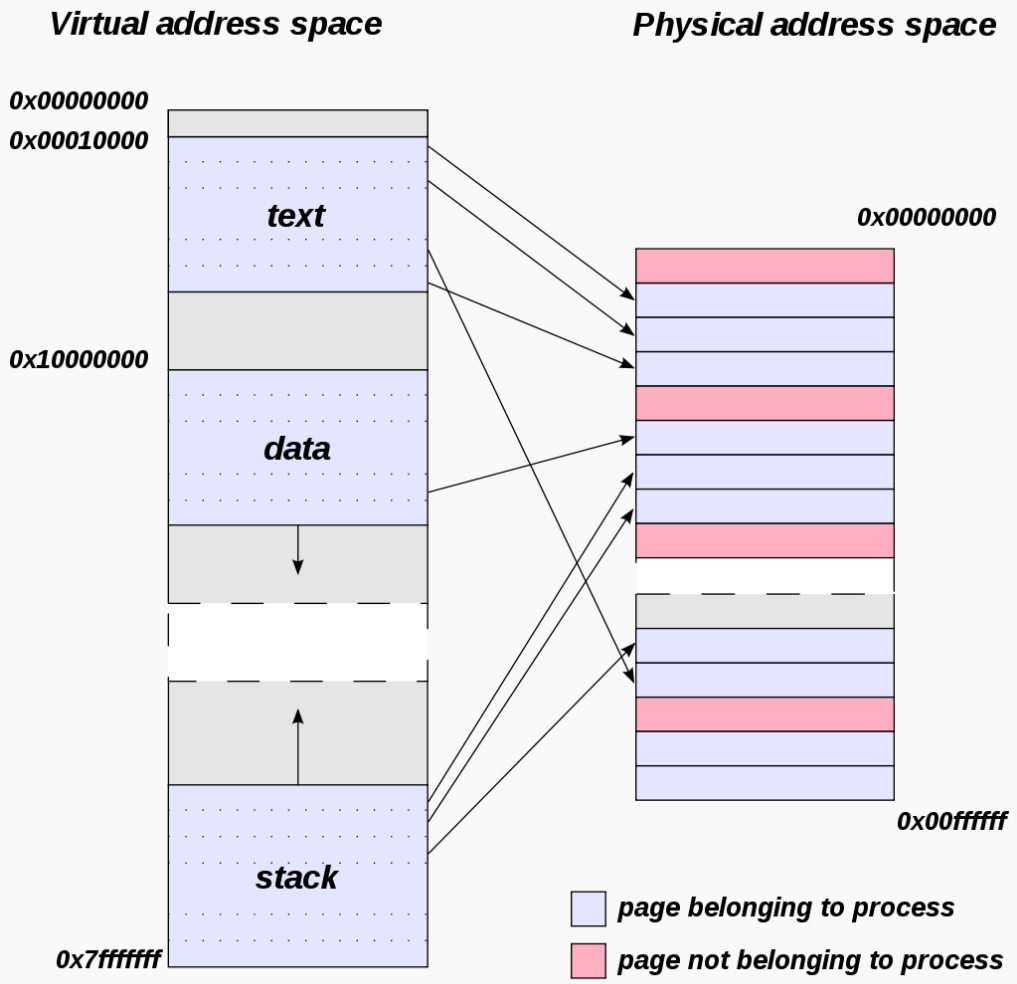



```
mov     eax, [ebp+0Ch]
mov     ecx, [eax+4]
push    ecx
call    dword ptr ds:__imp__atoi
add     esp, 4
mov     [ebp-4], eax
mov     edx, [ebp-4]
```


Înainte să ajungă să fie executate instrucțiunile sunt modificate (per bloc de instrucțiuni)
Inclusiv branch e modificat

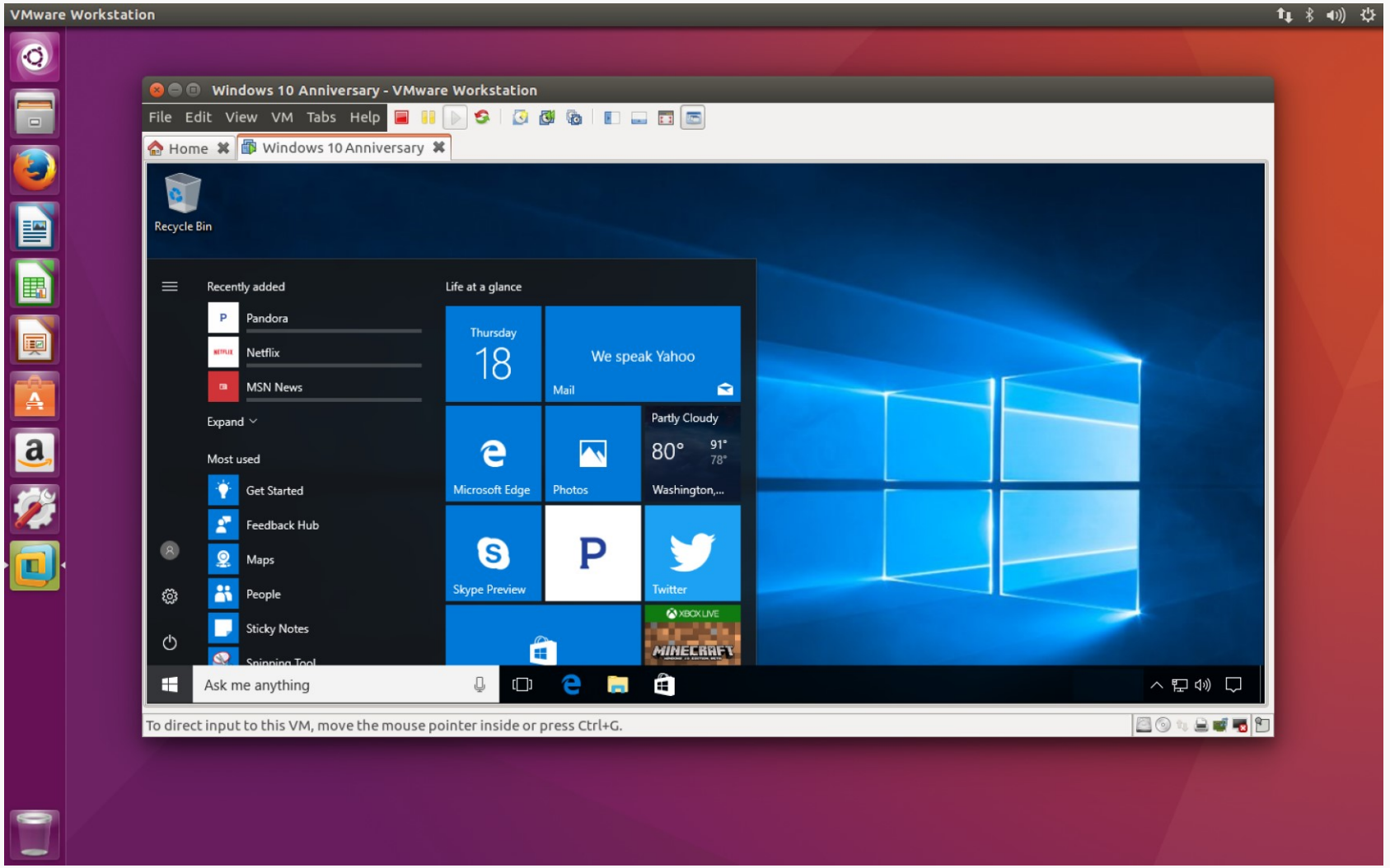
# Virtualizare RAM

- Shadow page tables
- Suport direct în hardware



# ~~Virtualizare~~ Emulare HDD

# ~~Virtualizare~~ Emulare Display



# ~~Virtualizare~~ Emulare I/O

- Mouse/Tastatură ?

# ~~Virtualizare~~ Emulare I/O

- Mouse/Tastatură ?
- Idem Display

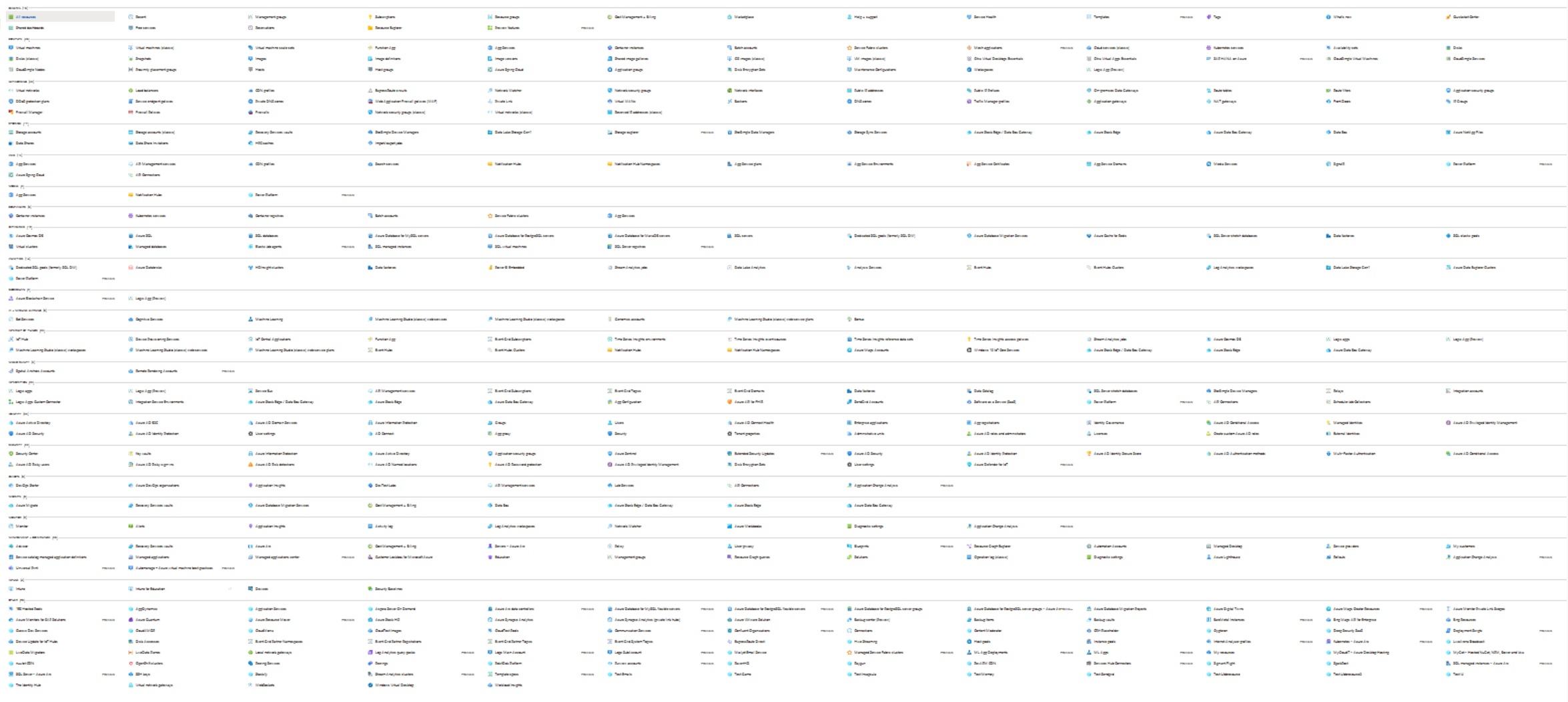
- Multe avantaje când vine vorba de drivere
  - Dacă există sistem de operare host se pot folosi driverele acestuia pentru periferice
  - Pentru sistemul de operare guest se poate oferi un singur dispozitiv virtual (un singur driver)
  - Portabilitate – se poate modifica hardware fără să modifici mașina virtuală

# Platform as a Service

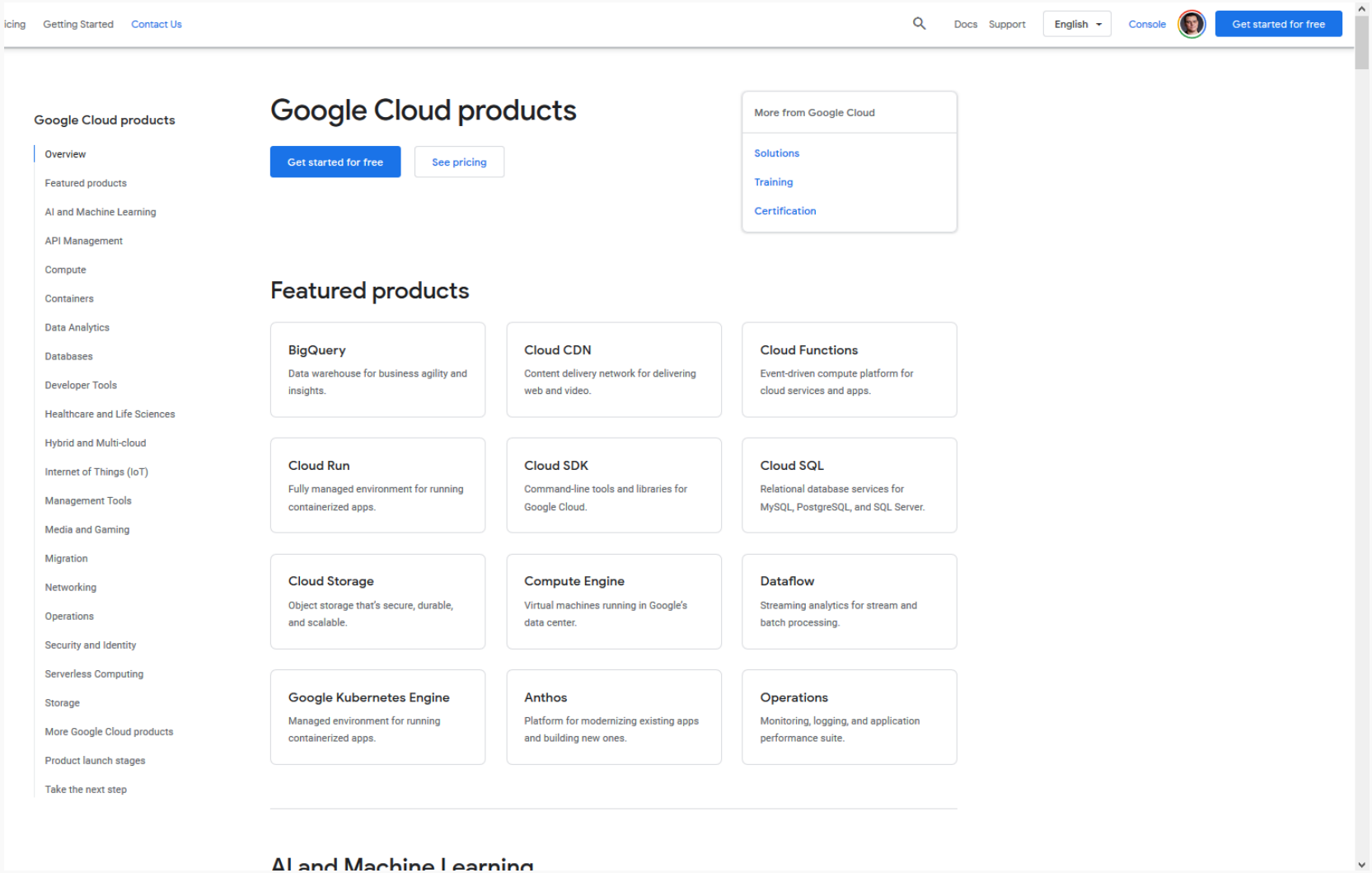
- Cea mai mare dezvoltare în ultimii ani.

- Baze de date cu capabilități diverse (sql/no-sql, diferite nivele de acid, diferite nivele de scalabilitate, diferite nivele de consistență)
- Analytics
- Blockchain
- Inteligență artificială
  - Face detection
  - Chat bots
  - GTP-3

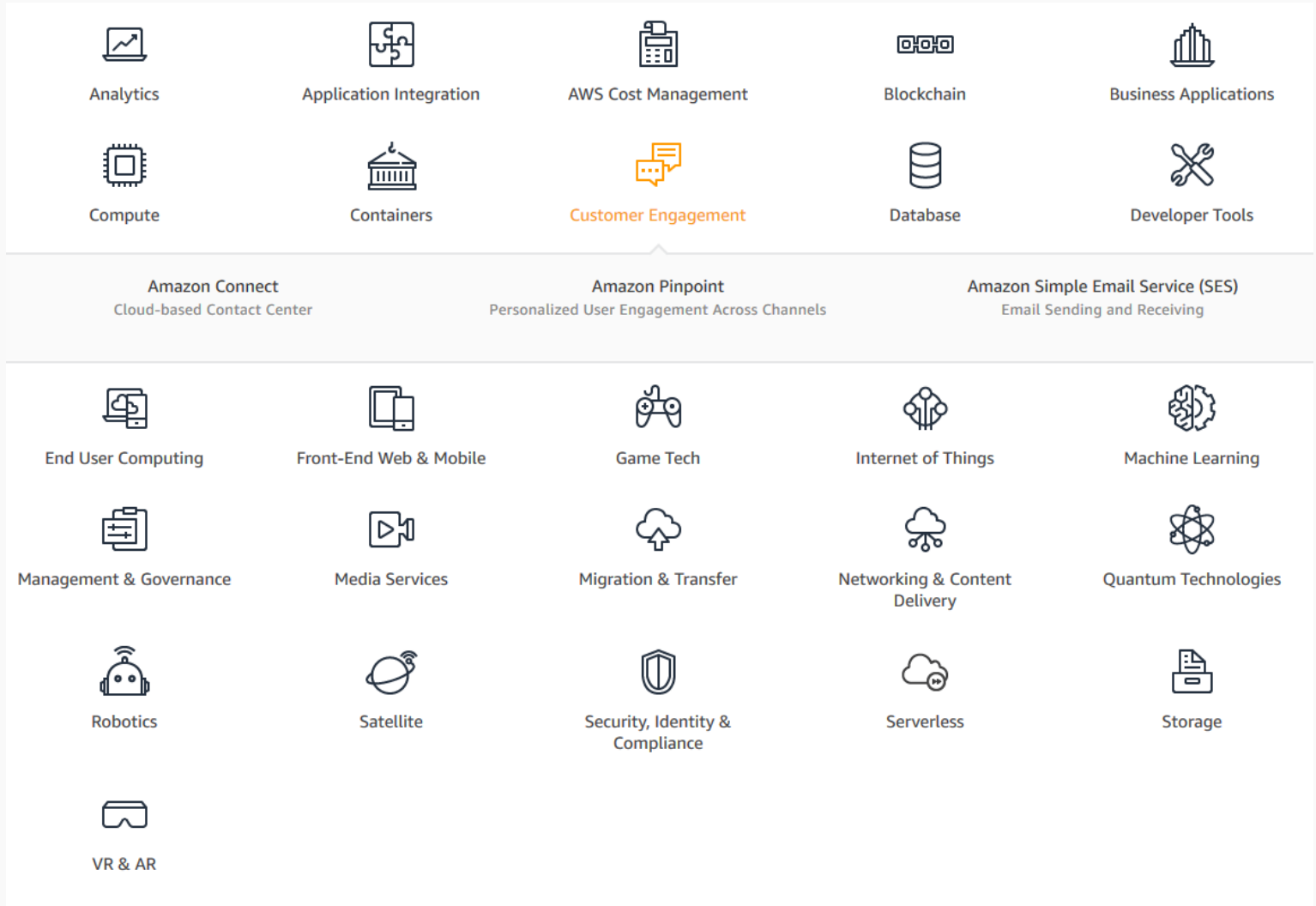
# Platform as a Service – Azure
# Majoritatea icoanelor sunt PaaS



# Platform as a Service – GCP
# (Majoritatea) Uitați-vă la scrollbar



# Platform as a Service – AWS
# (Majoritatea) Toate se deschid



# Software as a Service

- Majoritatea companiilor merg în această direcție

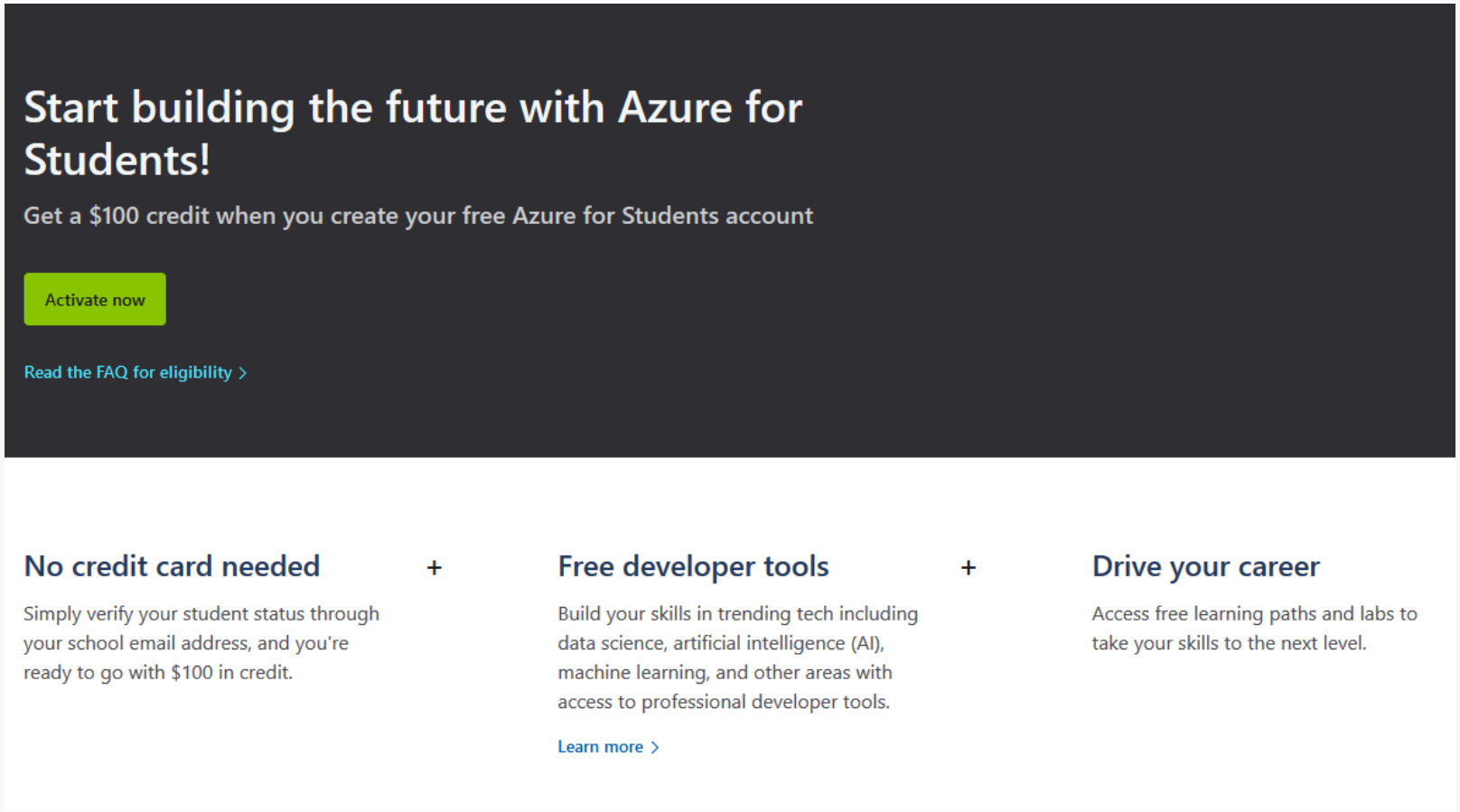




NETFLIX


# Azure for students

- https://azure.microsoft.com/en-us/free/students/



# Azure for students

- Folosiți contul de email mta.ro
- Parola este cea de pe email mta.ro (posibil diferită de cea de pe wiki)
- După intrarea în cont, pe Azure trebuie activați cei 100$.