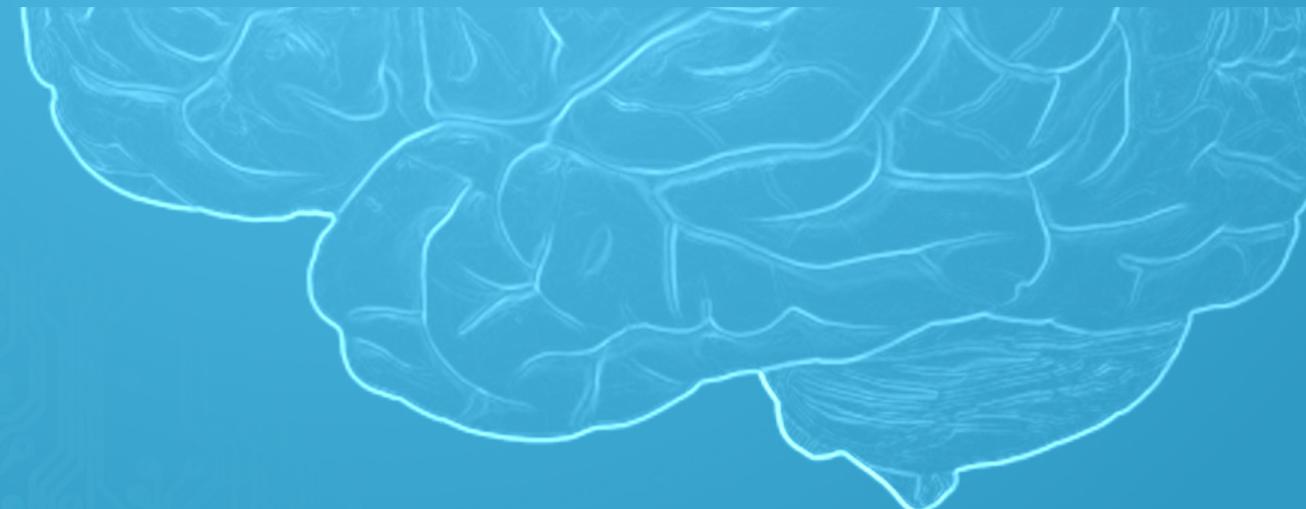
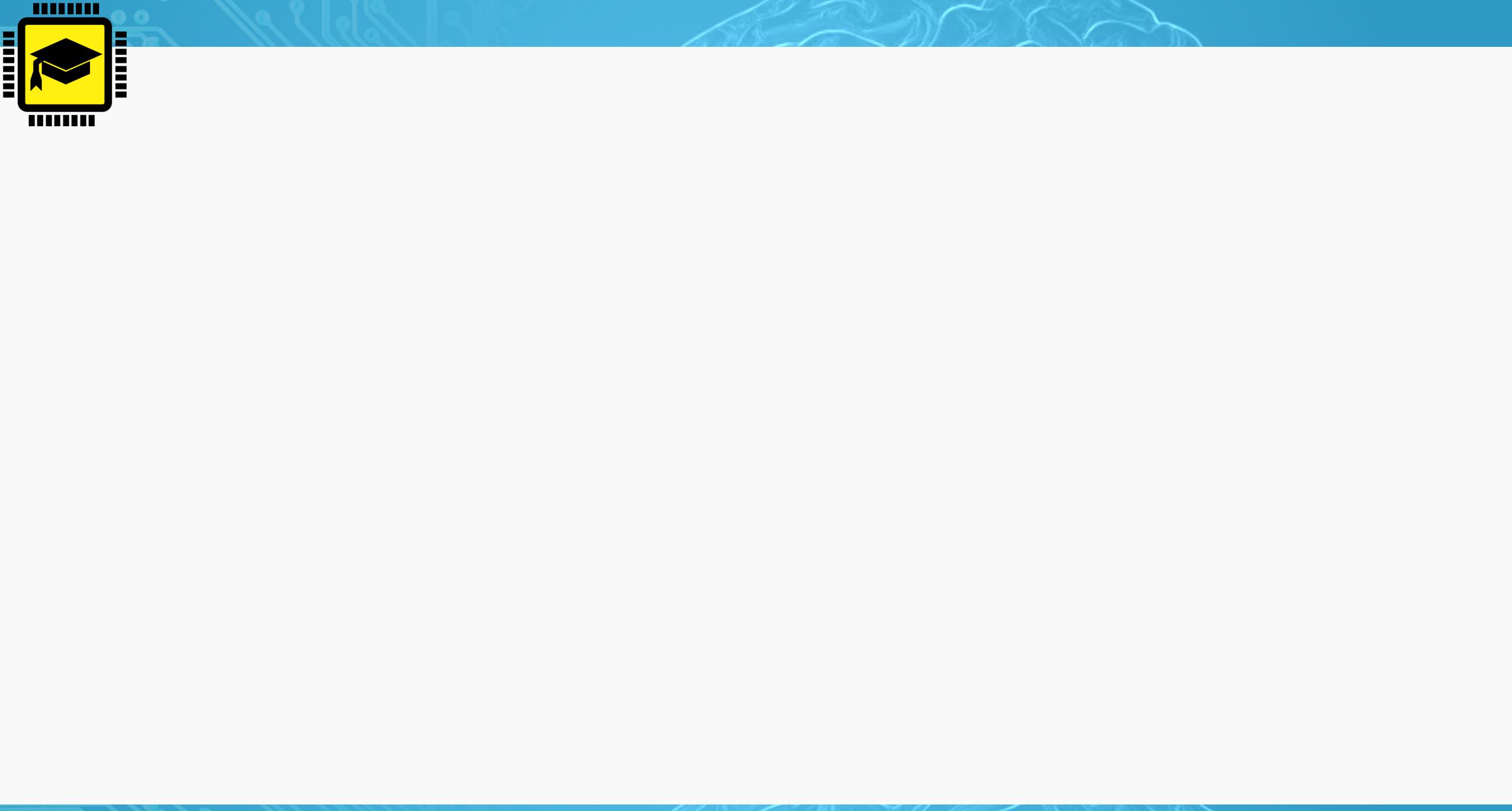


# Sisteme Tolerante la Defecte Introducere Cloud Computing

Dr. Ing. Cristian Chilipirea – cristian.chilipirea@gmail.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

1

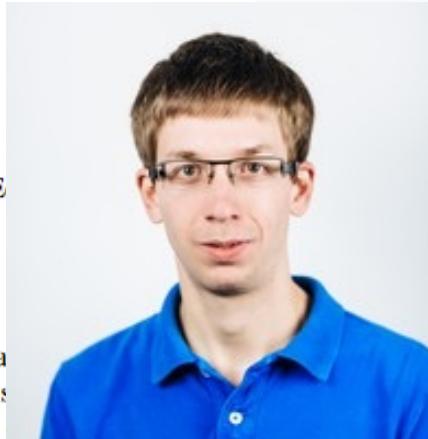
Cloud IT in purchase in hand prove prove with hour large



of computing as a  
attractive as a series  
ideas for new Internet  
the human expense  
ity does not meet the  
popular, thus missing  
sults as quickly as the  
for 1000 hours. The  
y of IT.



System E



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ardware is  
the large  
e concerned about over-  
stly resources, or under-  
ue. Moreover, companies  
sing 1000 servers for one  
ut paying a premium for



# 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).

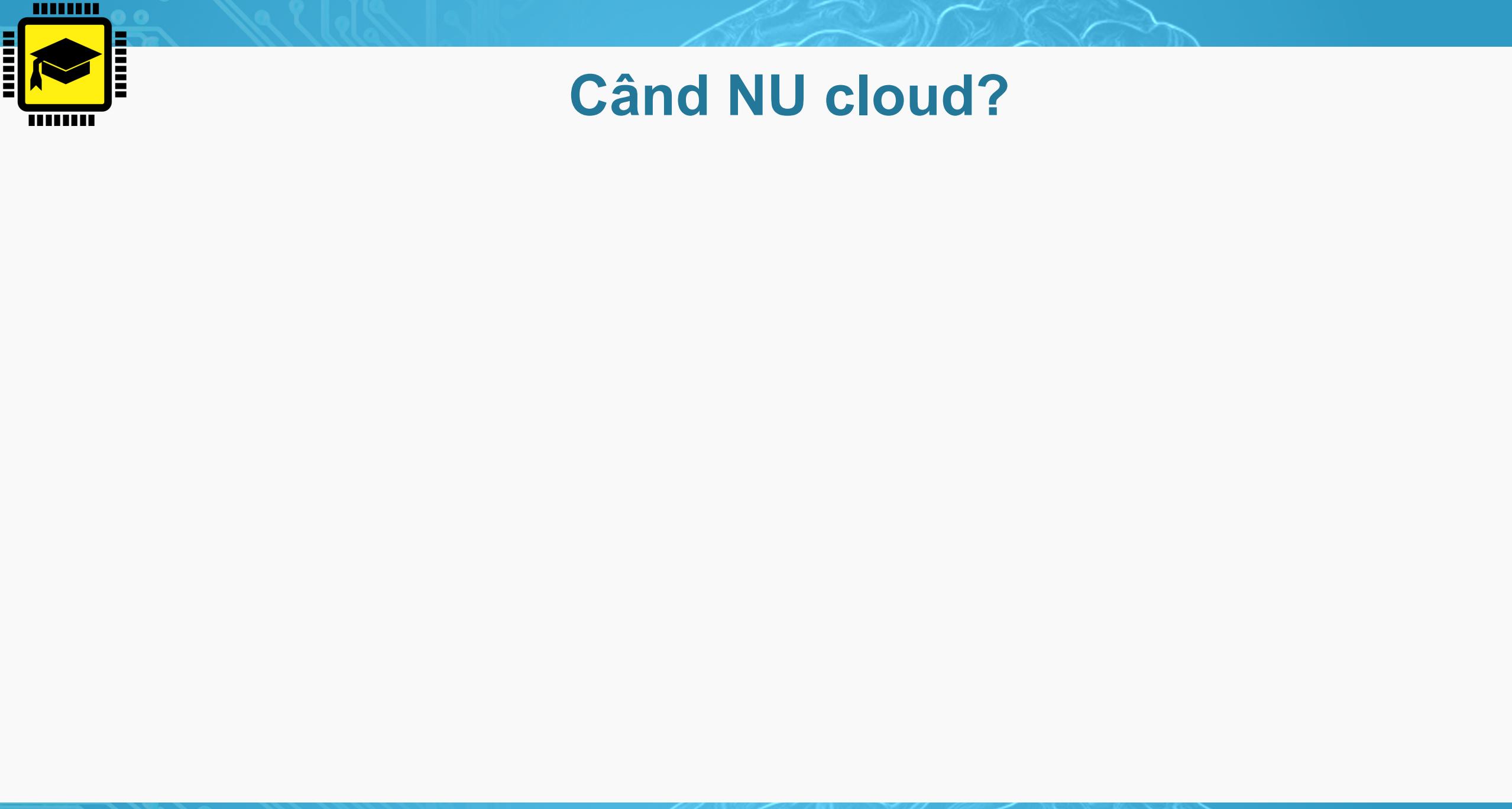
- Noutatea cloud-ului e că acest lucru se întâmplă automat.
- Majoritatea se plătesc la nivel de ore

**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?

## Date sensibile

- Poate fi chiar ilegal să pui anumite date (medicale) pe Cloud public

## Proiect foarte **mare** cu durată **mare**.

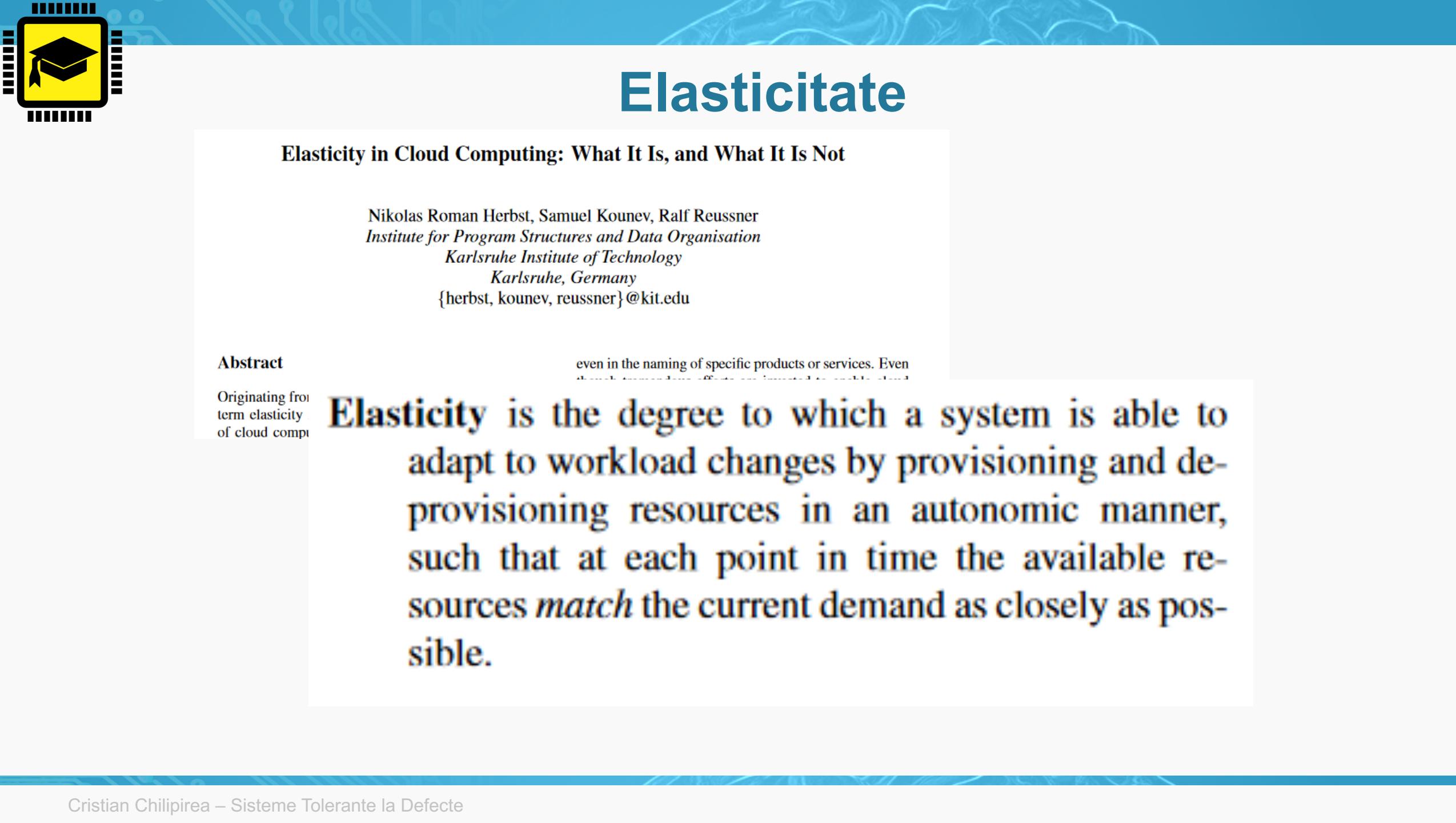
- cost cluster < cost multe resurse cloud \* perioadă timp

## 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

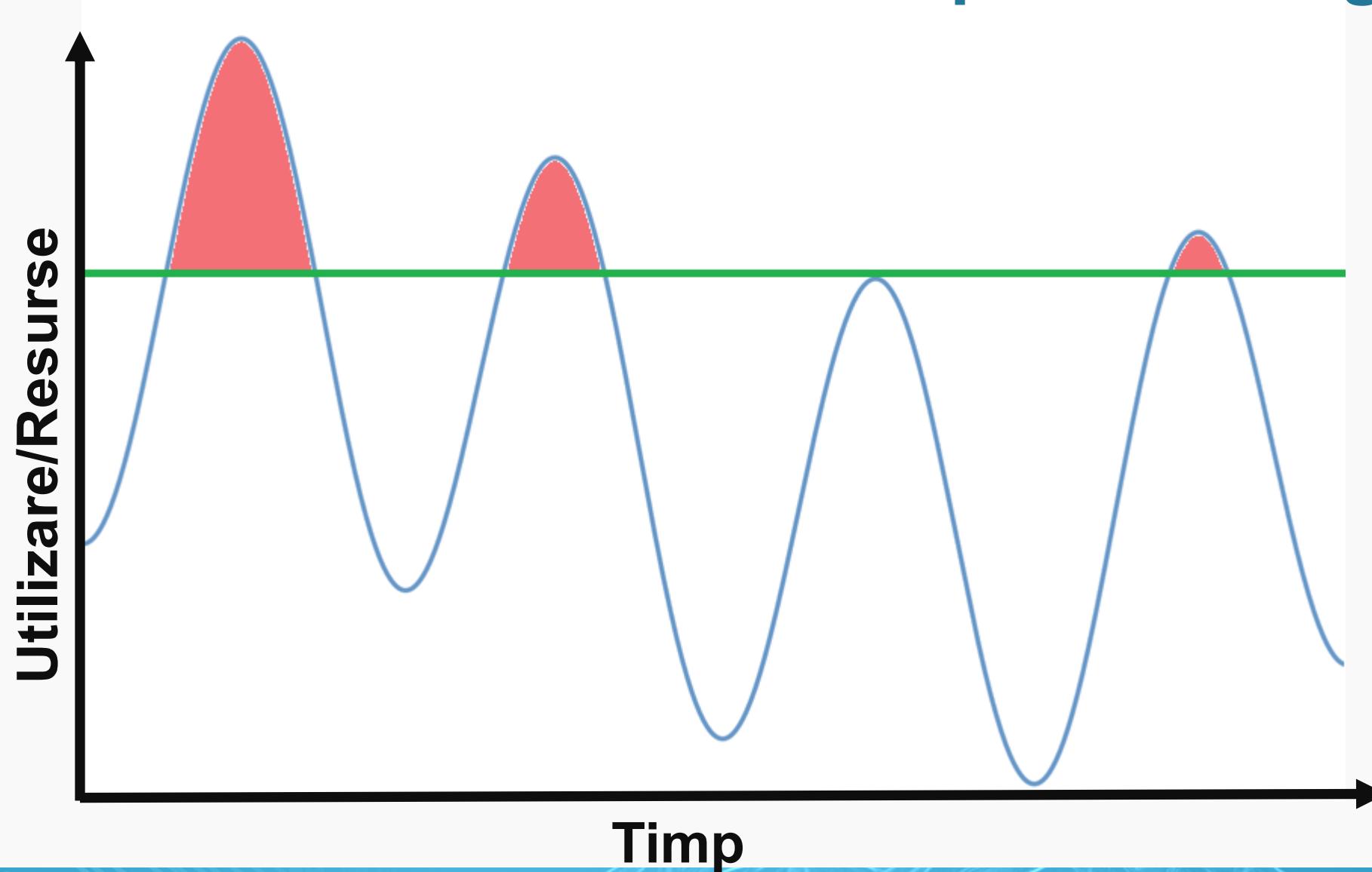
Originating from the term elasticity of cloud computing, the concept of elasticity has become widely used in the naming of specific products or services. Even

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.

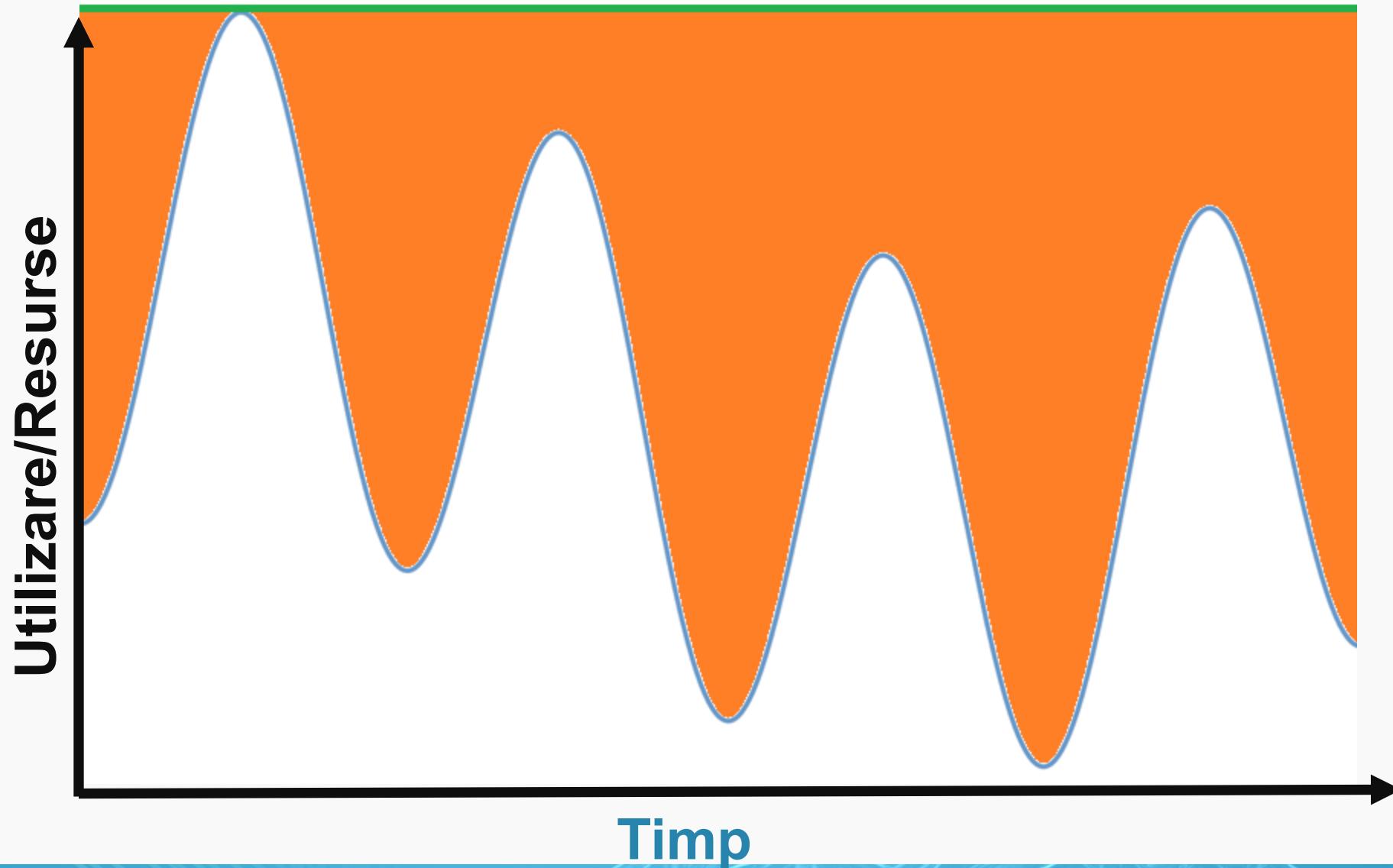


# Fără elasticitate – underprovisioning



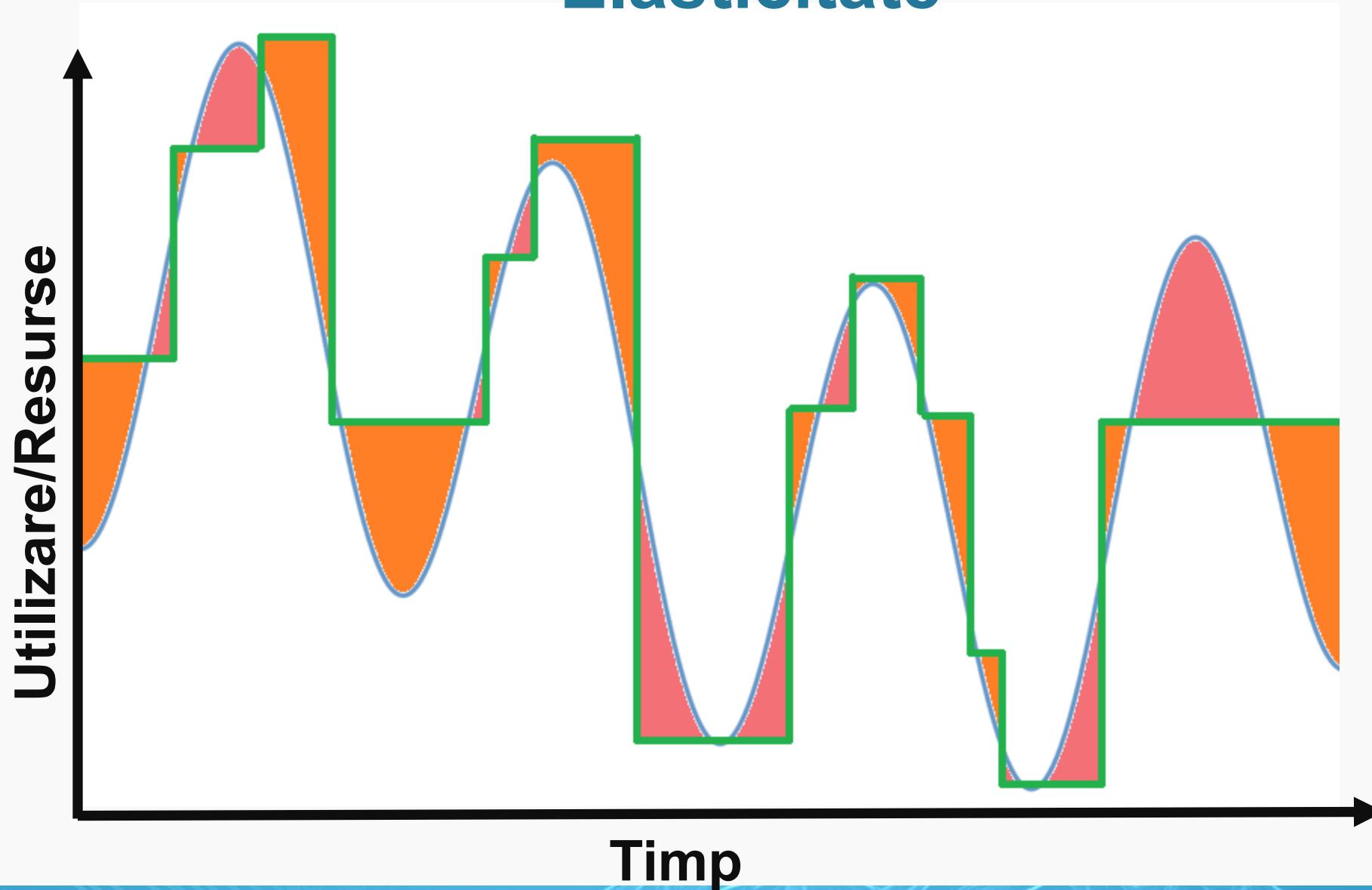


# Fără elasticitate – overprovisioning





# Elasticitate

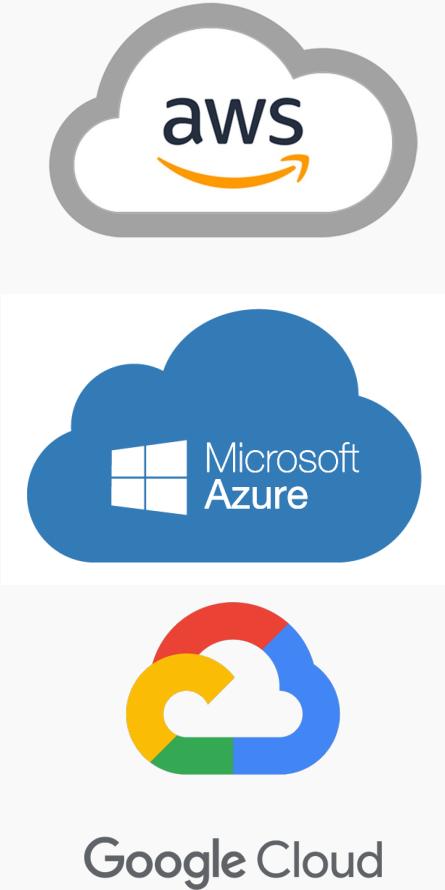




## Privat vs

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

## Public



și mulți alții....

## vs Hibrid

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 tolerantă la defecte



# X as a Service

X as a Service	Exemplu Efectiv
<b>Software as a Service</b>	Dropbox, Slack
<b>Platform as a Service</b>	Baze de date
<b>Infrastructure as a Service</b>	Mașini virtuale
<b>Metal as a Service</b>	Mașini fizice
<b>... as a Service</b>	



# 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)**

Combinata 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

Dependențe 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

Ex: [Simulator NES](#) (Warning multiple hours of intense fun)

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

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



# Reminder multi-tasking

## Assembly vs. machine code

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

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

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

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
```



Timer Interrupt





# Reminder multi-tasking



Timer Interrupt

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)



# 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



**Scheduler – kernel OS**

Program counter  
State  
Registers  
Codul e deja acolo





# Reminder multi-tasking



Scheduler – kernel OS

```
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



```
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]
```



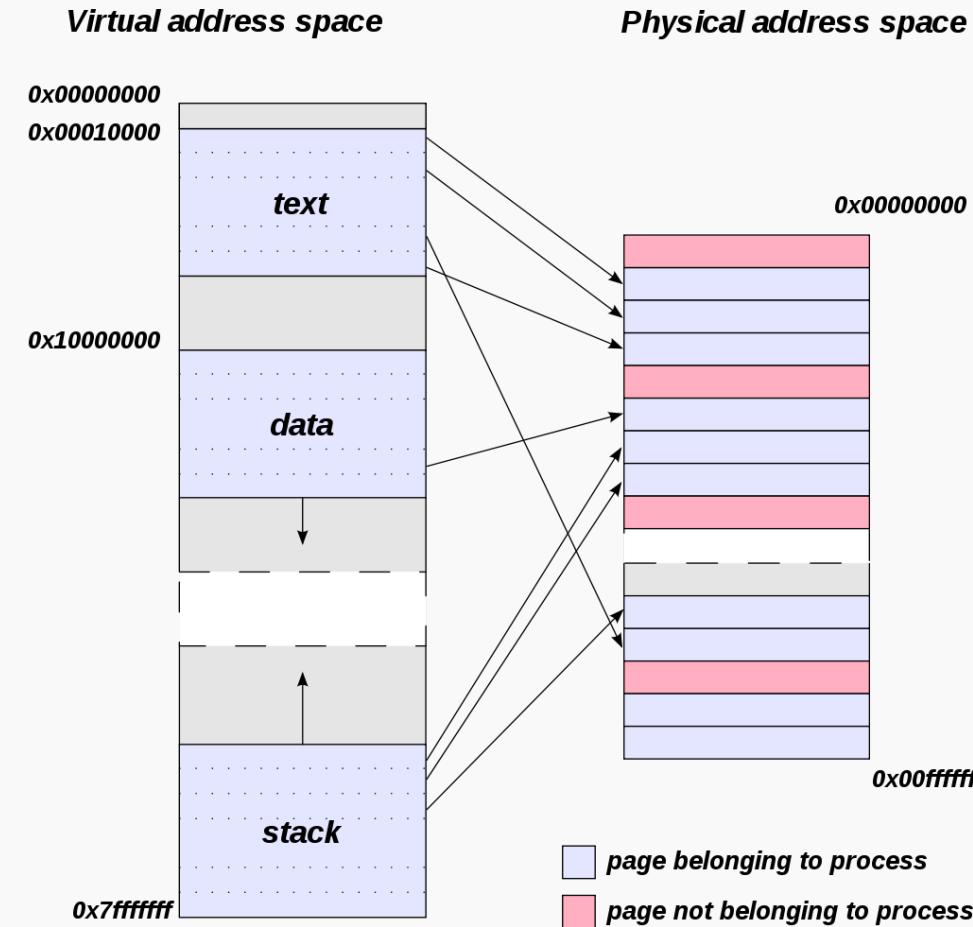


# Reminder multi-tasking

Toate programele cred că au acces la tot RAM-ul fără spațiu alocat kernel

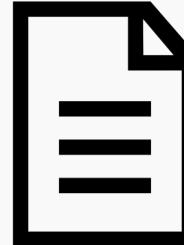
Soluția este paginarea (bucăți de RAM virtual mapate pe cel real)

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



Codul de rulat

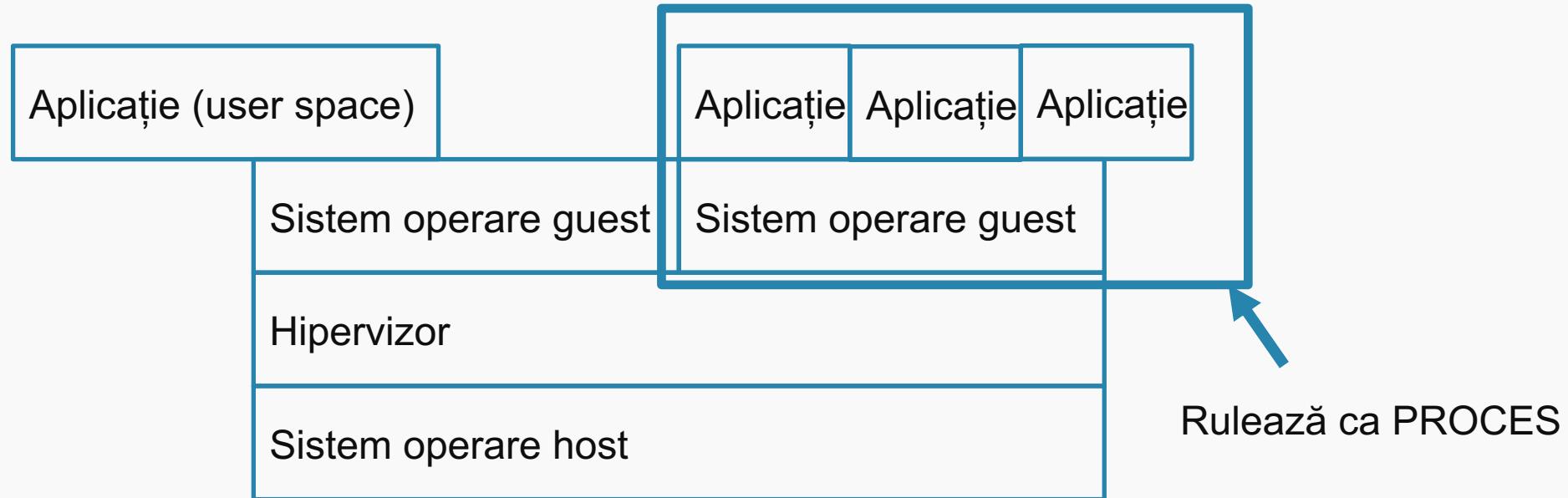
Trebuie reținută starea (un set de variabile)  
Trebuie reținuți regiștri (un vector)  
Majoritatea instrucțiunilor modifică starea  
sau regiștri  
Restul instrucțiunilor sunt citiri scrieri RAM sau  
periferice

Un malloc mare





# Virtualizare CPU





# Virtualizare CPU

---

## Formal Requirements for Virtualizable Third Generation Architectures

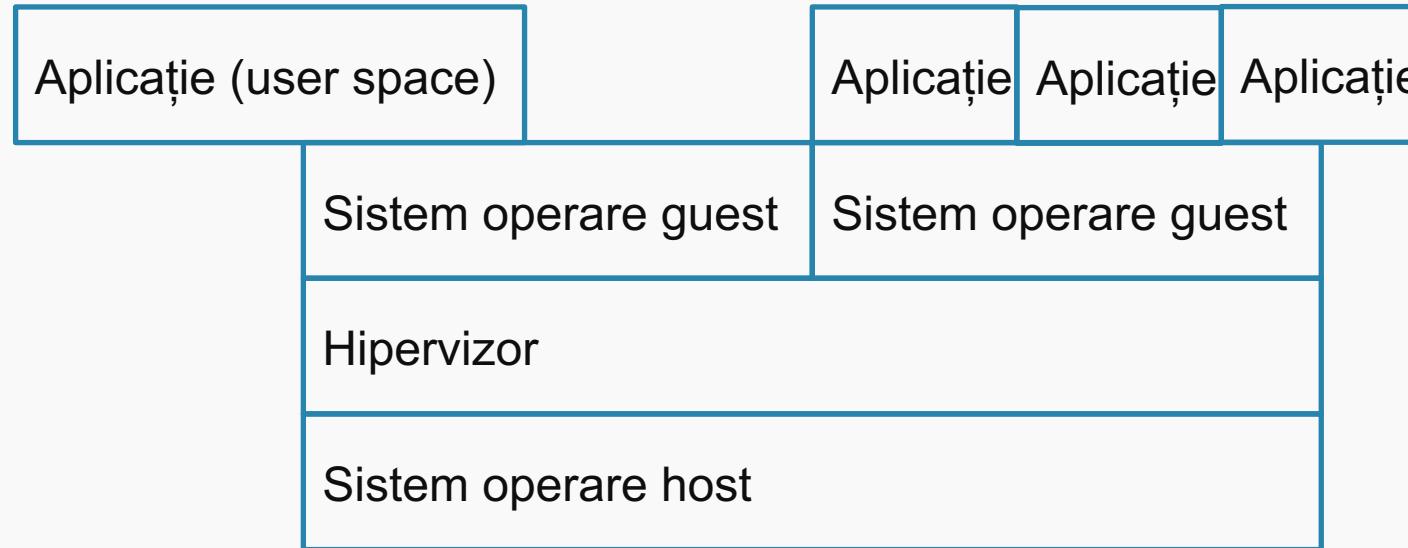
Gerald J. Popek  
University of California, Los Angeles  
and  
Robert P. Goldberg  
Honeywell Information Systems and  
Harvard University

---

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.

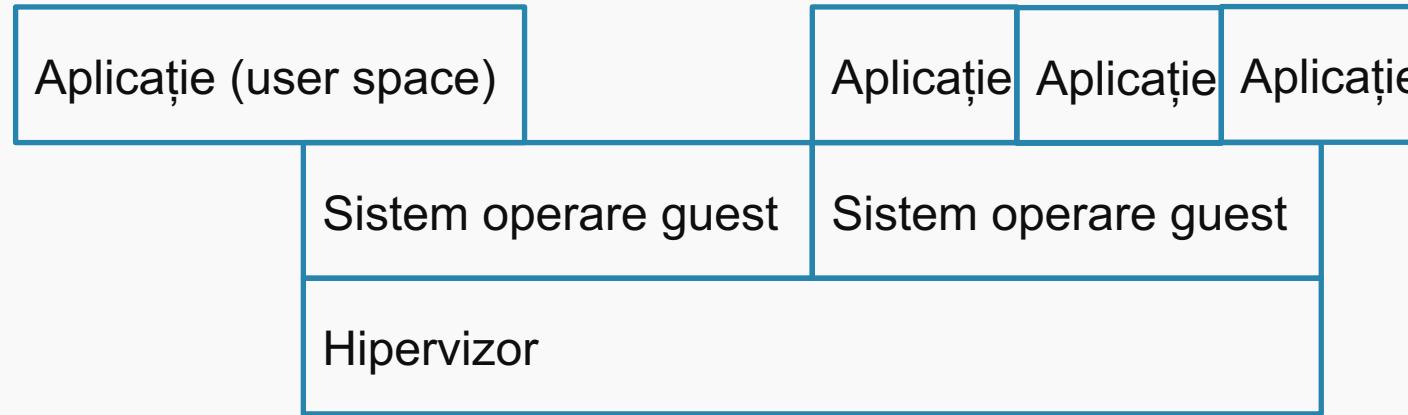


# Virtualizare CPU – Type 1



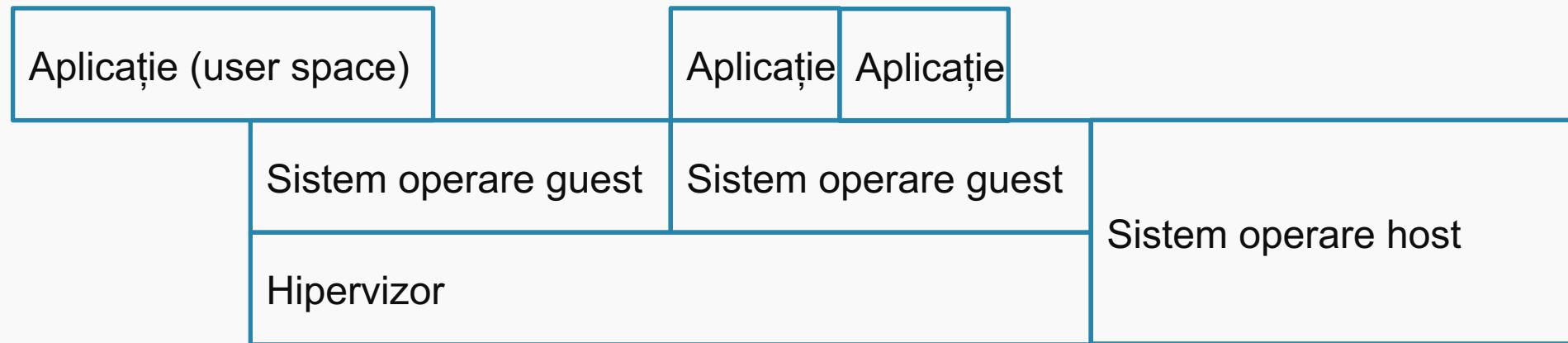


# Virtualizare CPU – Type 2





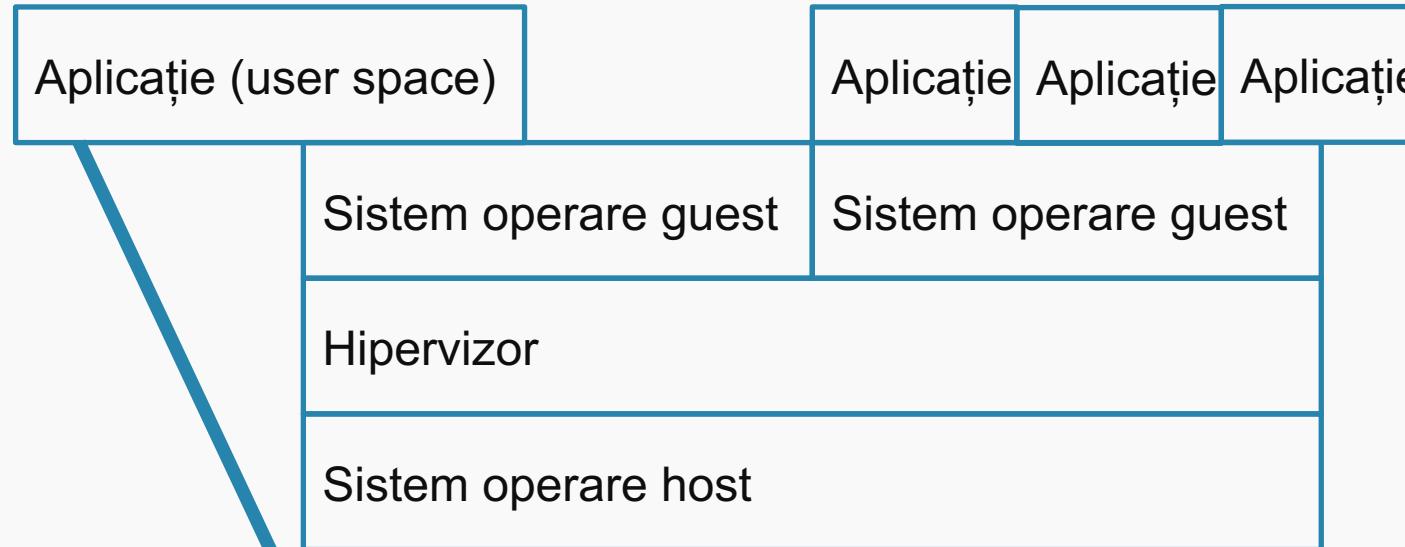
# Virtualizare CPU – Paravirtualizare





# Virtualizare CPU

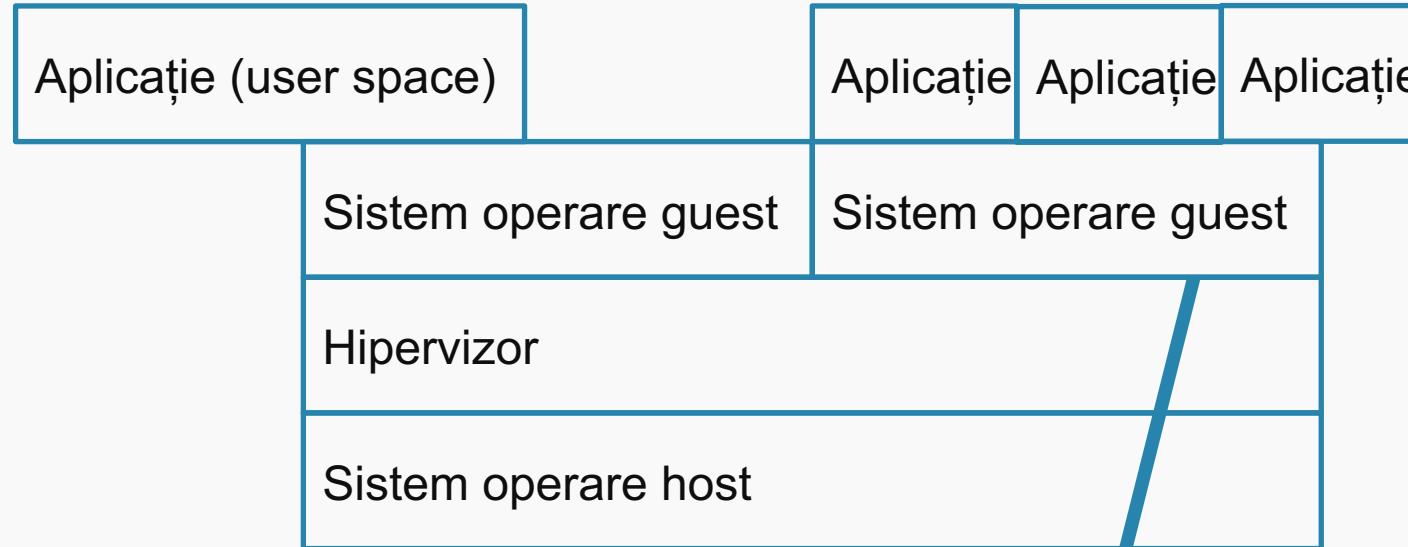
## Instrucțiuni simple (ex. add, mov din memoria sa)





# Virtualizare CPU – trap and execute

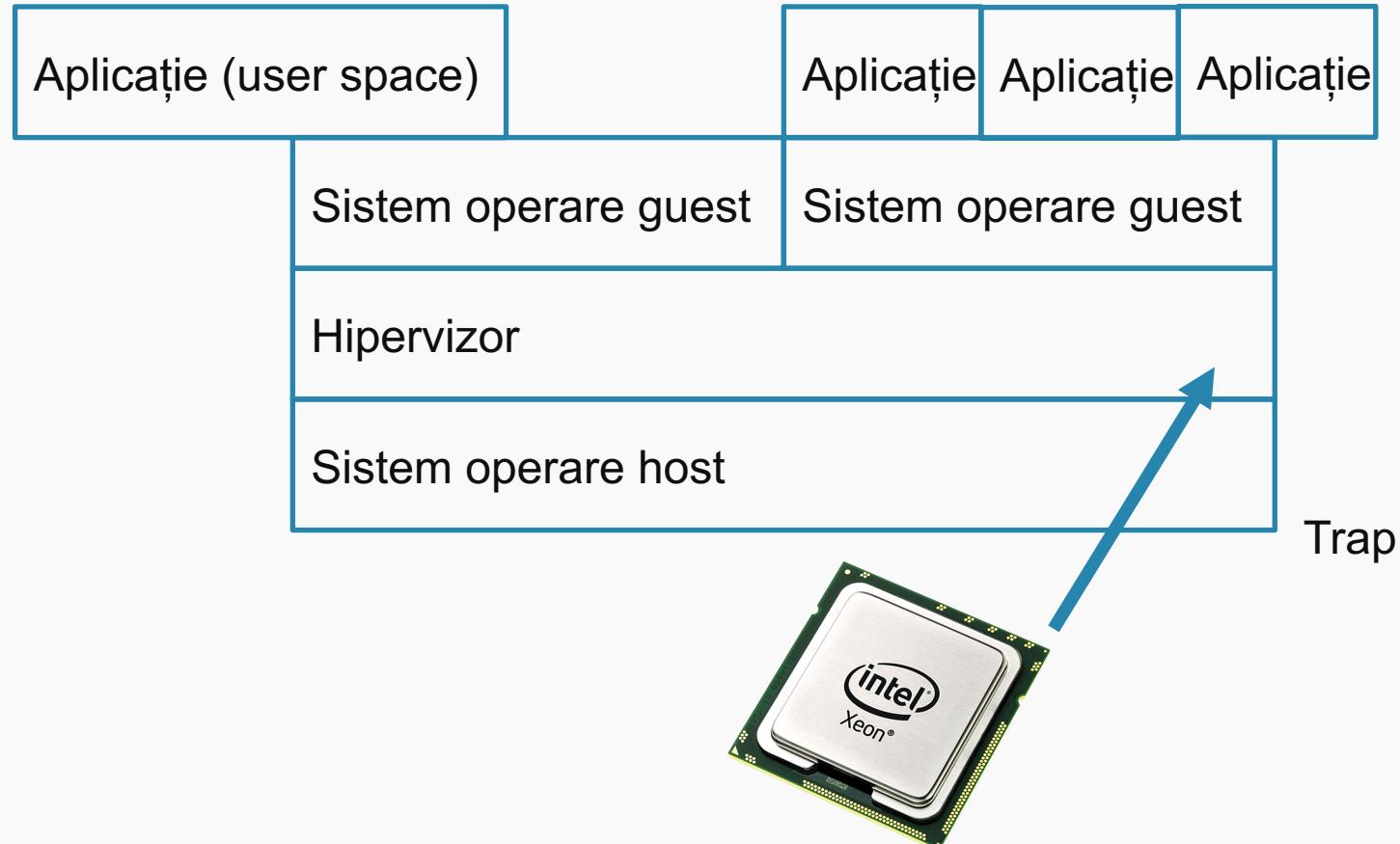
## Instrucțiuni kernel (ex. umblat cu I/O, sist încreruperi)





# Virtualizare CPU – trap and execute

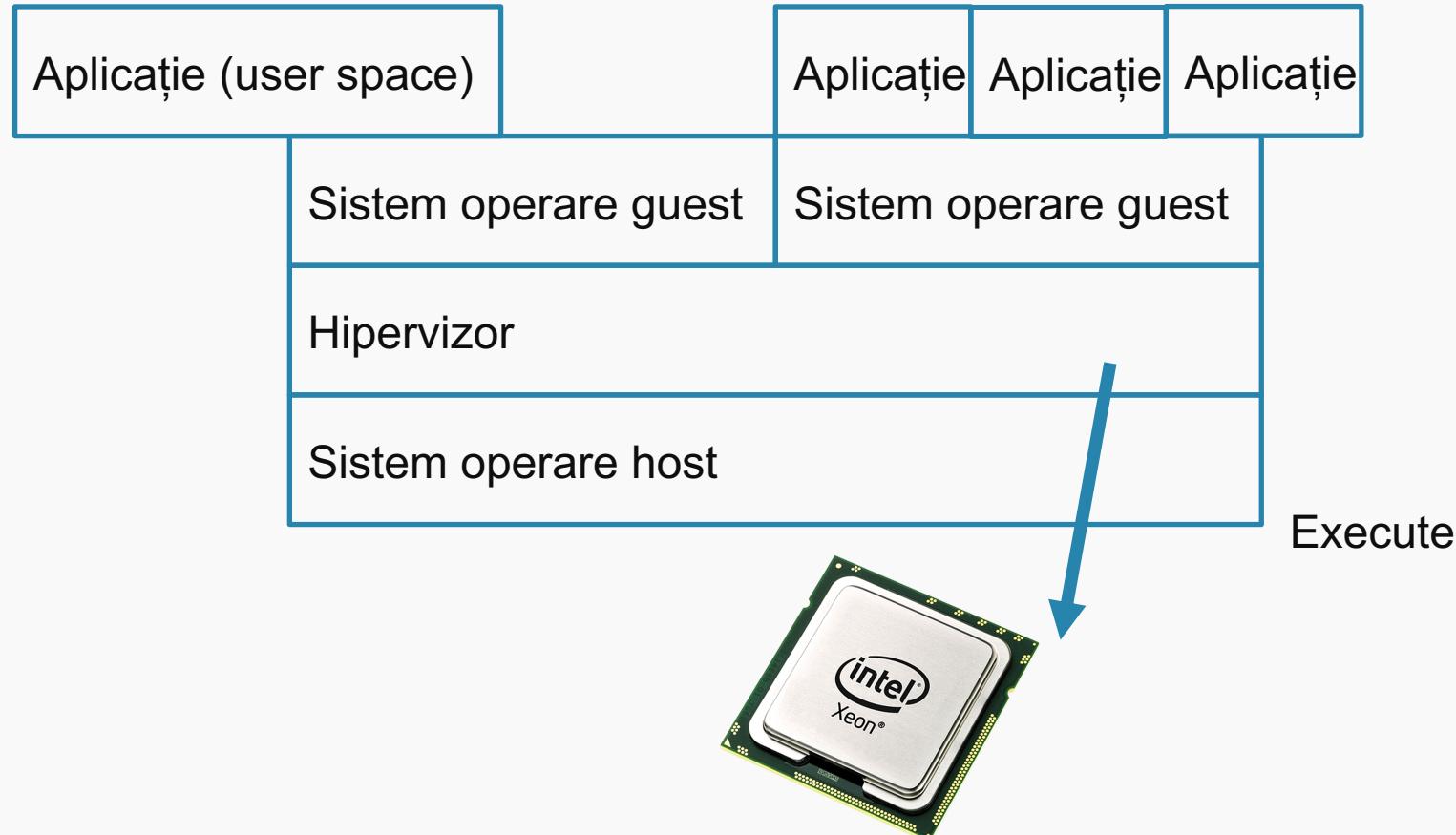
## Instrucțiuni kernel (ex. umblat cu I/O, sist încreruperi)





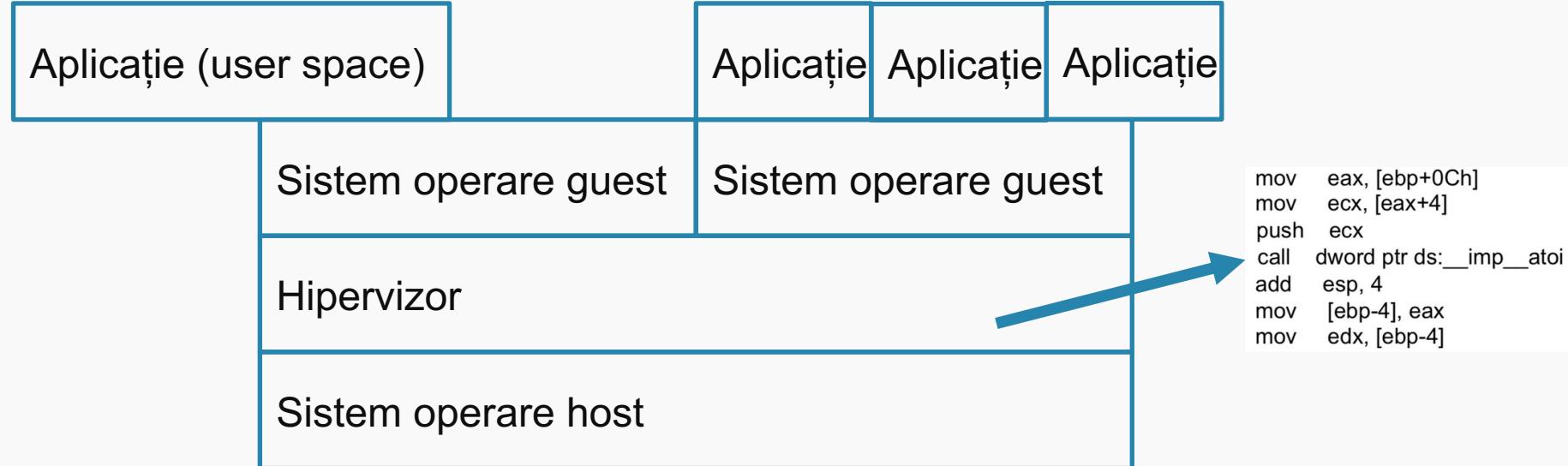
# Virtualizare CPU – trap and execute

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





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



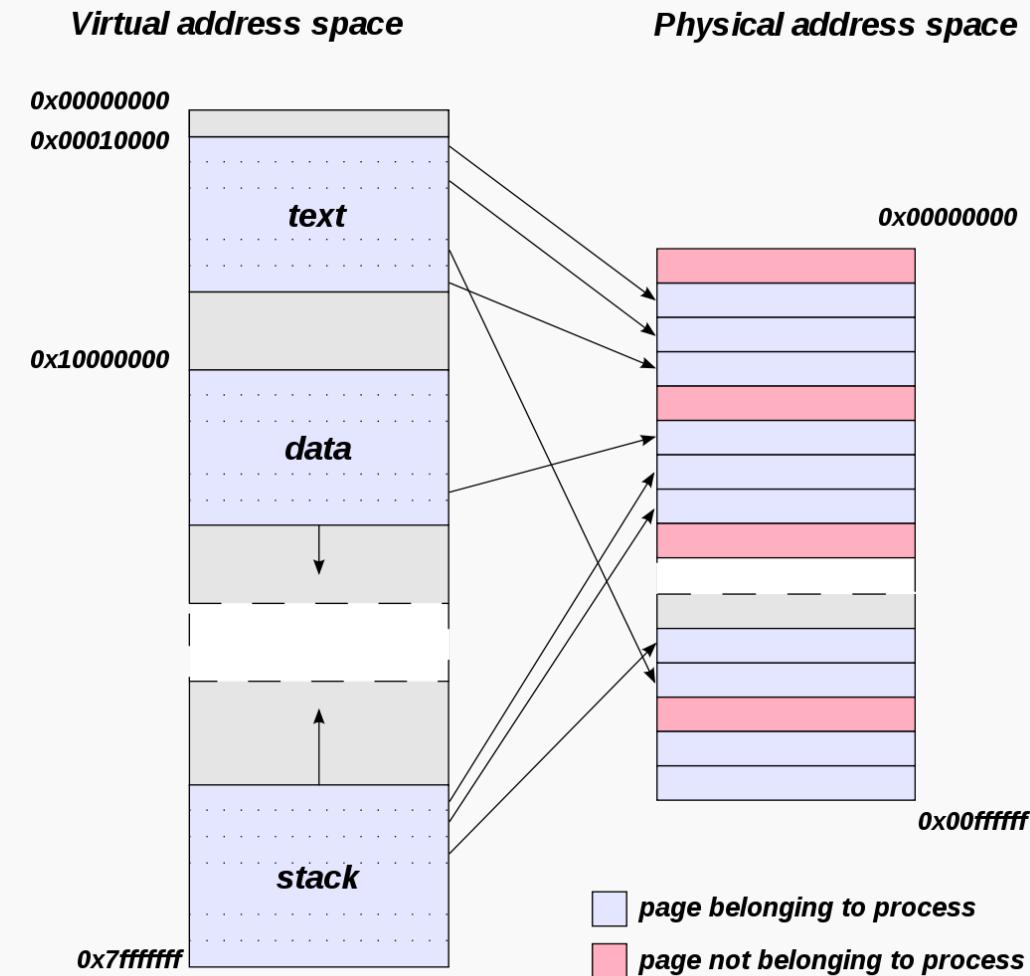
Înainte să ajungă să fie executate  
instrucțiunile sunt modificate (per  
bloc de instrucțiuni)  
Inclusiv branch e modificat



# Virtualizare RAM

Shadow page tables

Suport direct în hardware



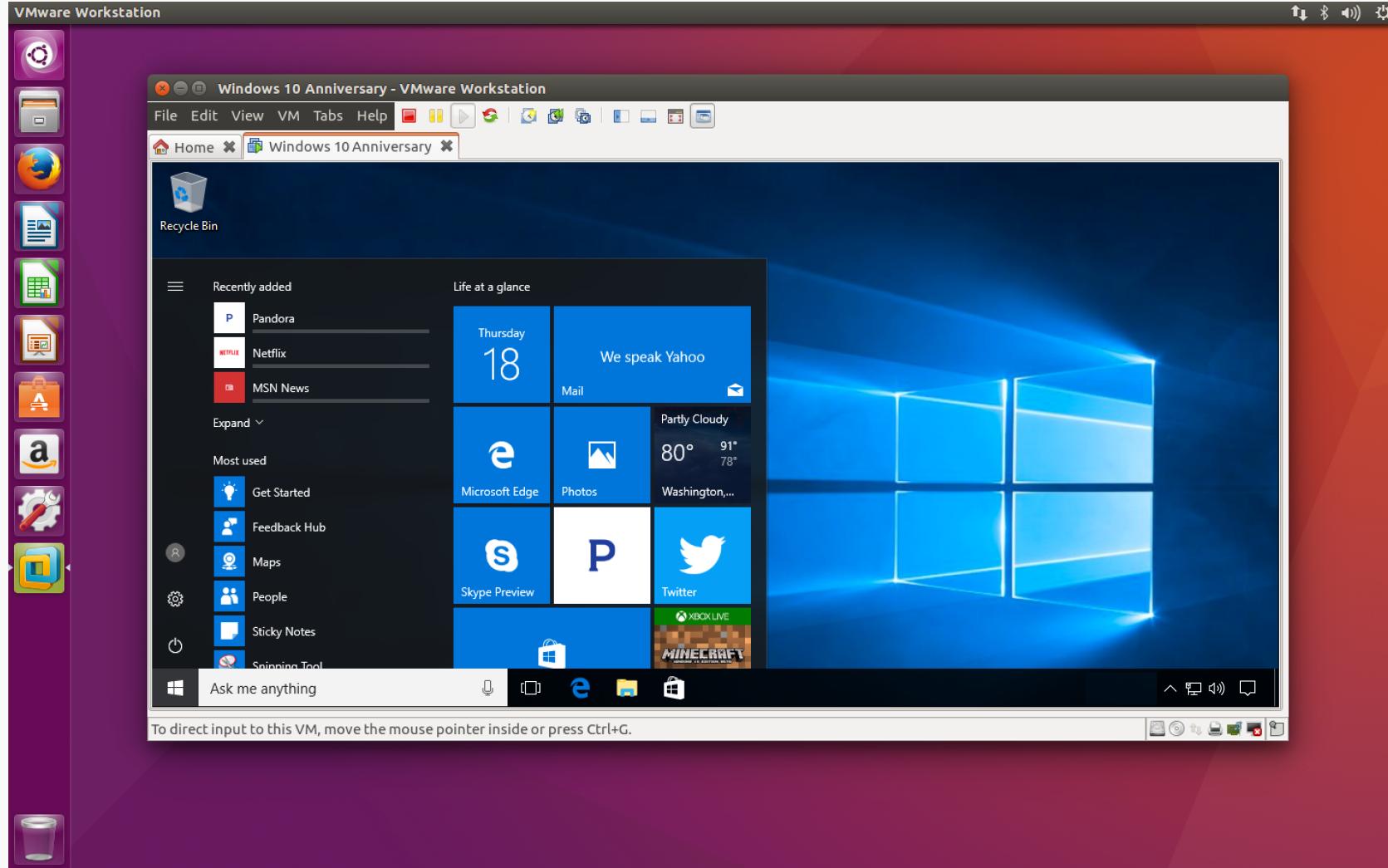


# Virtualizare Emulare HDD





# 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 drivele 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

Inteligentă artificială

- Face detection
- Chat bots
- GTP-3



# Platform as a Service – Azure

## Majoritatea icoanelor sunt PaaS



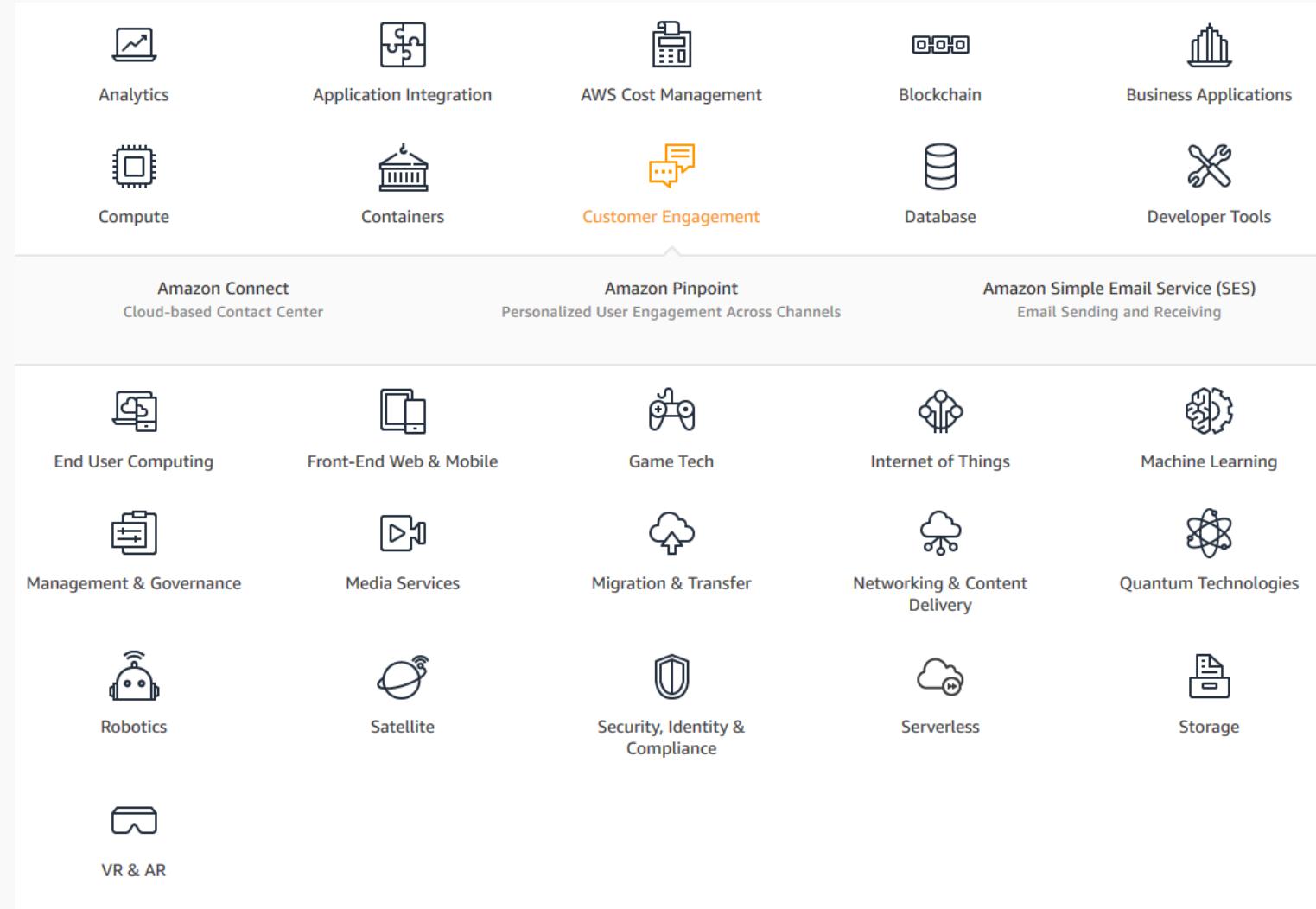


# Platform as a Service – GCP (Majoritatea) Uitați-vă la scrollbar

The screenshot shows the Google Cloud products page. On the left, there's a sidebar titled "Google Cloud products" with a "Overview" section selected. Other categories listed include Featured products, AI and Machine Learning, API Management, Compute, Containers, Data Analytics, Databases, Developer Tools, Healthcare and Life Sciences, Hybrid and Multi-cloud, Internet of Things (IoT), Management Tools, Media and Gaming, Migration, Networking, Operations, Security and Identity, Serverless Computing, Storage, More Google Cloud products, Product launch stages, and Take the next step. In the center, there's a main heading "Google Cloud products" with "Get started for free" and "See pricing" buttons. Below this, there's a section titled "Featured products" containing cards for various services: BigQuery (Data warehouse for business agility and insights), Cloud CDN (Content delivery network for delivering web and video), Cloud Functions (Event-driven compute platform for cloud services and apps), Cloud Run (Fully managed environment for running containerized apps), Cloud SDK (Command-line tools and libraries for Google Cloud), Cloud SQL (Relational database services for MySQL, PostgreSQL, and SQL Server), Cloud Storage (Object storage that's secure, durable, and scalable), Compute Engine (Virtual machines running in Google's data center), Dataflow (Streaming analytics for stream and batch processing), Google Kubernetes Engine (Managed environment for running containerized apps), Anthos (Platform for modernizing existing apps and building new ones), and Operations (Monitoring, logging, and application performance suite). On the right, there's a sidebar titled "More from Google Cloud" with links to Solutions, Training, and Certification.



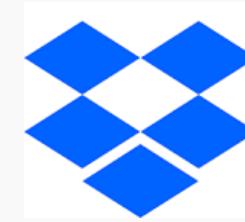
# Platform as a Service – AWS (Majoritatea) Toate se deschid





# Software as a Service

Majoritatea companiilor merg în această direcție



# NETFLIX





# Azure for students

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

## Start building the future with Azure for Students!

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+

### Drive your career

Access free learning paths and labs to take your skills to the next level.



# 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\$.