



# Arhitecturi Paralele

## Scurtă introducere în Cloud Computing

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# 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](mailto:abovetheclouds@cs.berkeley.edu))

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

February 10, 2009

KEYWORDS: Cloud Computing, Utility Computing, Internet Data

### 1 Executive

Cloud Computing  
IT industry, making  
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in hardware to decrease  
provisioning for a  
provisioning for o  
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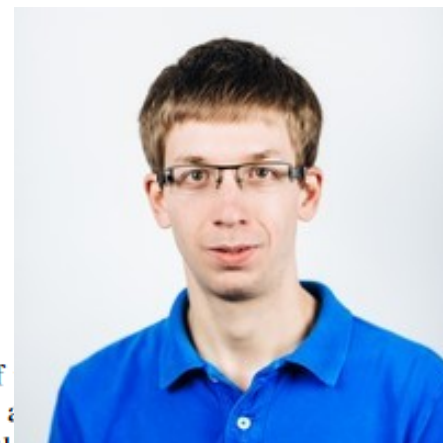


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# Cloud-ul este despre Cost \$\$\$\$

- **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**.

- $\text{cost cluster} < \text{cost multe resurse cloud} * \text{periodă timp}$

- **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

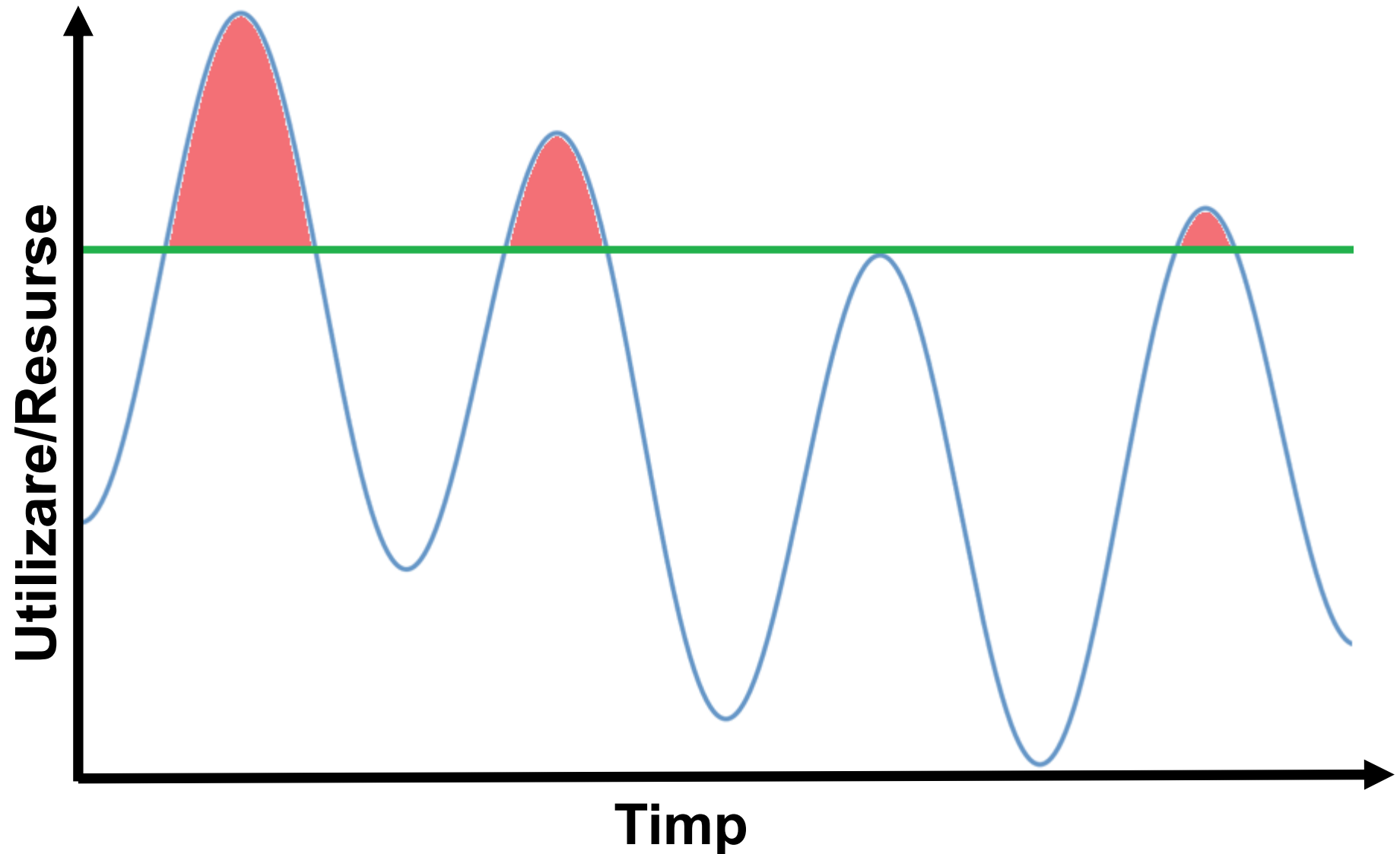
Originating from  
term elasticity  
of cloud comput

even in the naming of specific products or services. Even  
though some have efforts are invested to enable cloud

**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.

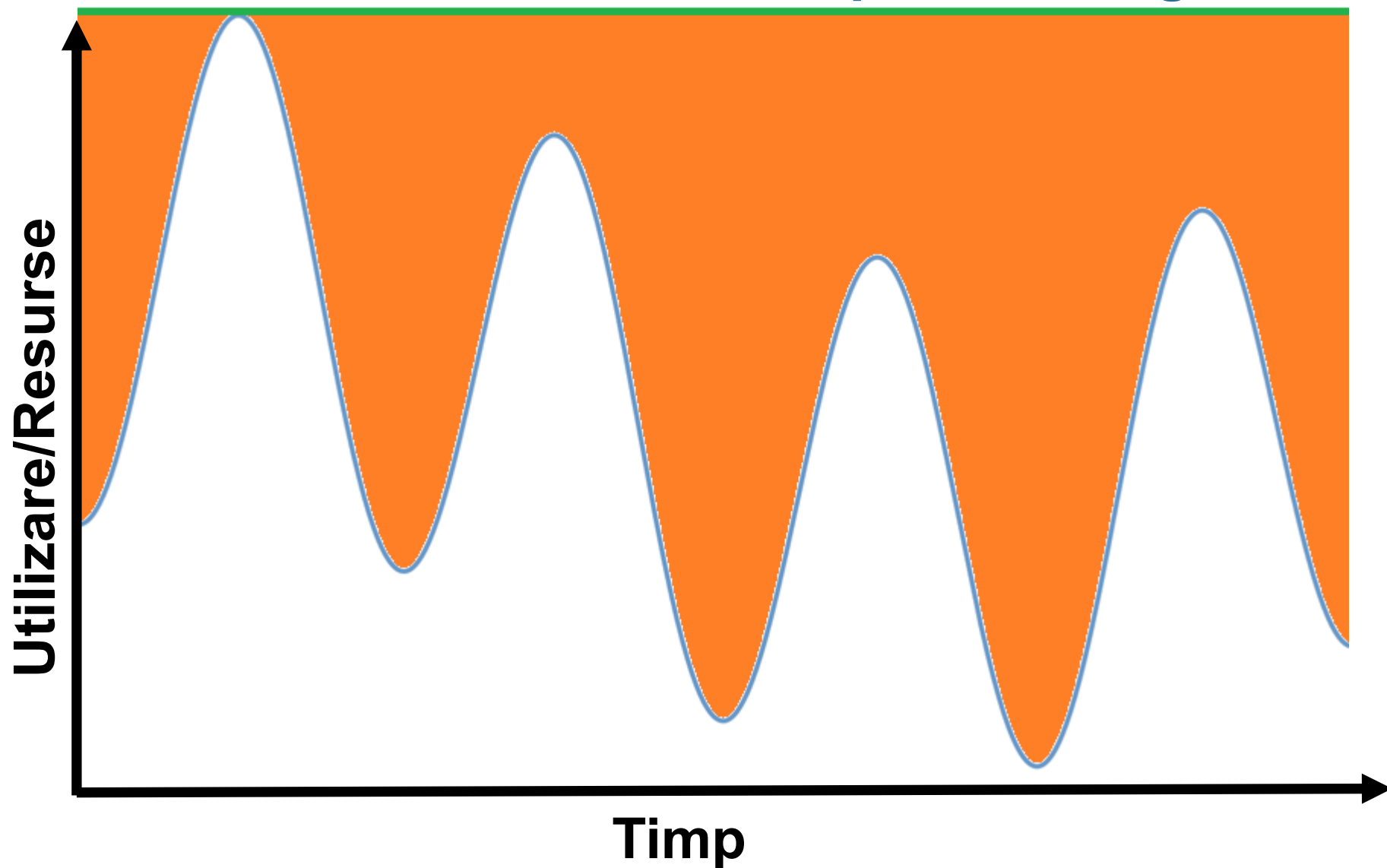


## Fără elasticitate – underprovisioning





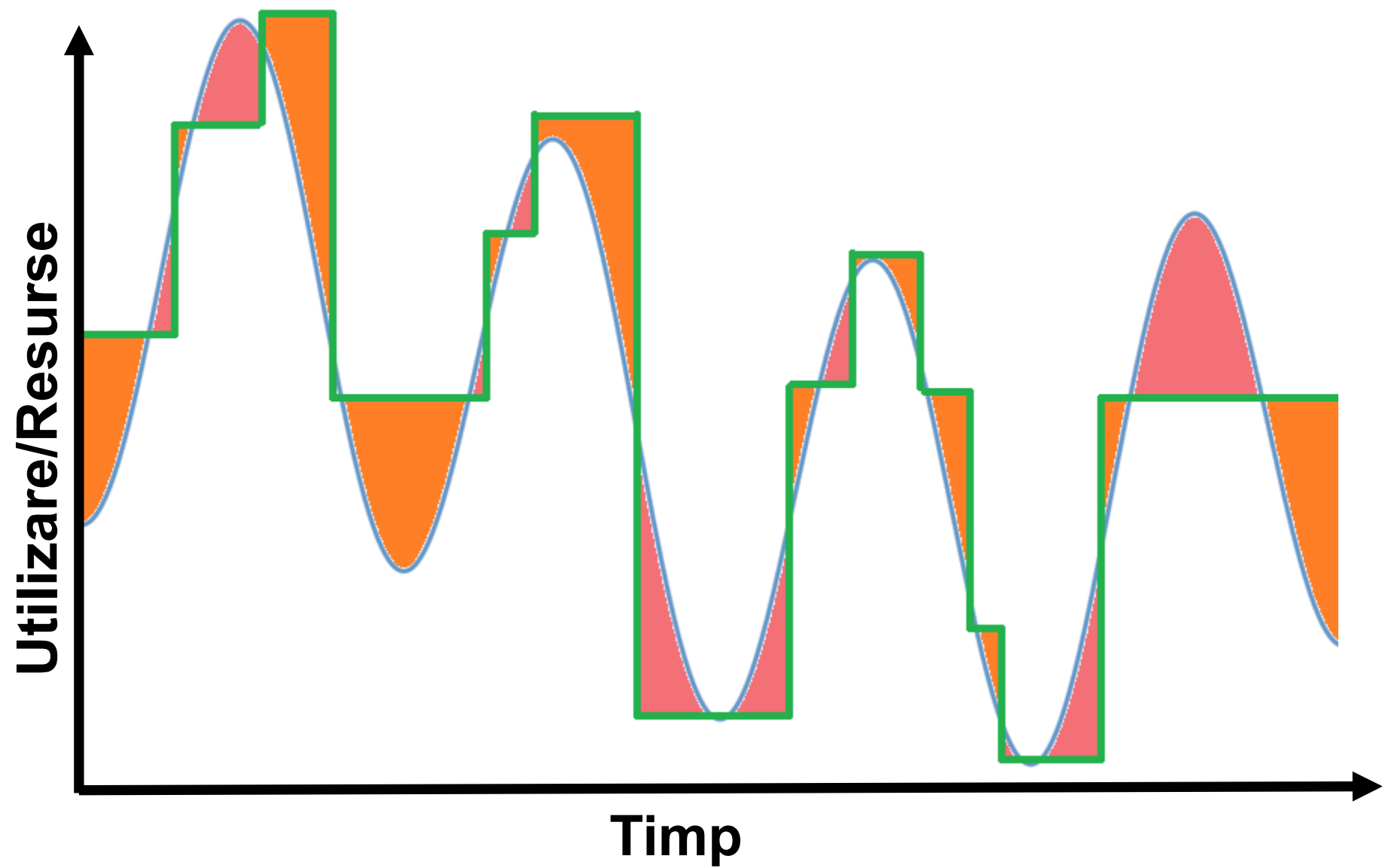
## Fără elasticitate – overprovisioning







# 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
<b>Software</b> as a Service	Dropbox, Slack
<b>Platform</b> as a Service	Baze de date
<b>Infrastructure</b> as a Service	Mașini virtuale
<b>Metal</b> 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



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Hipervizoare:





## 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
- 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





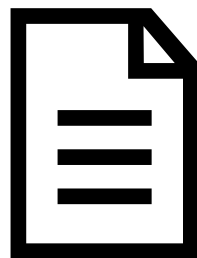
# Reminder multi-tasking

## 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
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jnae foo
retl
```



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



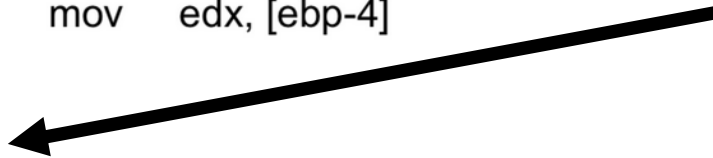
**Scheduler** – kernel OS





# 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



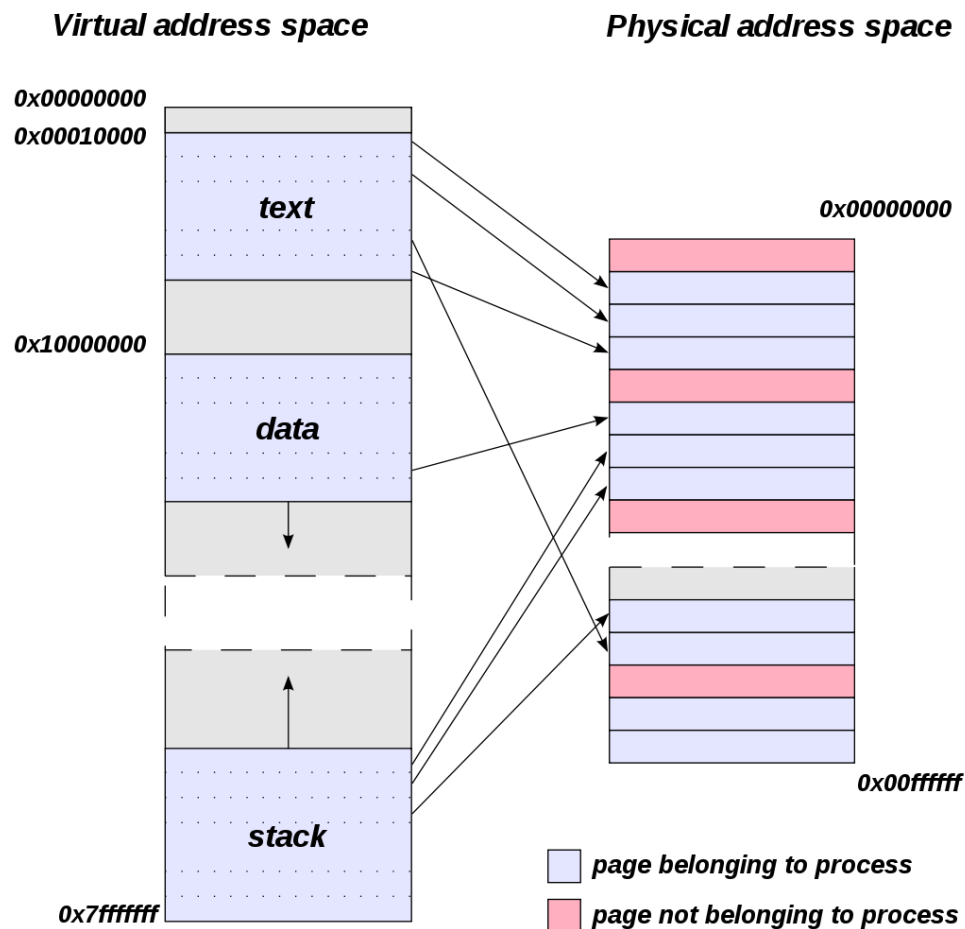
```
mov    eax, [ebp+0Ch]
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push   ecx
call   dword ptr ds:__imp__atoi
add    esp, 4
mov    [ebp-4], eax
mov    edx, [ebp-4]
```





# 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

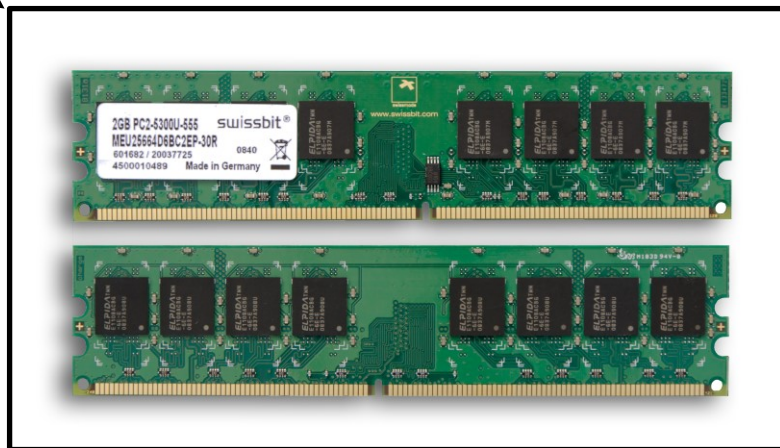


Trebuie reținută starea (un set de variabile)  
Trebuie reținuți regiștrii (un vector)  
Majoritatea instrucțiunilor modifică starea  
sau regiștrii  
Restul instrucțiunilor sunt citiri/scrieri RAM sau  
periferice



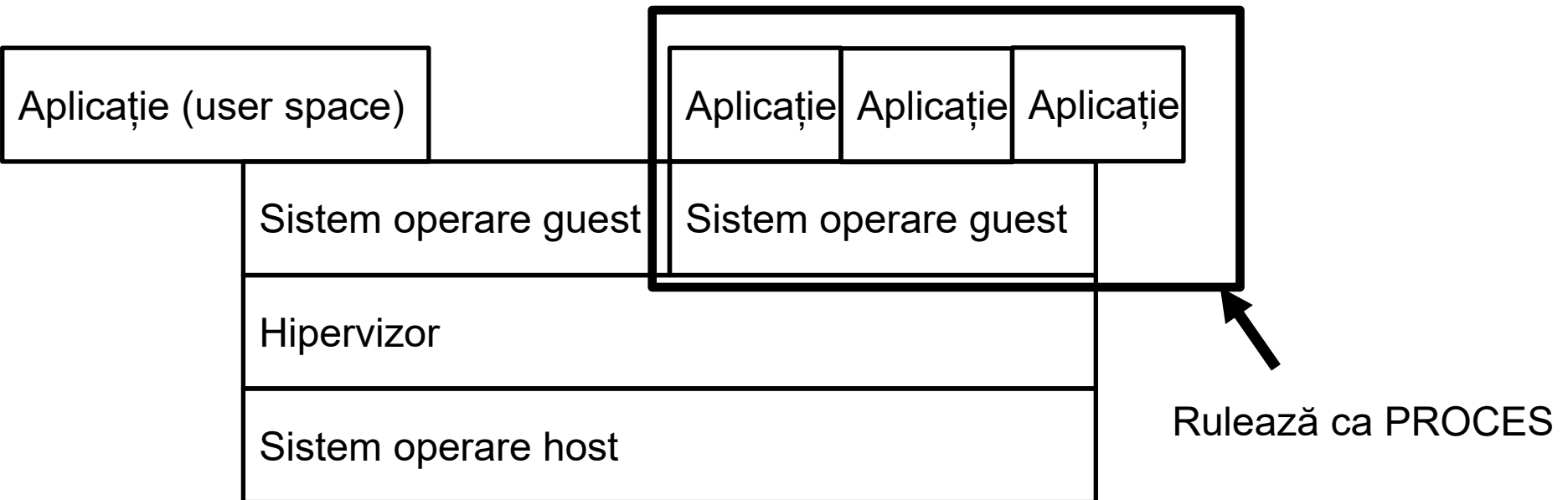
Codul de rulat

Un malloc mare





# Virtualizare CPU





# Virtualizare CPU

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## Formal Requirements for Virtualizable Third Generation Architectures

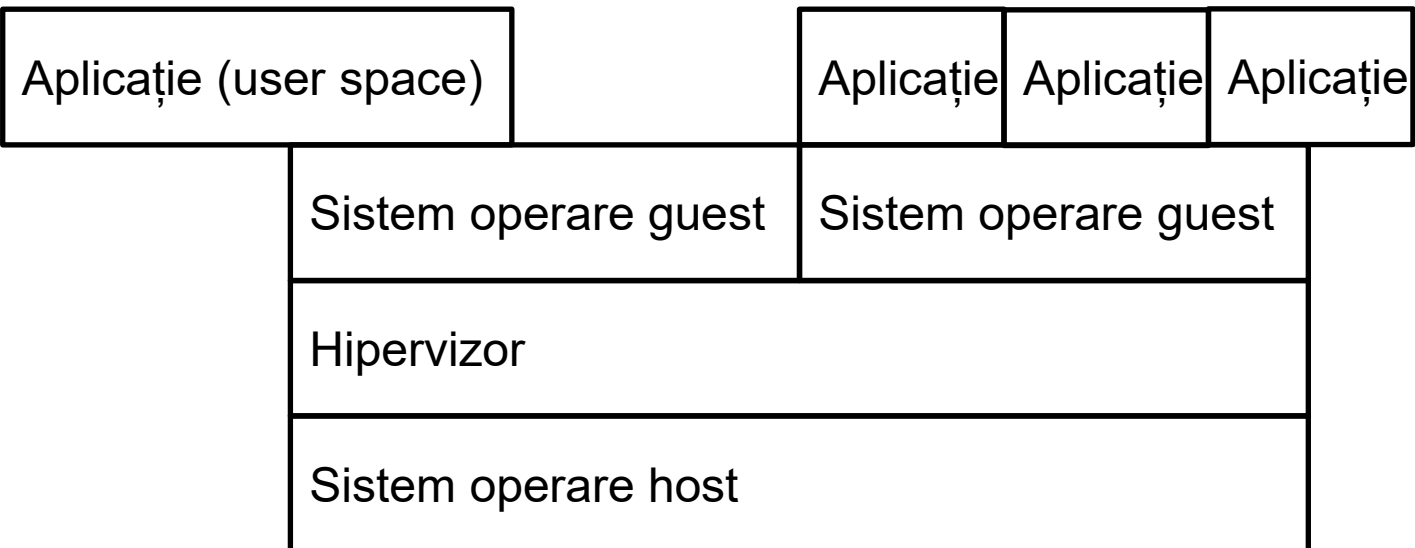
Gerald J. Popek  
University of California, Los Angeles  
and  
Robert P. Goldberg  
Honeywell Information Systems and  
Harvard University

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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.

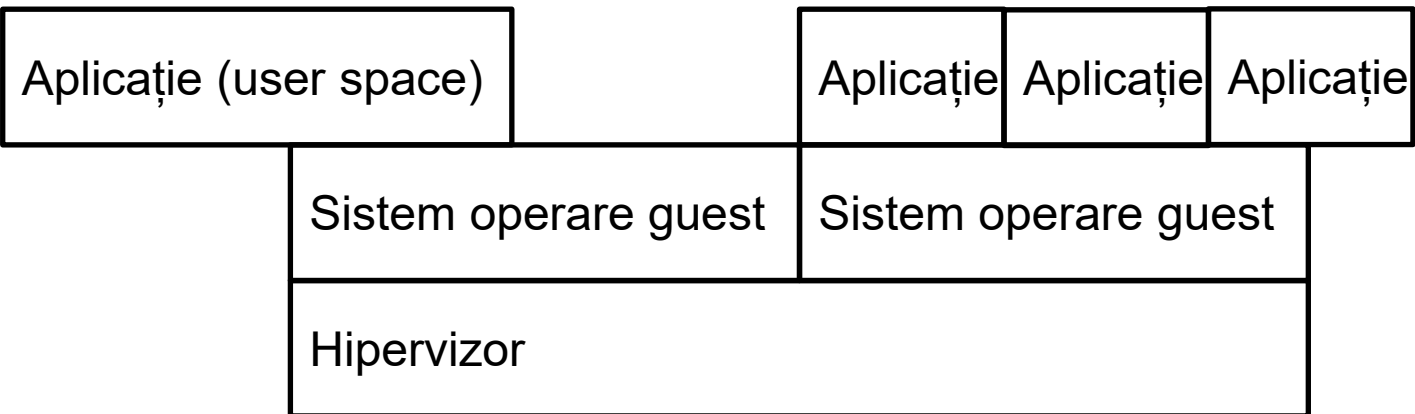


# Virtualizare CPU – Type 1





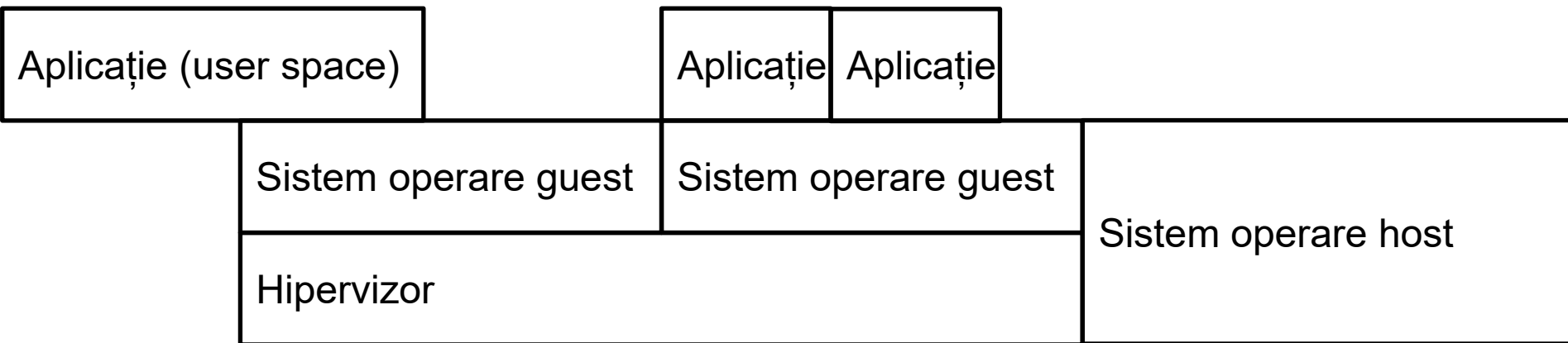
## Virtualizare CPU – Type 2







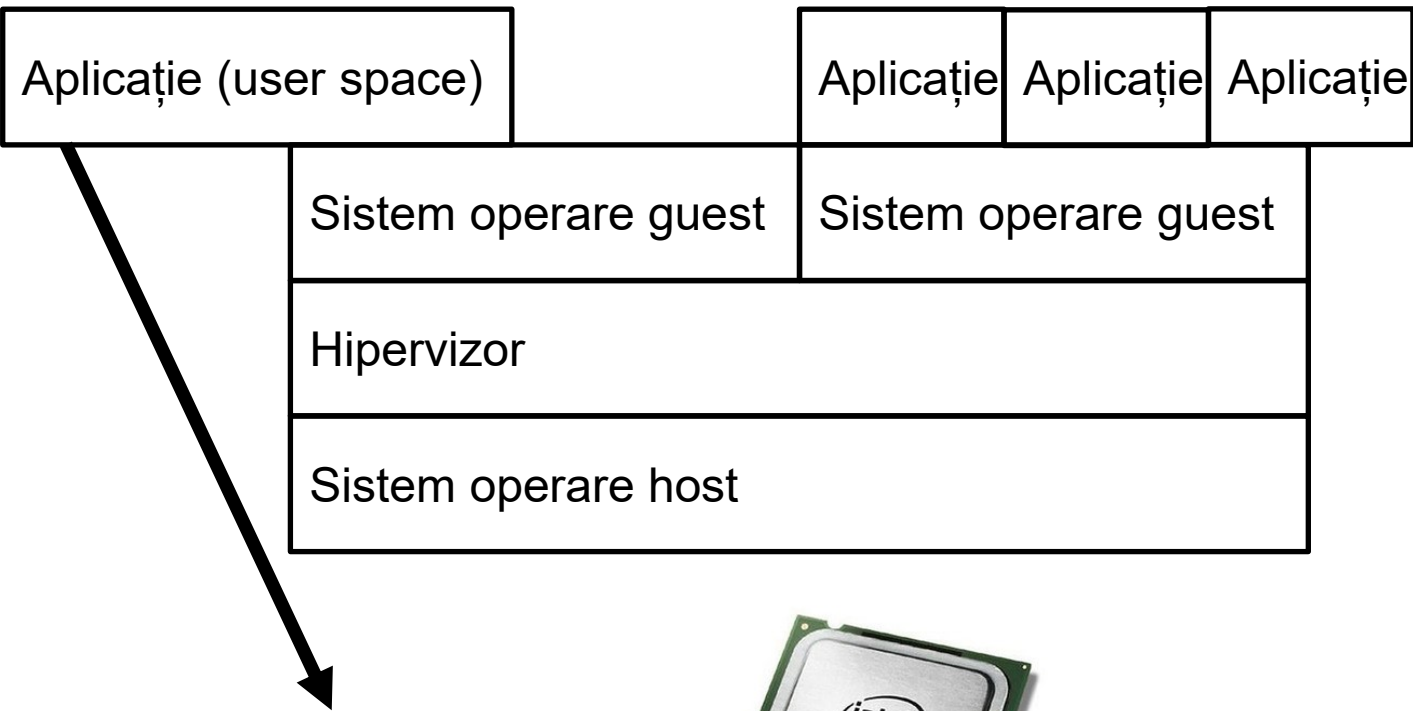
# Virtualizare CPU – Paravirtualizare





# Virtualizare CPU

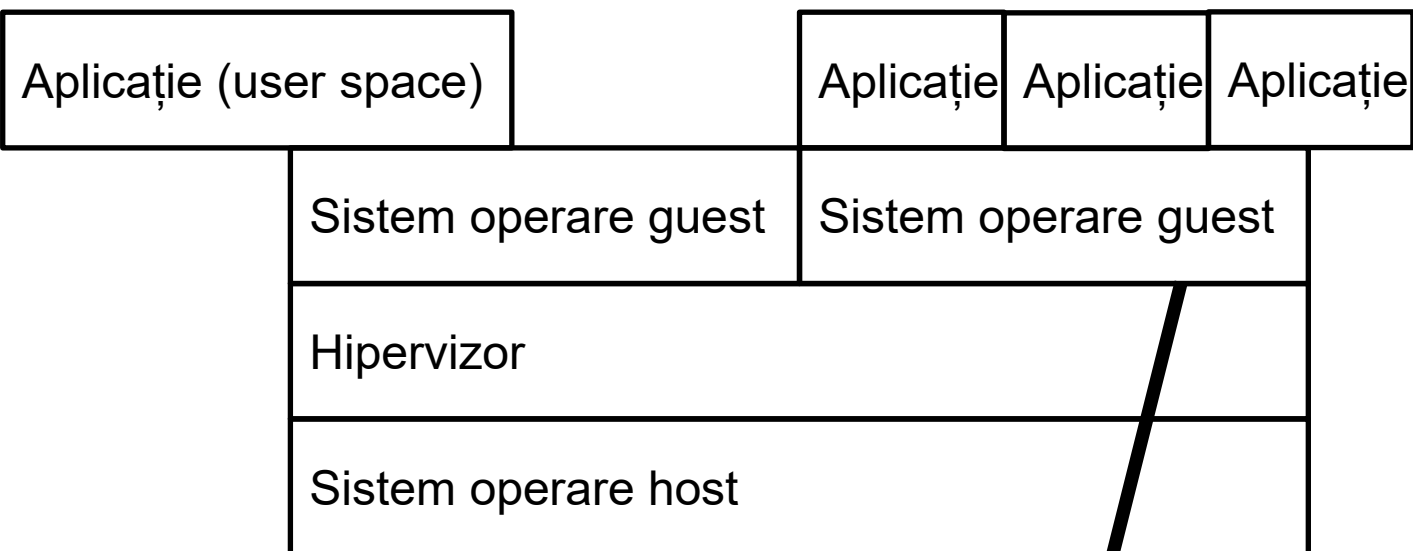
## Instrucțiuni simple (ex. add, mov din memoria sa)





# Virtualizare CPU – trap and execute

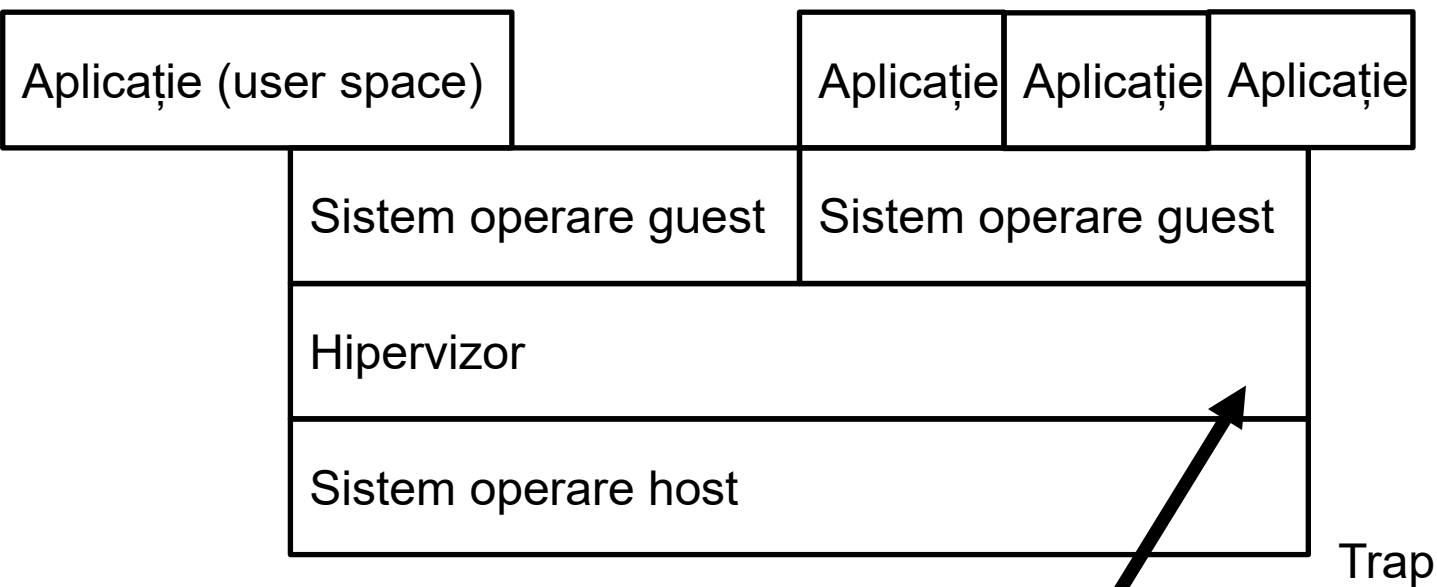
## Instrucțiuni kernel (ex. umblat cu I/O, sist întreruperi)





# Virtualizare CPU – trap and execute

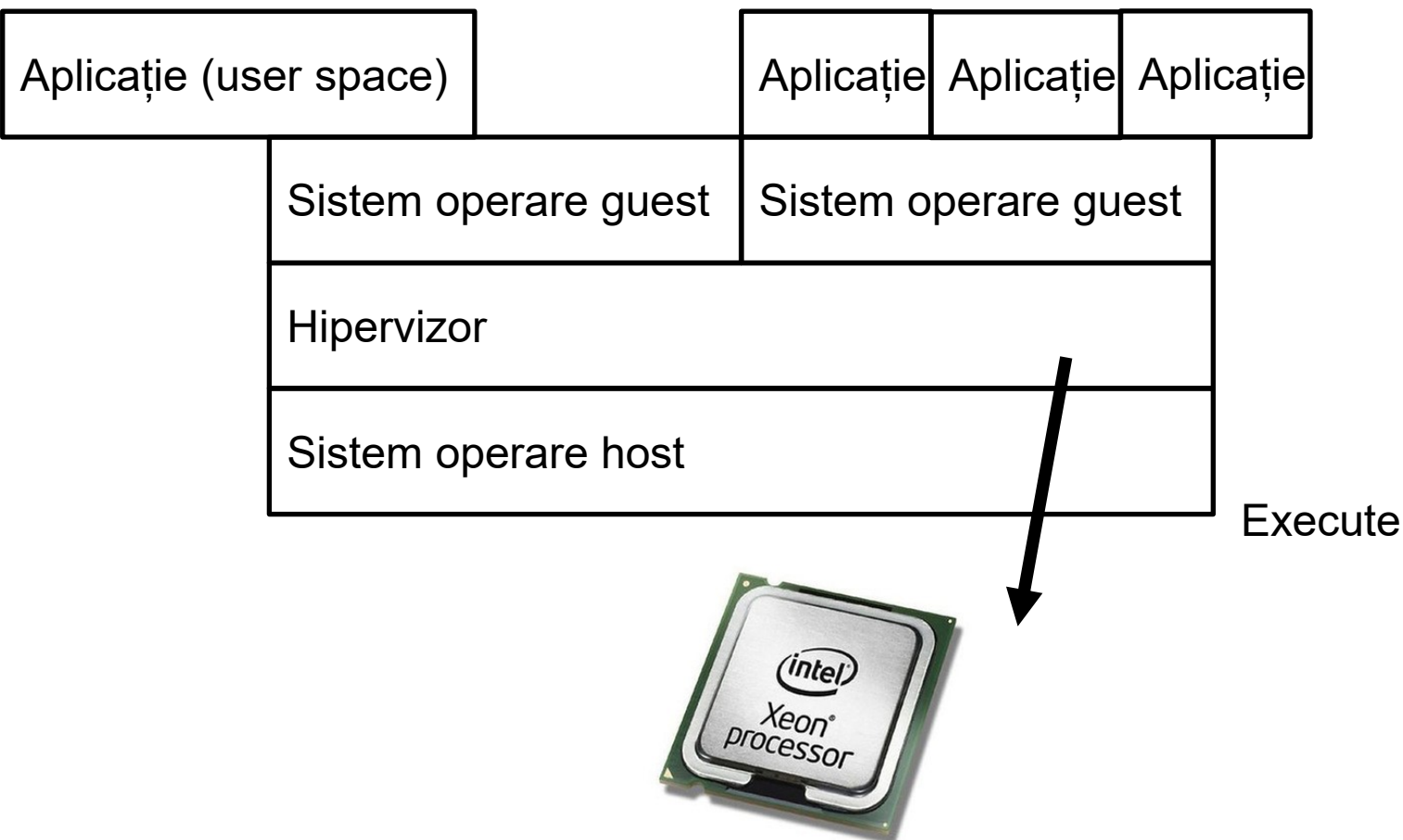
## Instrucțiuni kernel (ex. umblat cu I/O, sist întreruperi)





# Virtualizare CPU – trap and execute

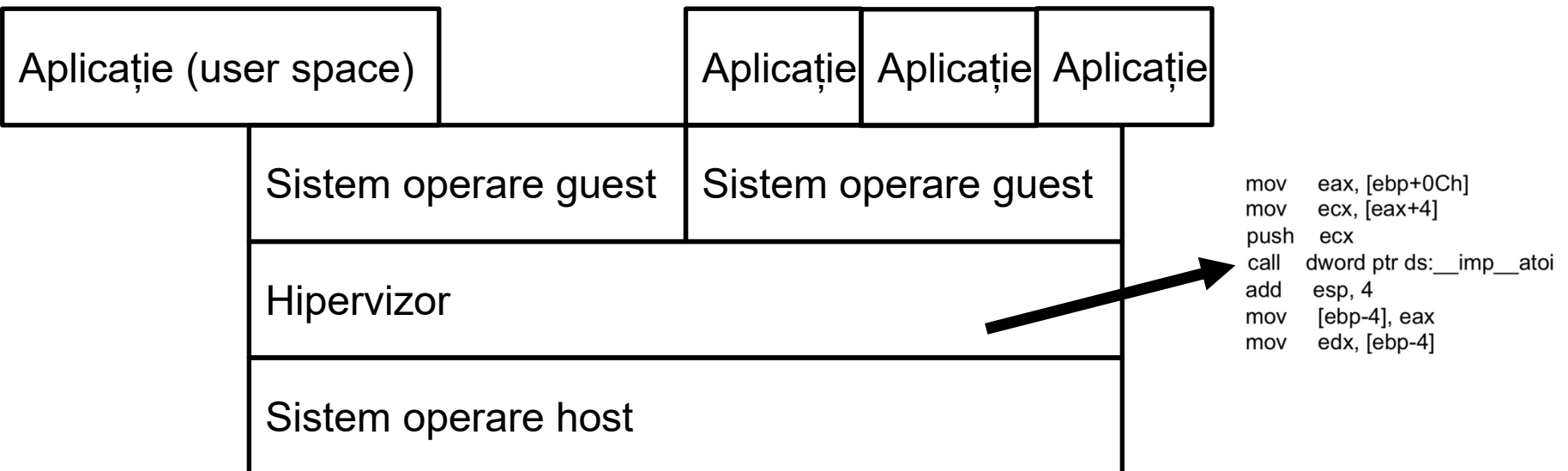
## Instrucțiuni kernel (ex. umblat cu I/O, sist întreruperi)





# Virtualizare CPU – rescriere instrucțiuni (emulare)

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



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





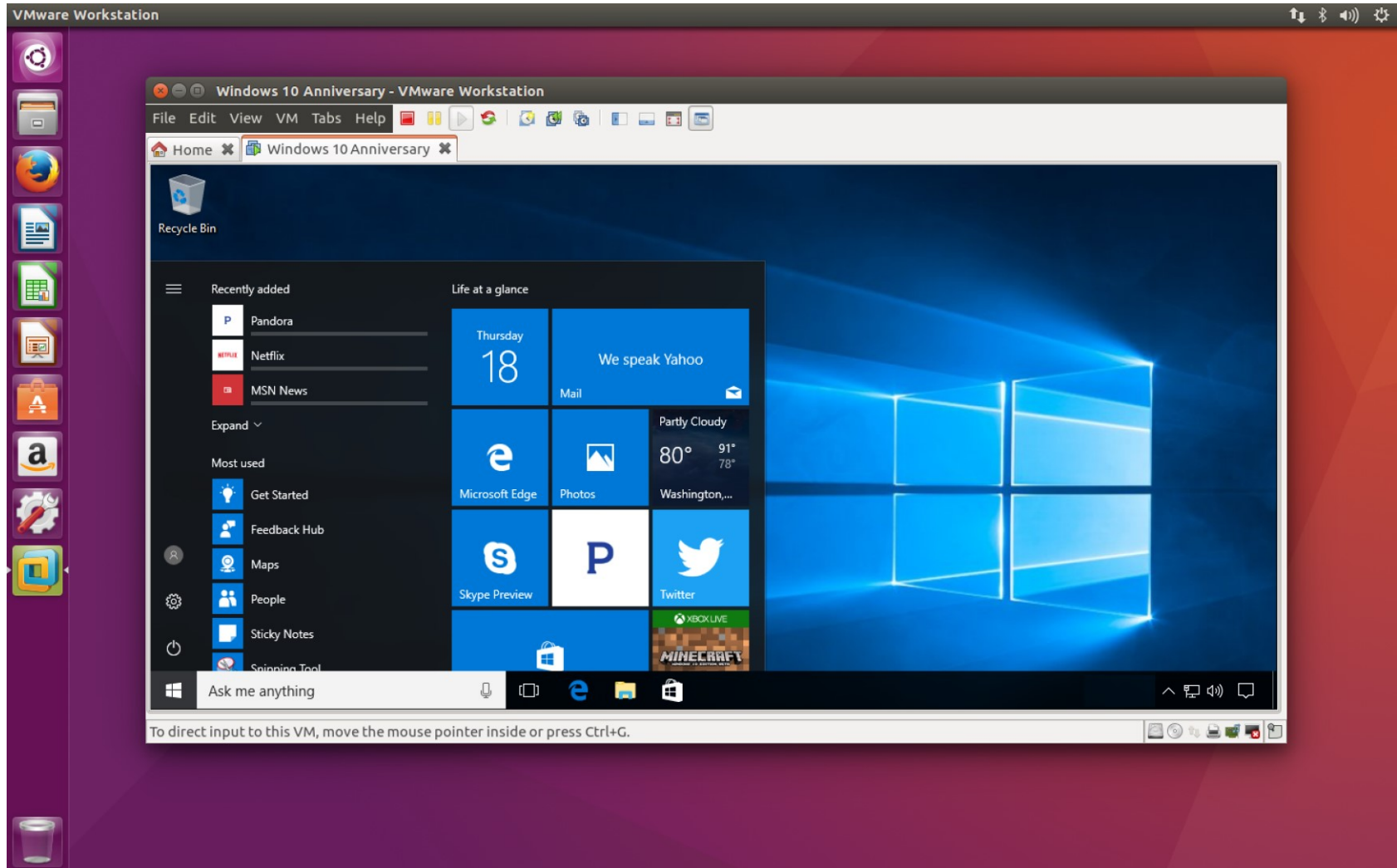
# Virtualizare Emulare HDD







# Virtualizare Emulare Display





# 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 modifichi 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

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

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## Featured products

<b>BigQuery</b> Data warehouse for business agility and insights.	<b>Cloud CDN</b> Content delivery network for delivering web and video.	<b>Cloud Functions</b> Event-driven compute platform for cloud services and apps.
<b>Cloud Run</b> Fully managed environment for running containerized apps.	<b>Cloud SDK</b> Command-line tools and libraries for Google Cloud.	<b>Cloud SQL</b> Relational database services for MySQL, PostgreSQL, and SQL Server.
<b>Cloud Storage</b> Object storage that's secure, durable, and scalable.	<b>Compute Engine</b> Virtual machines running in Google's data center.	<b>Dataflow</b> Streaming analytics for stream and batch processing.
<b>Google Kubernetes Engine</b> Managed environment for running containerized apps.	<b>Anthos</b> Platform for modernizing existing apps and building new ones.	<b>Operations</b> Monitoring, logging, and application performance suite.

## AI and Machine Learning



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



Analytics



Application Integration



AWS Cost Management



Blockchain



Business Applications



Compute



Containers



Customer Engagement



Database



Developer Tools

Amazon Connect

Cloud-based Contact Center

Amazon Pinpoint

Personalized User Engagement Across Channels

Amazon Simple Email Service (SES)

Email Sending and Receiving



End User Computing



Front-End Web & Mobile



Game Tech



Internet of Things



Machine Learning



Management & Governance



Media Services



Migration & Transfer



Networking & Content  
Delivery



Quantum Technologies



Robotics



Satellite



Security, Identity &  
Compliance



Serverless



Storage



VR & AR

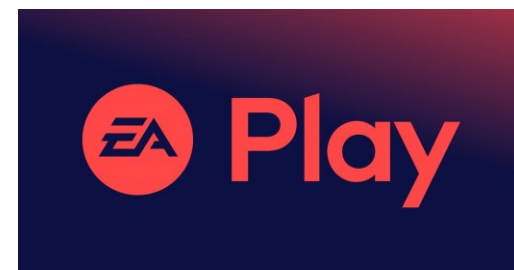


# Software as a Service

- Majoritatea companiilor merg în această direcție



# NETFLIX





# Azure for students

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

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# 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\$.