Sisteme Tolerante la Defecte
Introducere Cloud Computing

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

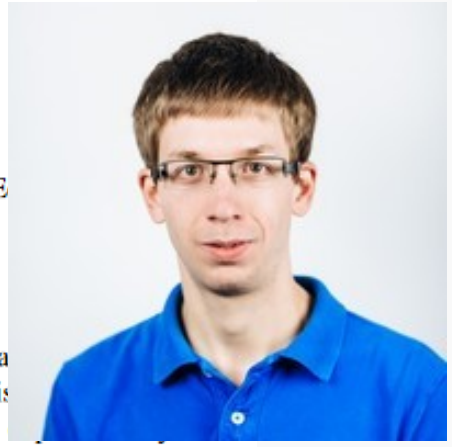
Articol științific principal despre Cloud

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. T… 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

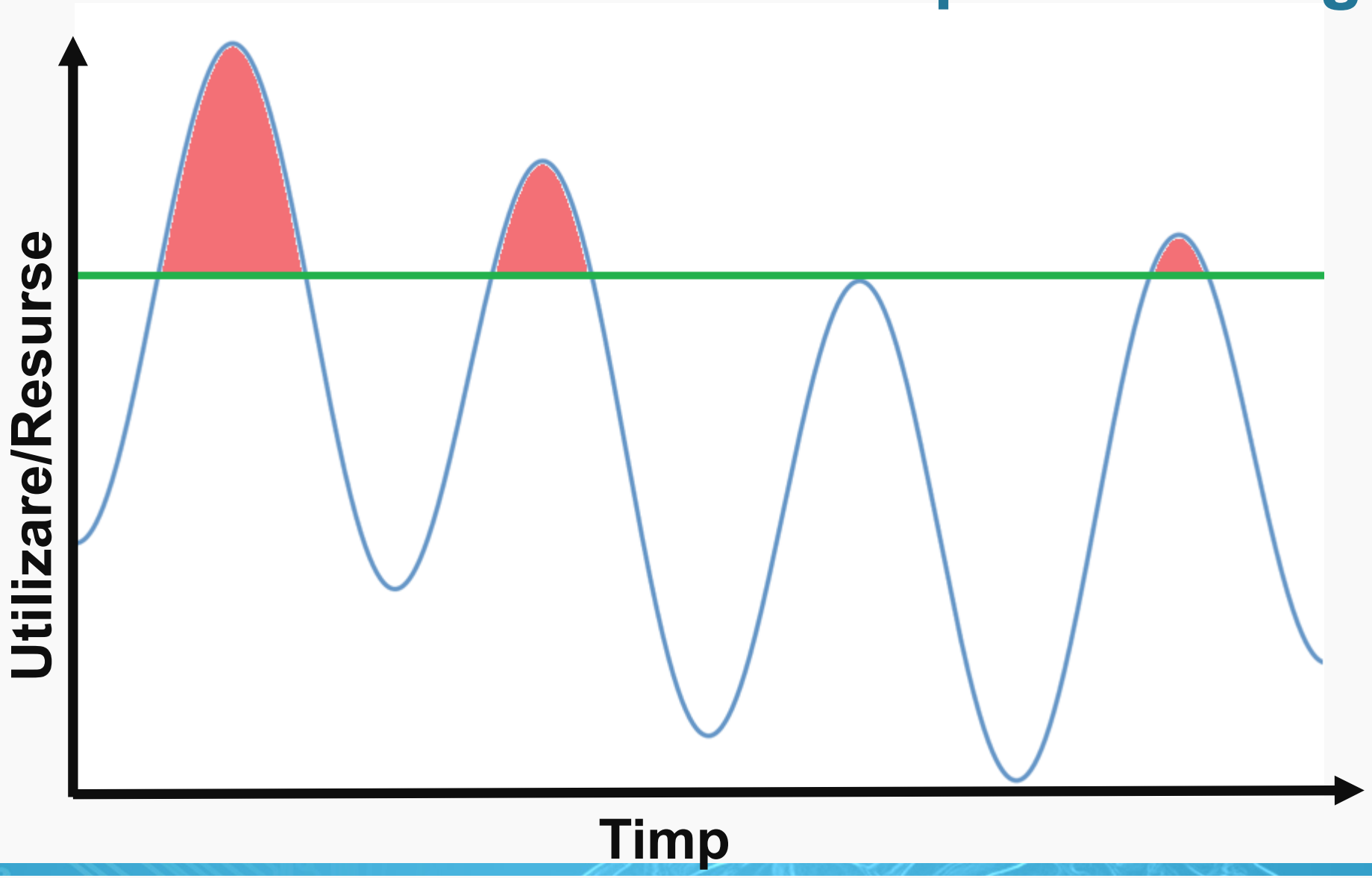
Abstract

Originating fro
term elasticity
of cloud compu

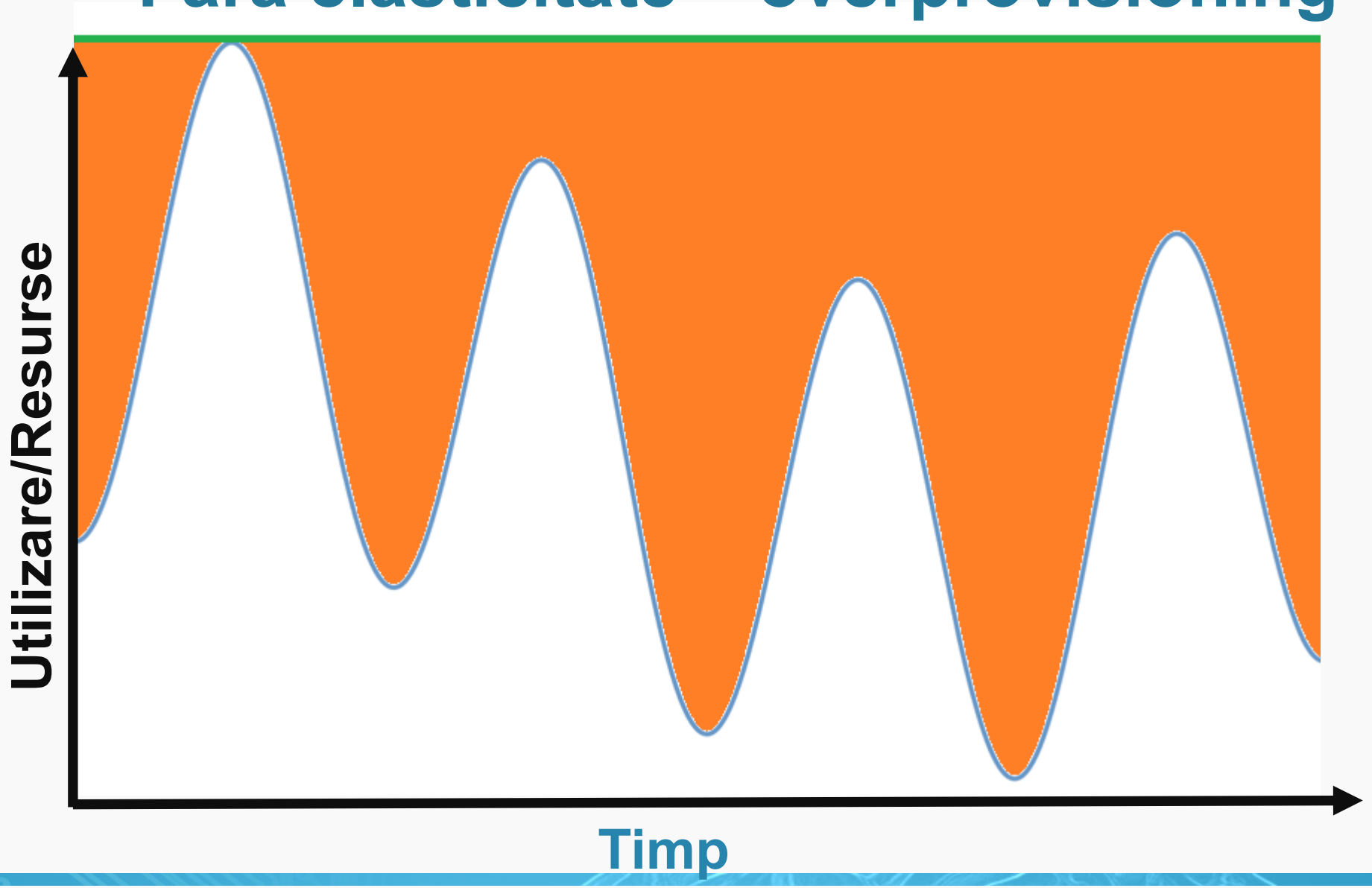
even in the naming of specific products or services. Even

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.

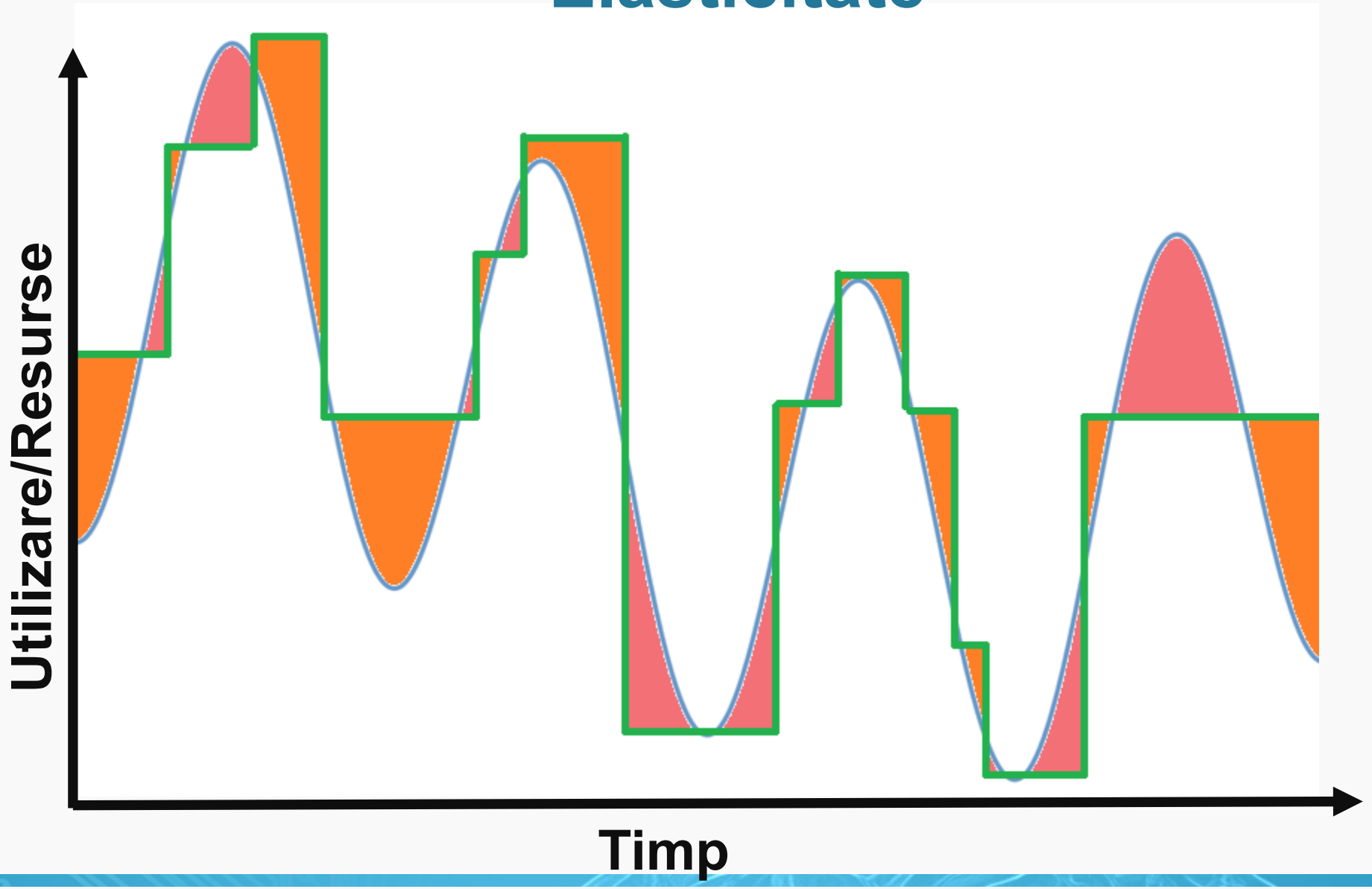
Fără elasticitate – underprovisioning



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 as a Service	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

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
	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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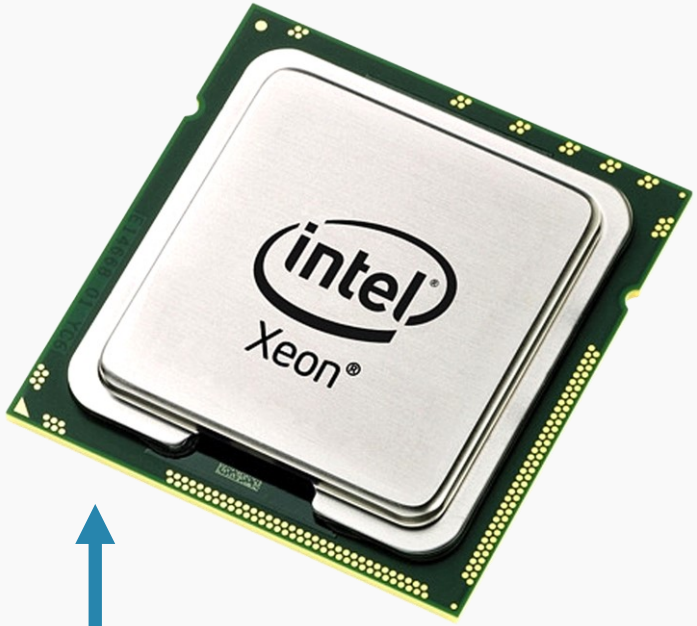

Timer Interrupt

Reminder multi-tasking

Program counter

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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

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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

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```
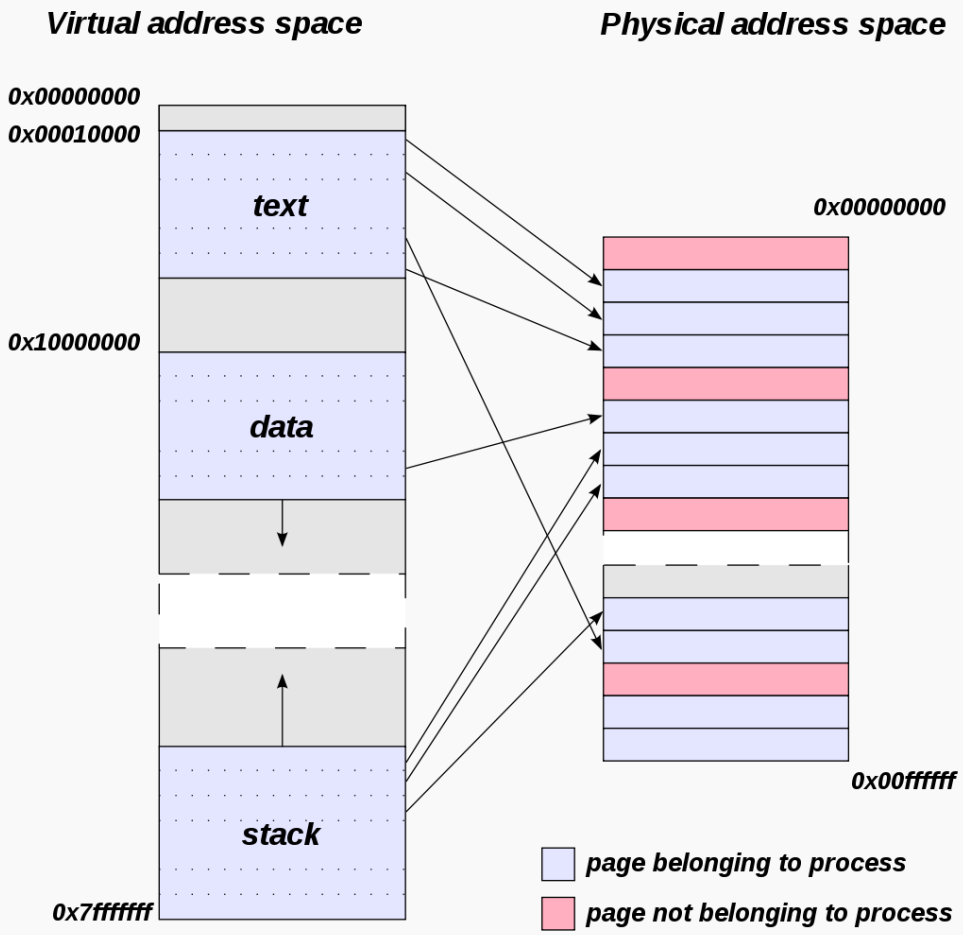

Reminder multi-tasking

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



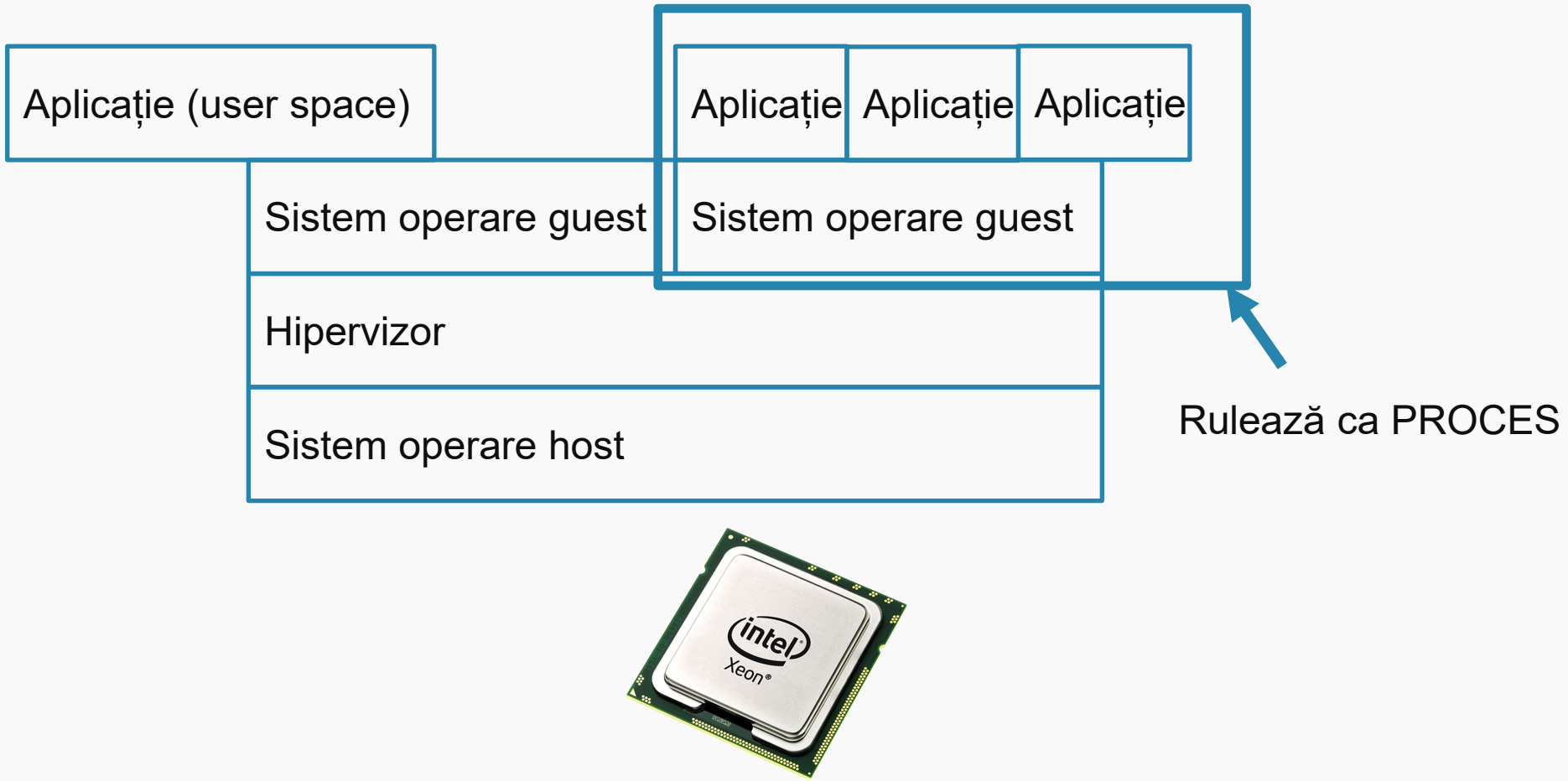
Emulare CPU-RAM

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



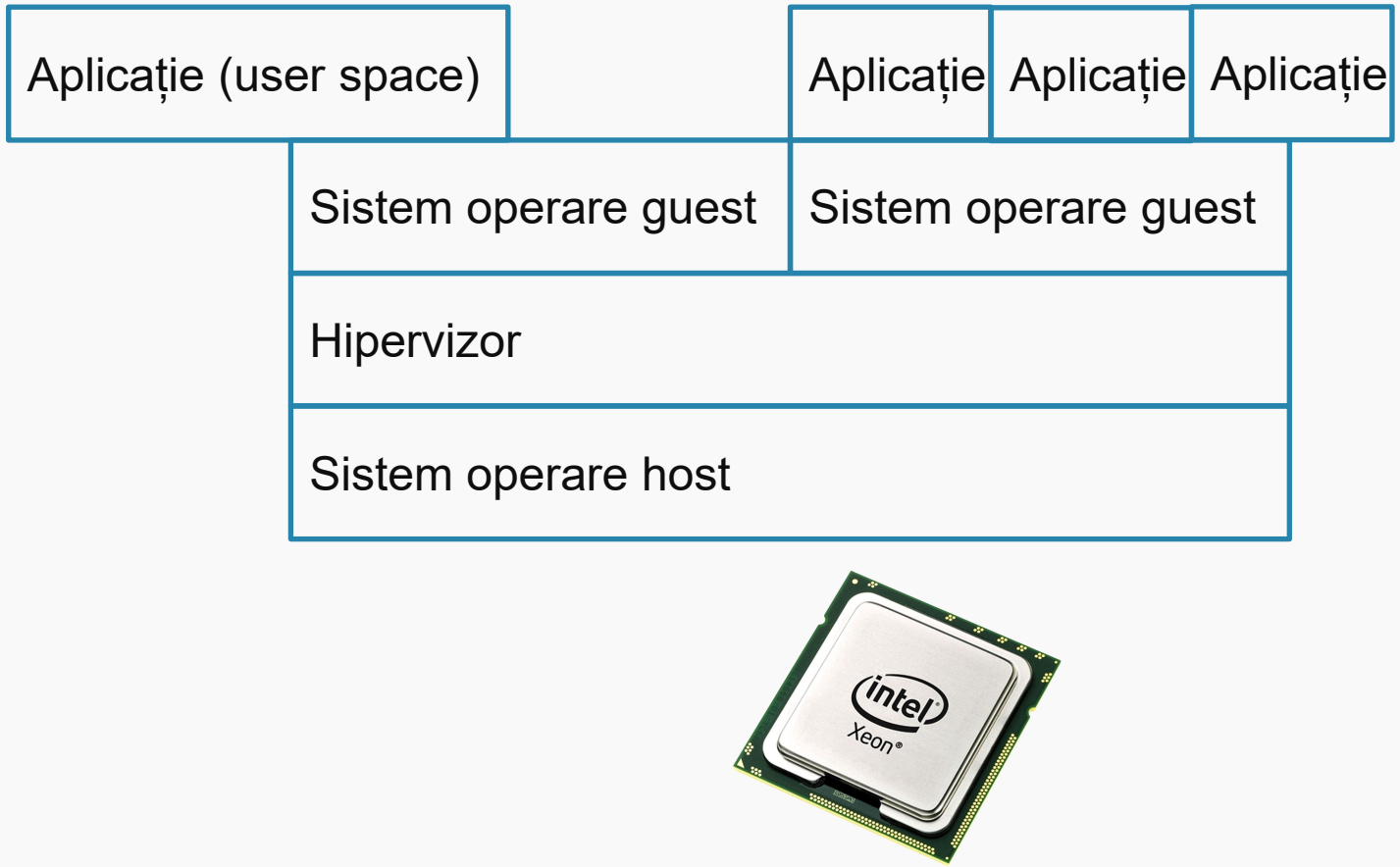
Virtualizare CPU

Formal Requirements for Virtualizable Third Generation Architectures

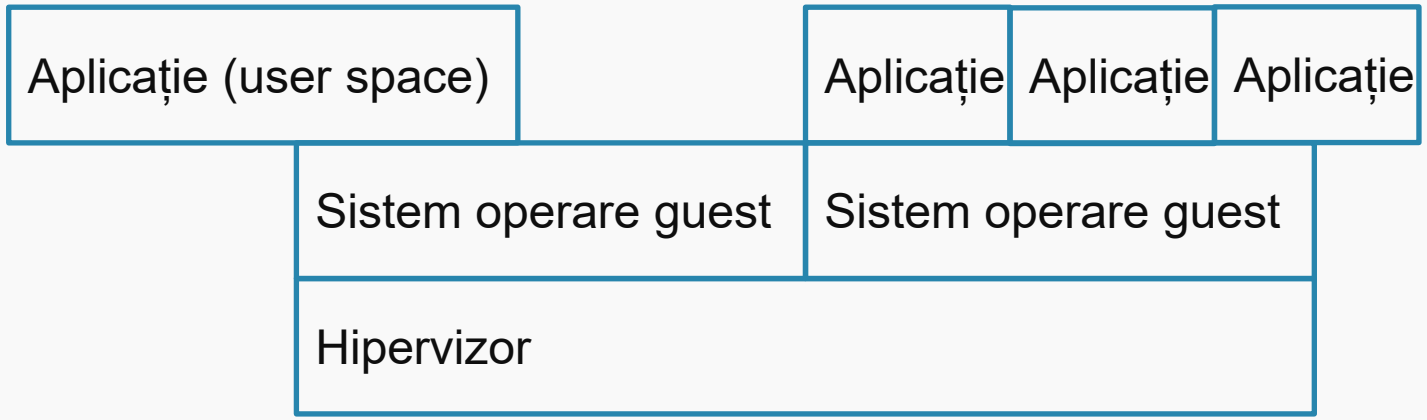
Gerald J. Popek
University of California, Los Angeles
and
Robert P. Goldberg
Honeywell Information Systems and
Harvard University

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.

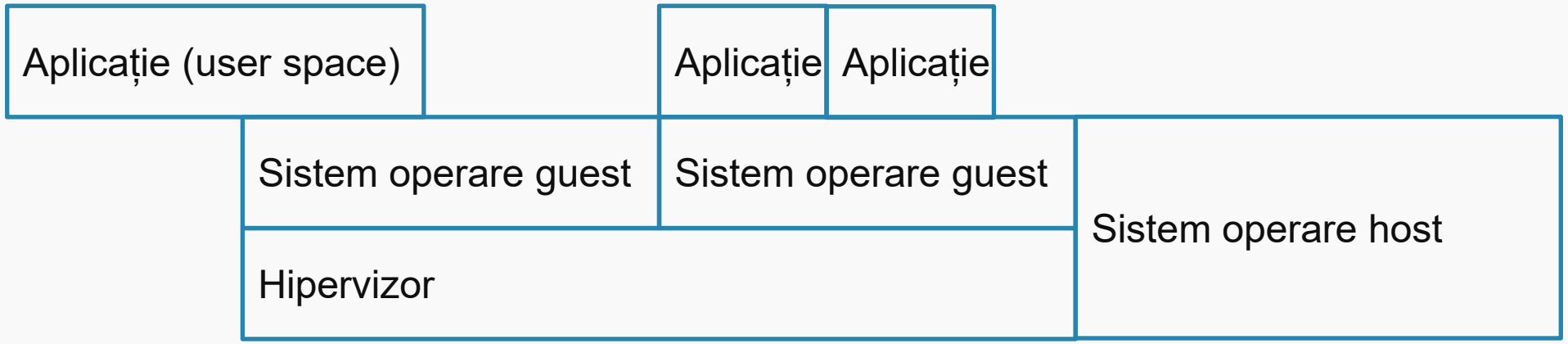
Virtualizare CPU – Type 1



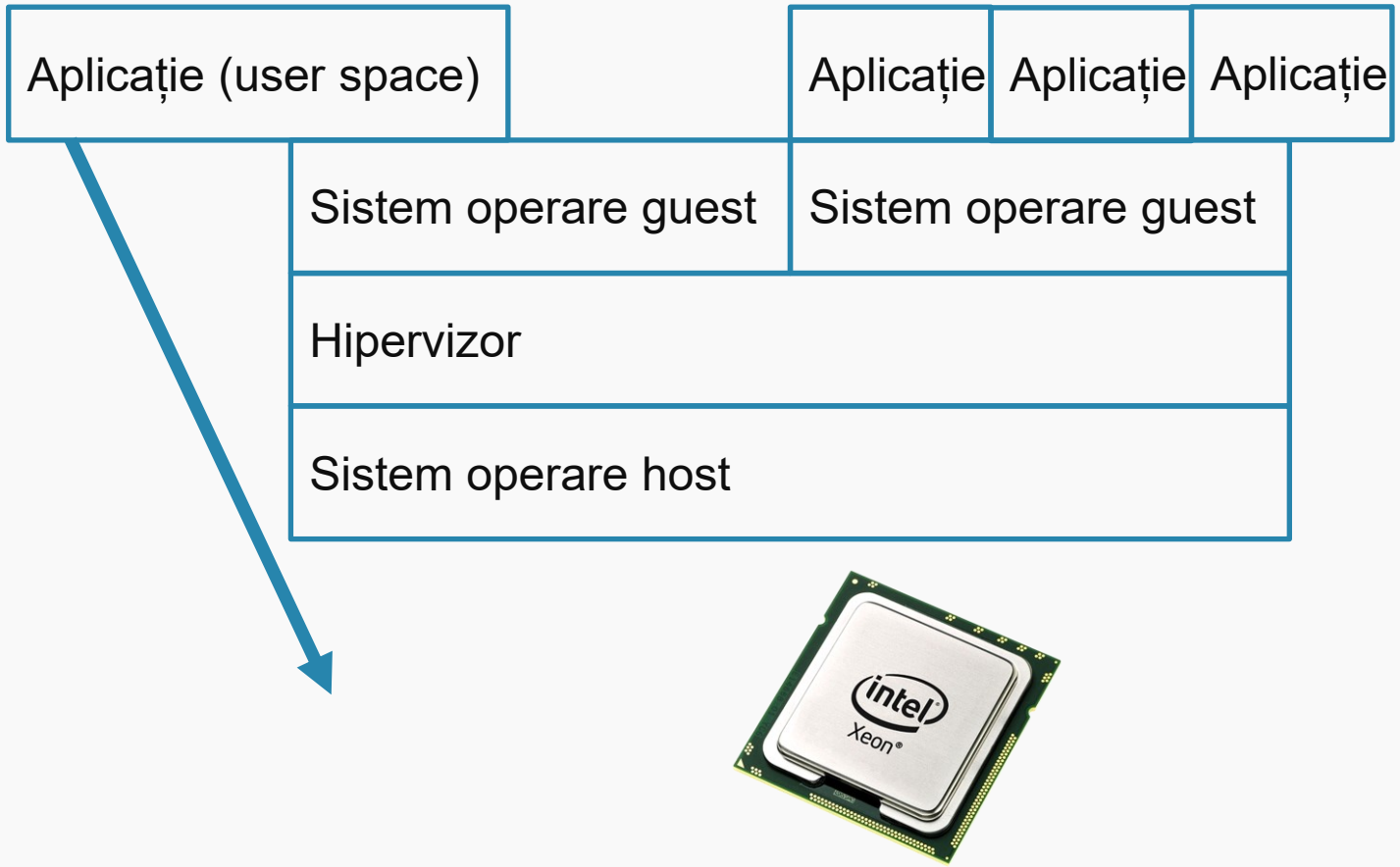
Virtualizare CPU – Type 2



Virtualizare CPU – Paravirtualizare

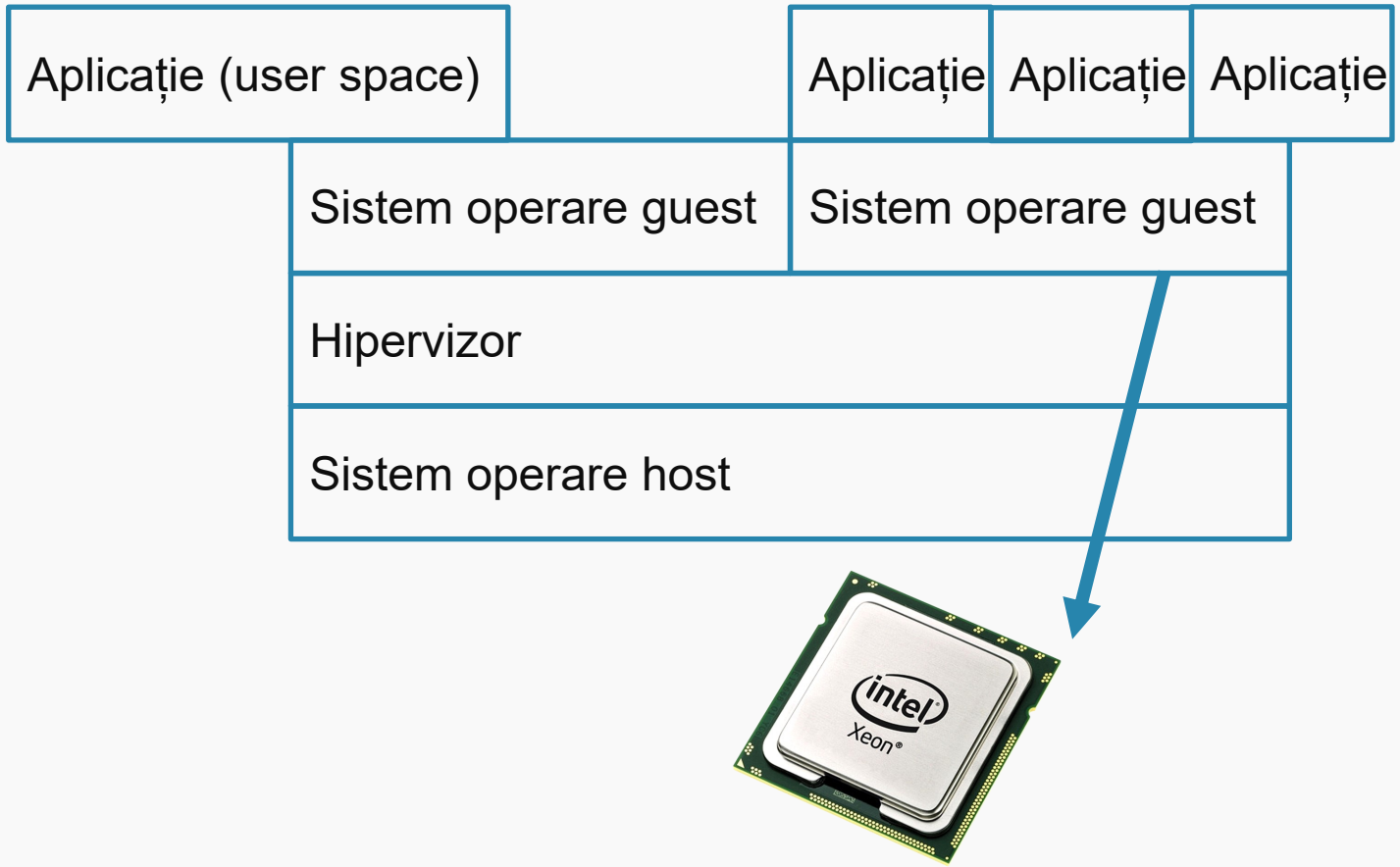


Virtualizare CPU
Instrucțiuni simple (ex. add, mov din memoria sa)



Virtualizare CPU – trap and execute

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



Virtualizare CPU – trap and execute

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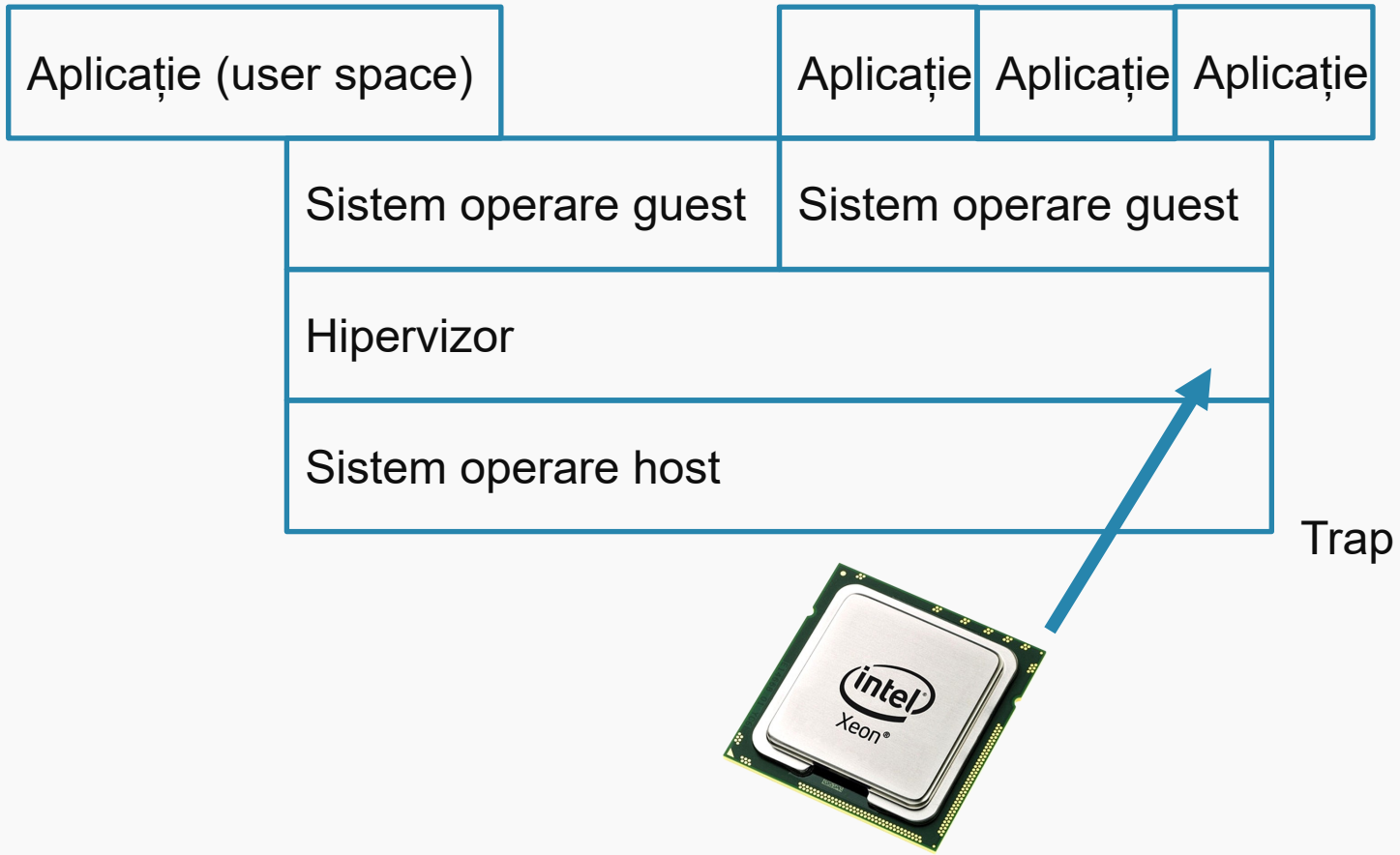

Virtualizare CPU – trap and execute

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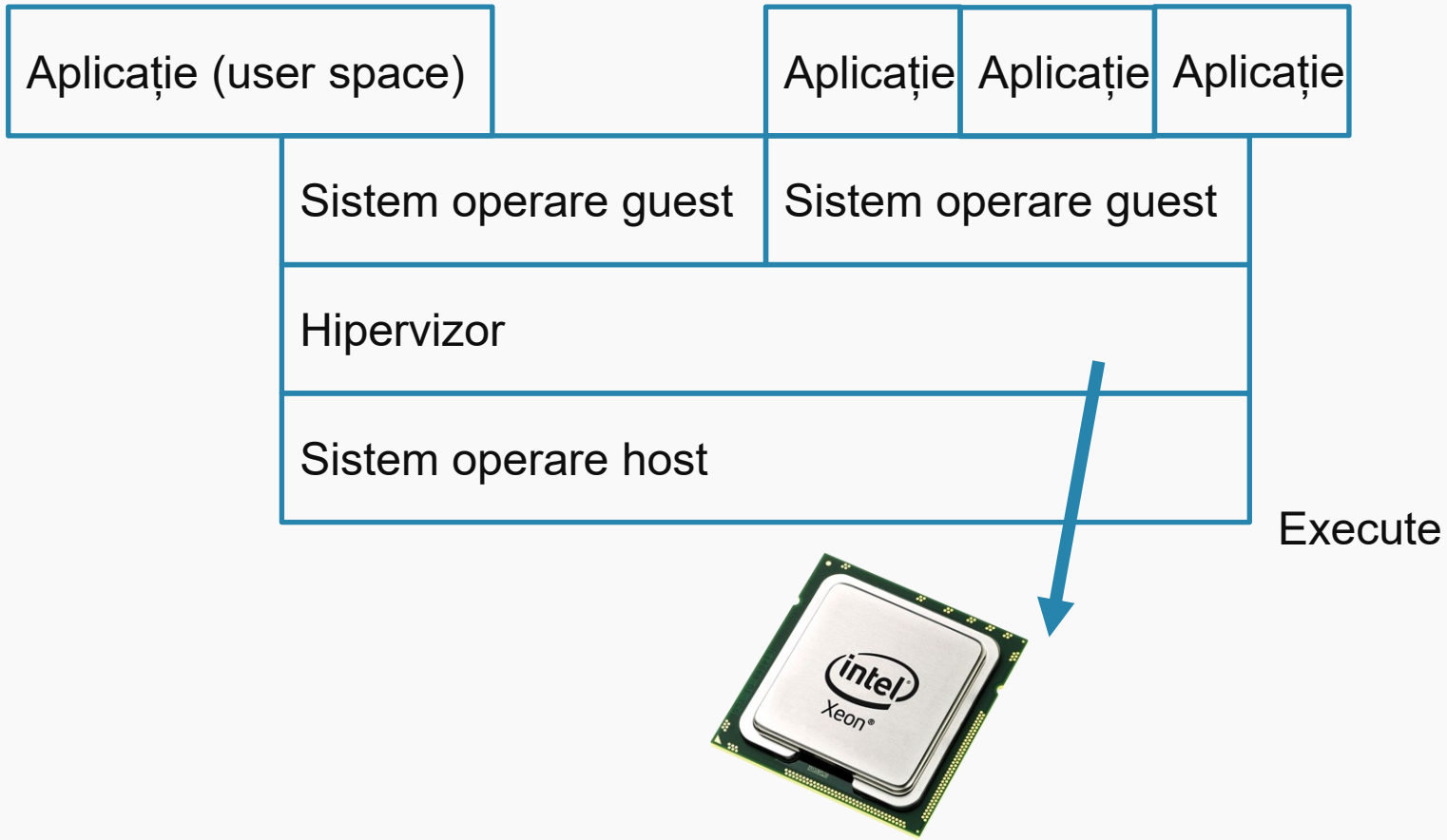
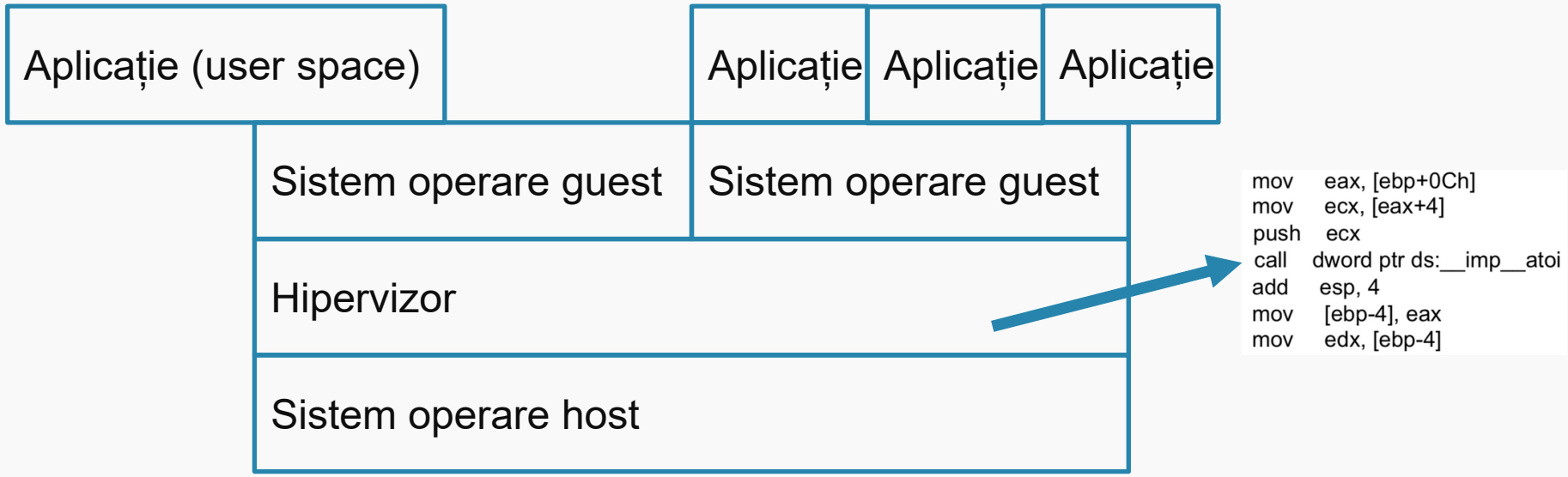


Virtualizare CPU – rescriere instrucțiuni (emulare)
Instrucțiuni kernel (ex. umblat cu I/O, sist întreruperi)



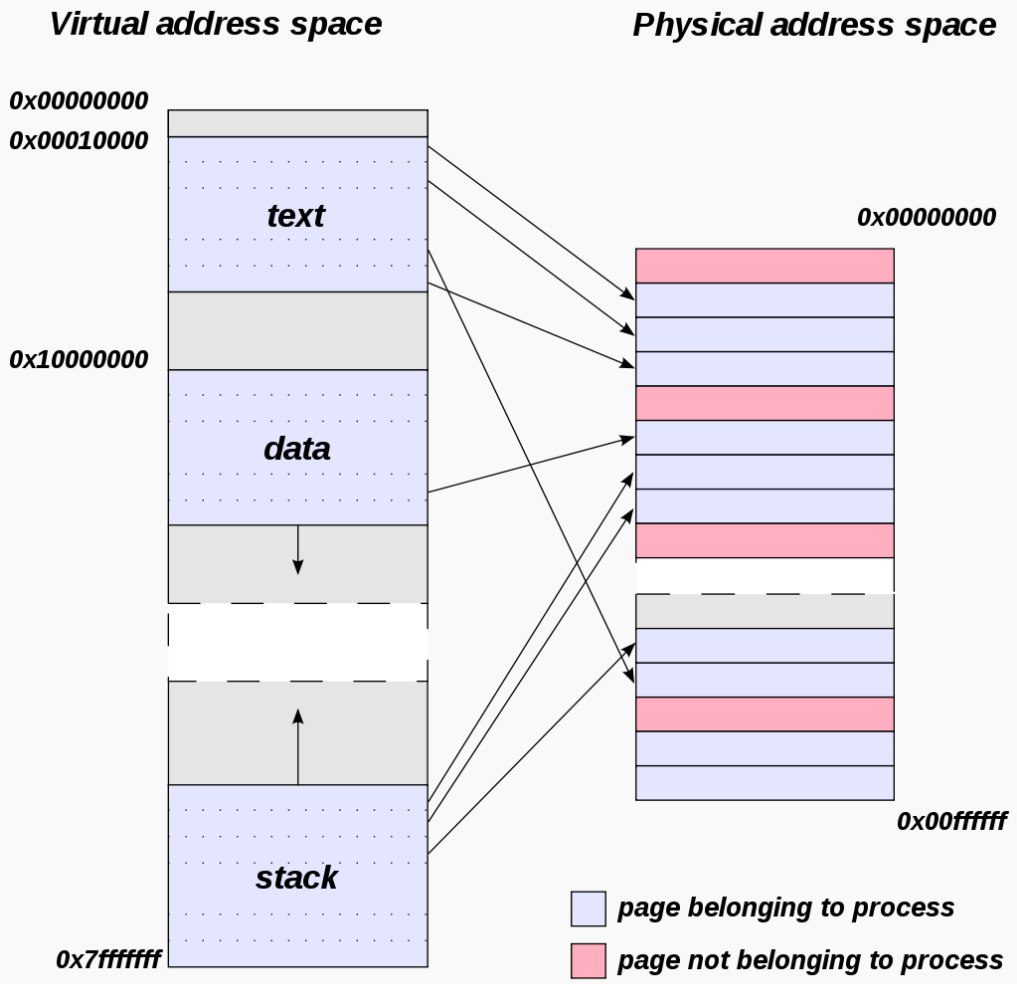

```
mov     eax, [ebp+0Ch]
mov     ecx, [eax+4]
push    ecx
call    dword ptr ds:__imp__atoi
add     esp, 4
mov     [ebp-4], eax
mov     edx, [ebp-4]
```

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

Virtualizare RAM

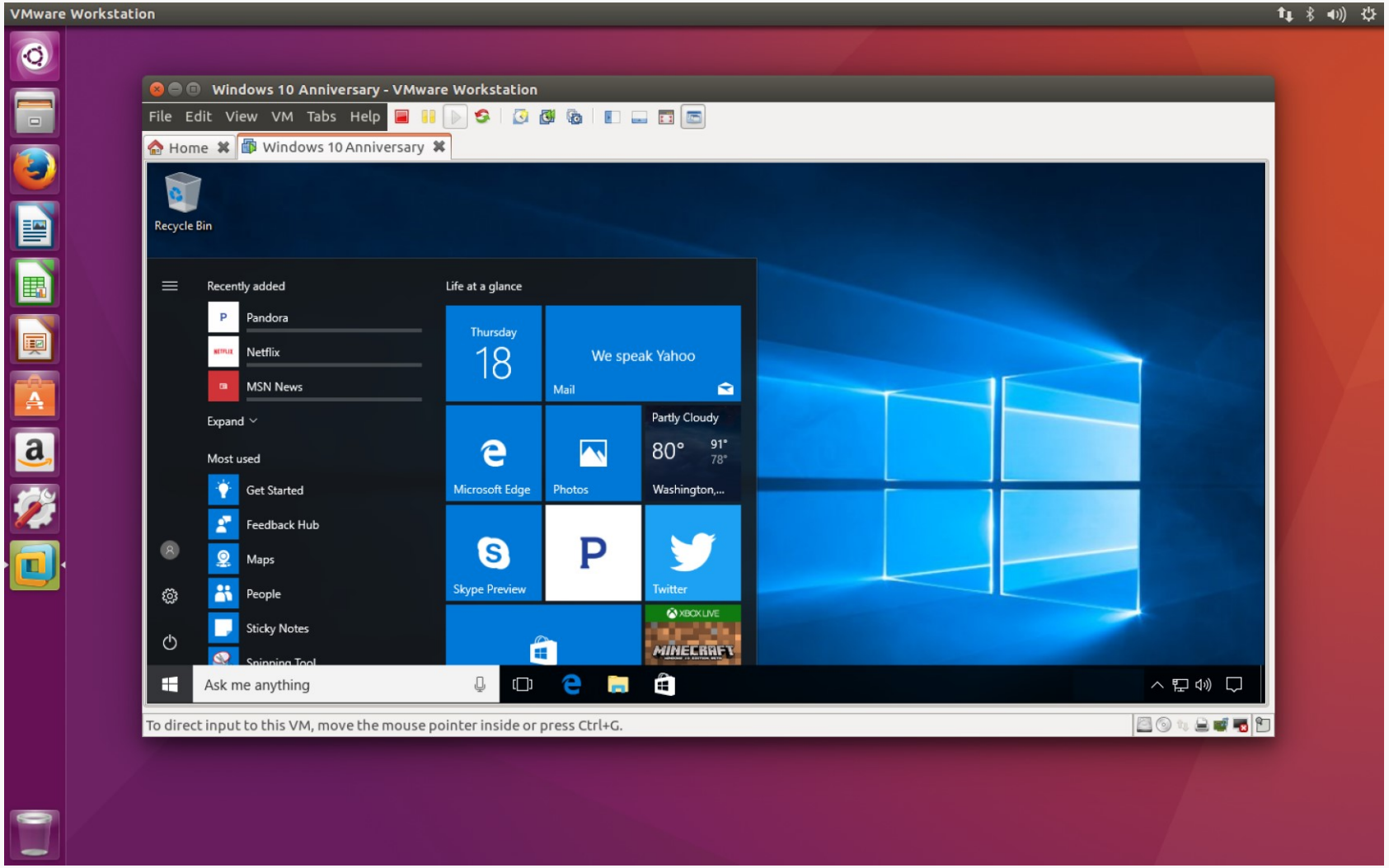
Shadow page tables

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)

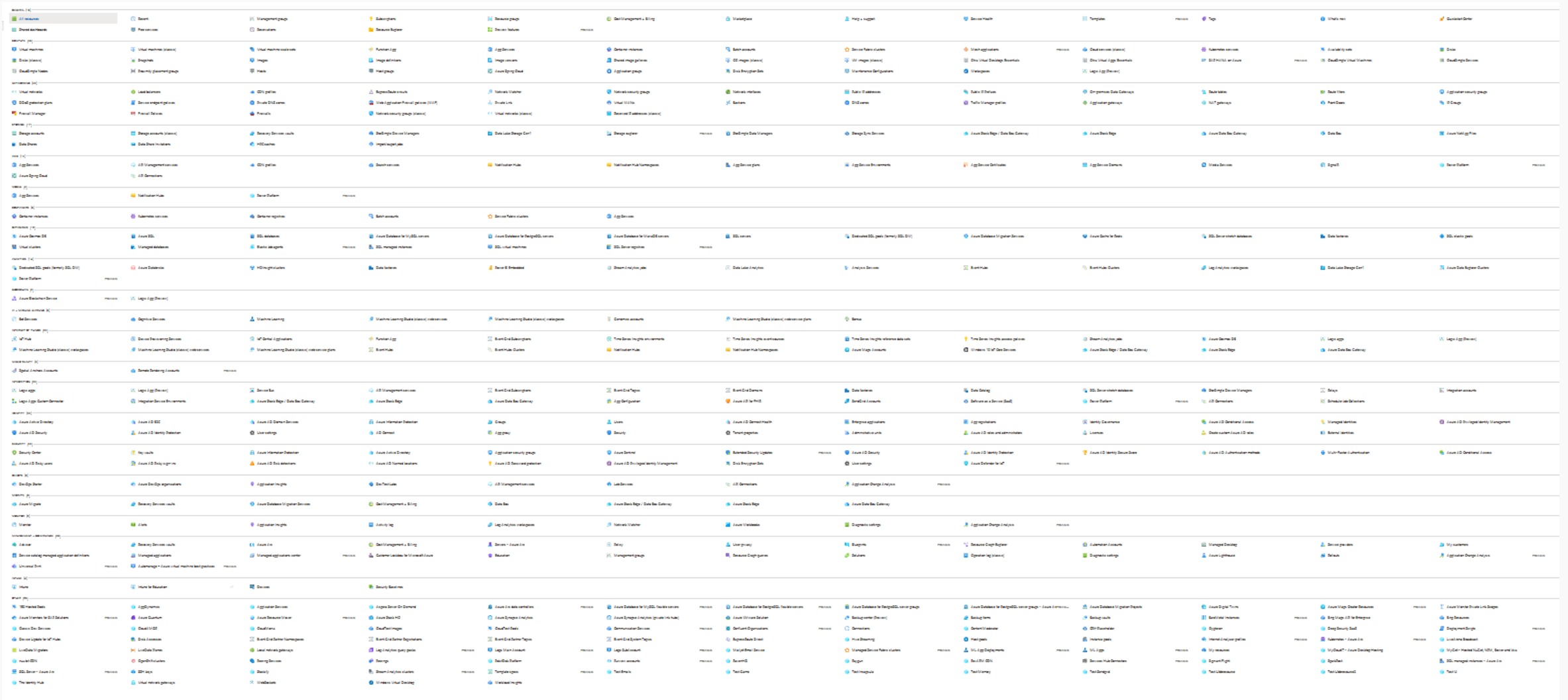
Analytics

Blockchain

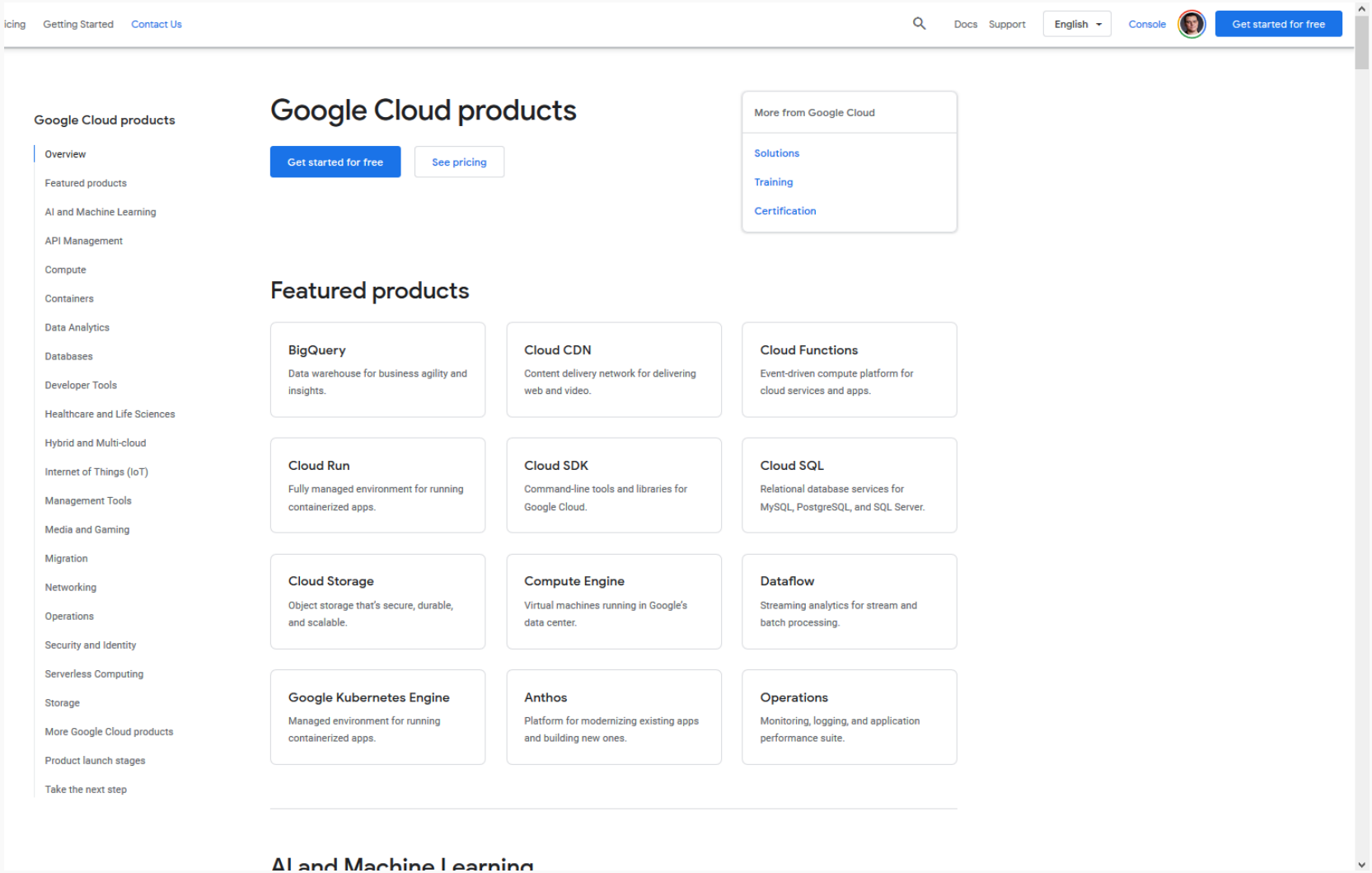
Inteligență artificială

- Face detection
- Chat bots
- GTP-3

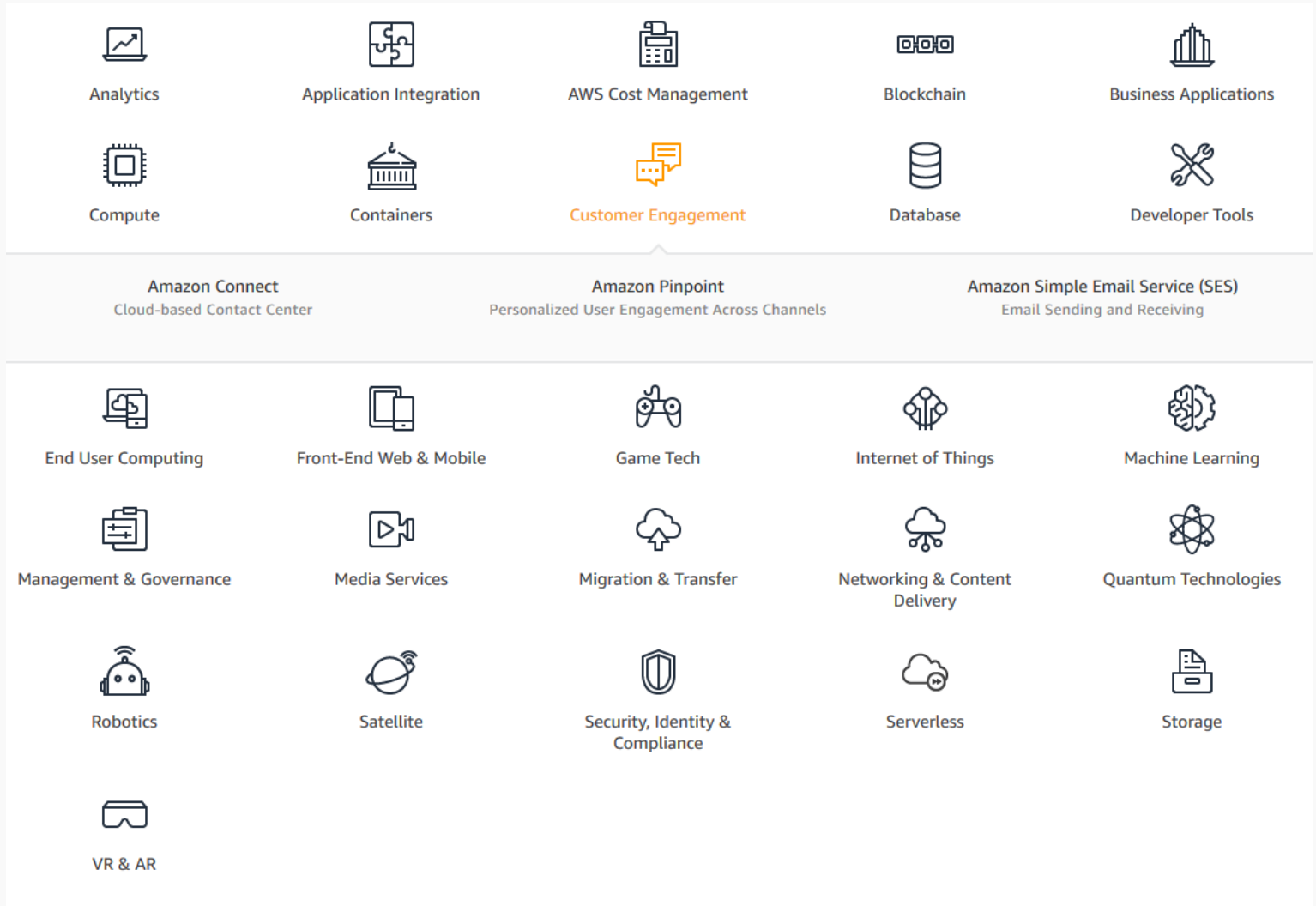
Platform as a Service – Azure
Majoritatea icoanelor sunt PaaS



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



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



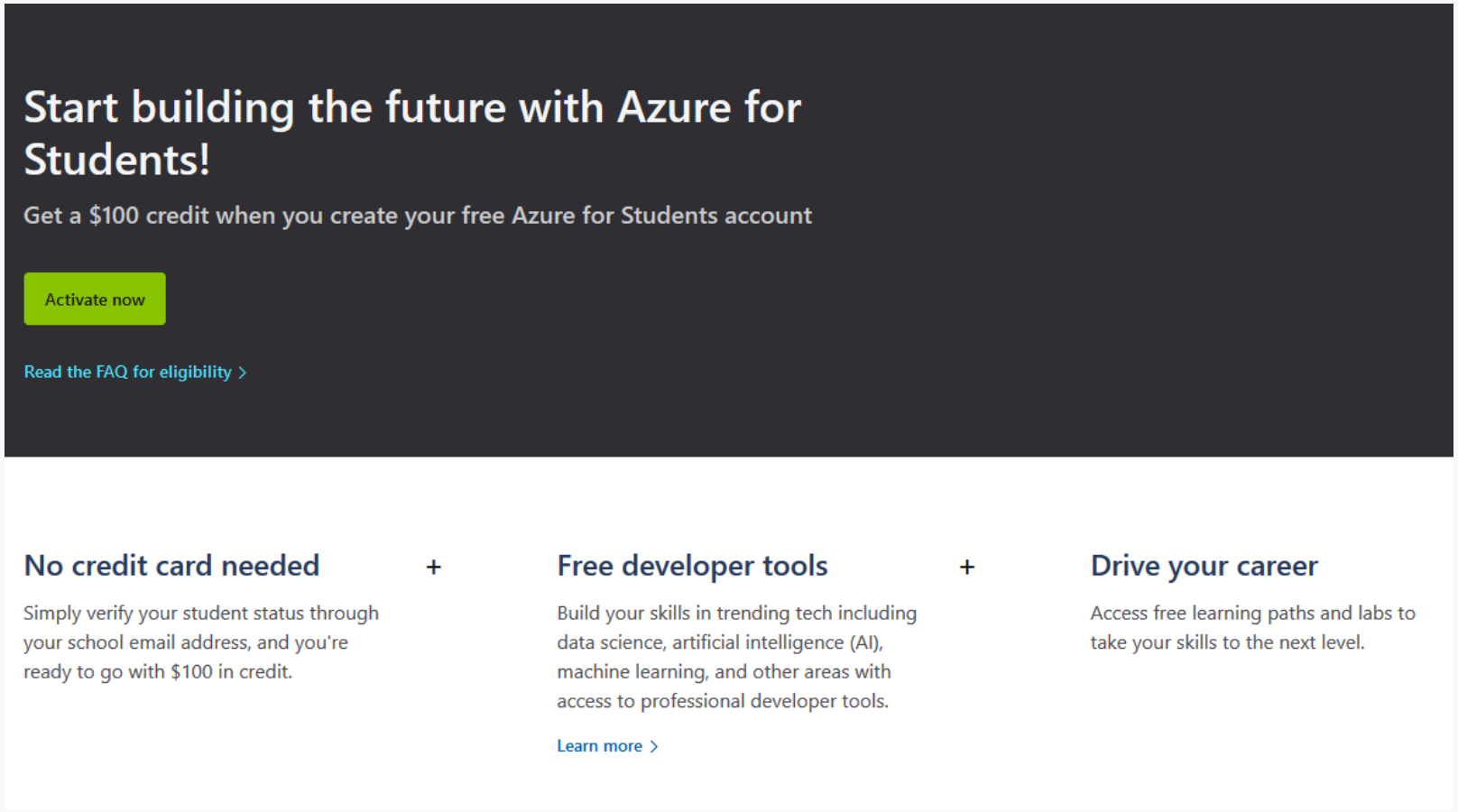
Software as a Service

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$.