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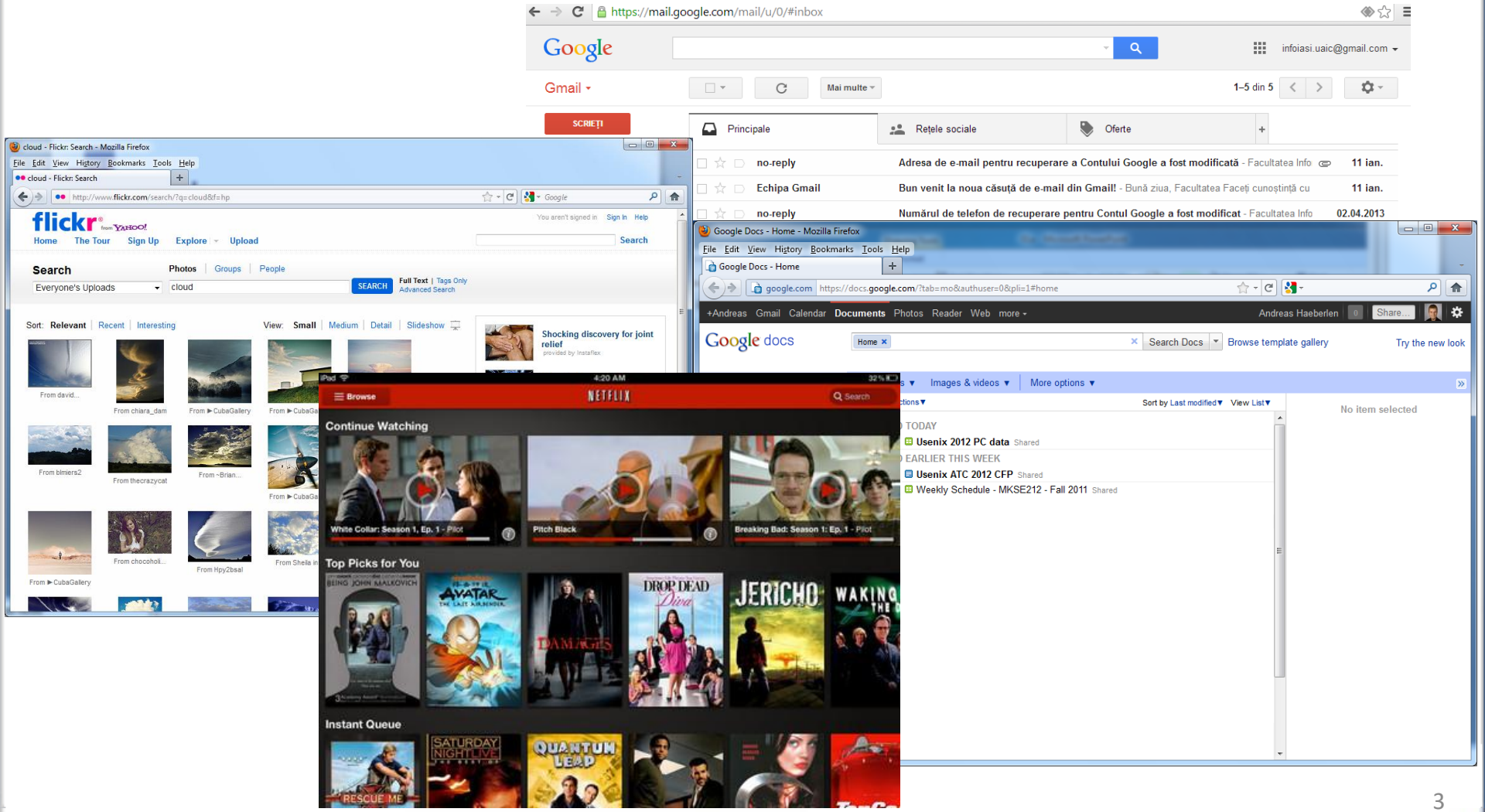
Cloud Computing - Imagine de ansamblu- -I-

Cuprins

- De ce Cloud Computing?
- Istorie & Evolutie
- Grid/Cluster computing – aspecte generale
- Cloud Computing – definitii
- Grid versus Cloud
- Cloud Computing - aspecte

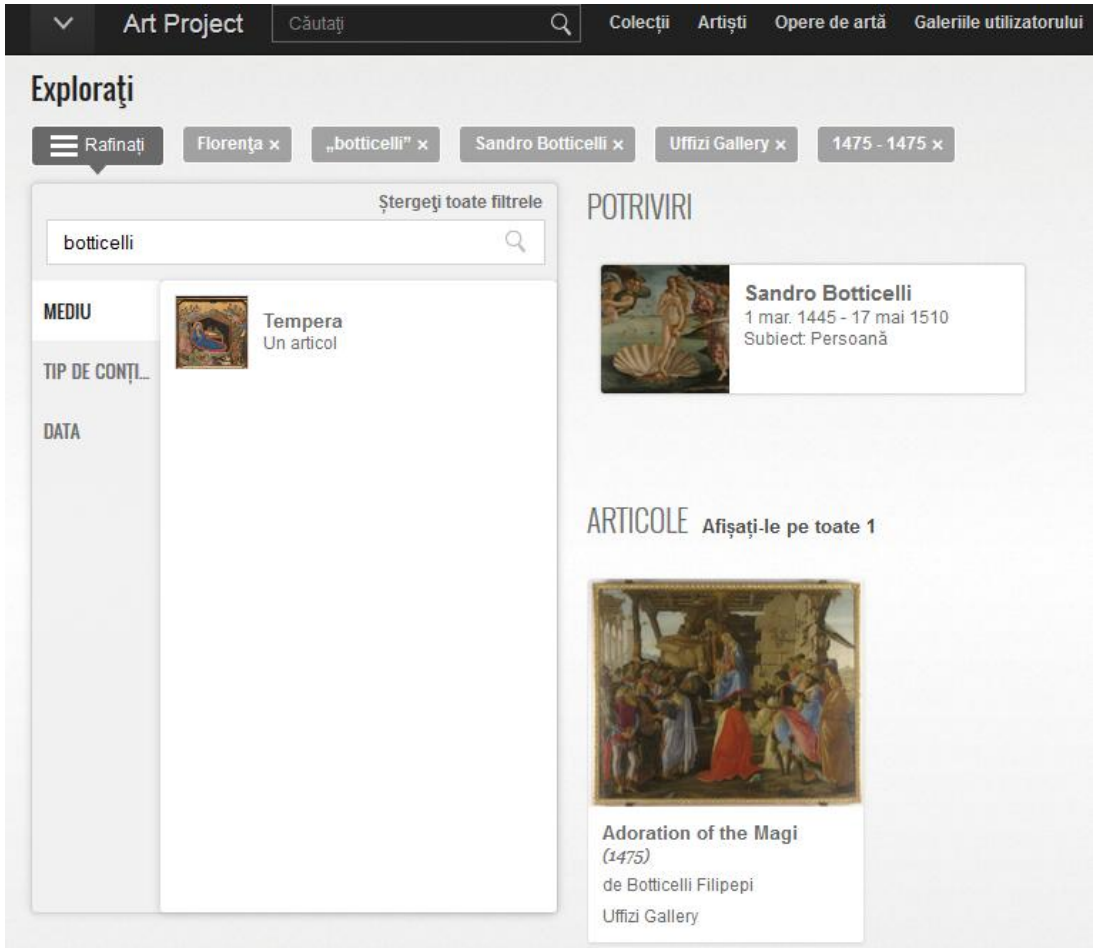
Cloud Computing

- Ati folosit Cloud Computing?



Cloud Computing

- Cloud computing “in buzunar”?

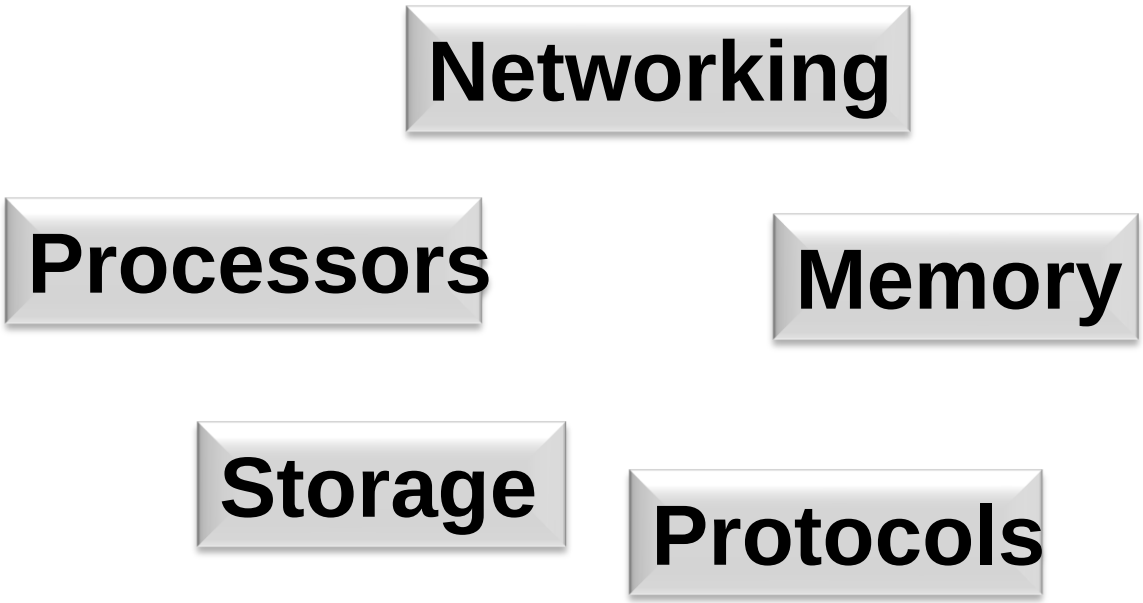


De ce Cloud Computing?

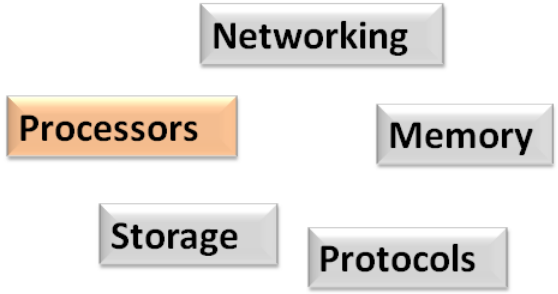
- Intelegerea principiilor de baza (Curs 2 ….)
  - Cum se poate construi ceva ce este scalabil, robust, etc.?
  - Diverse medii de dezvoltare
- Ce este in spatele unei platforme Cloud?
  - Cum functioneaza? Avantajele? Dezavantaje?
  - Tehnologii: Web Services, SOA, Ajax, XML, NoSQL, MapReduce,….
- Vrei sa construiesti urmatorul Facebook?
  - Scalabilitate, eficienta, rezistenta la erori, securitate, …
- Cunoasterea impactului asupra societatii (Curs 13)
  - Vulnerabilitati, elemente legate de securitate, …
- Anticiparea unui viitor posibil (Curs 14)
- **Cum s-a ajuns la Cloud Computing? (Acum☺)**

Istorie & Evolutie

- 1945-1985: “computers were large and expensive”
- … imbunatatiri:

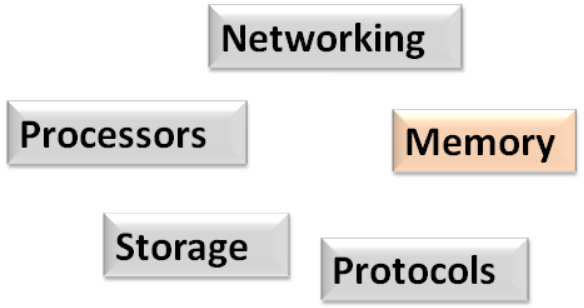


Istorie & Evolutie



- Industria microprocesoarelor (8-biti, 16,32,64,…) a cunoscut o evolutie rapida
- Computerele au devenit
  - De dimensiuni mai mici
  - Costuri mai ieftine
  - Mai rapide
- "…from machine that cost 10 million dollars and executed 1 instruction per second we have come to machines that cost 1000 dollars and are able to execute 1 billion instructions per second, a price/performance gain of 1013"

Istorie & Evolutie

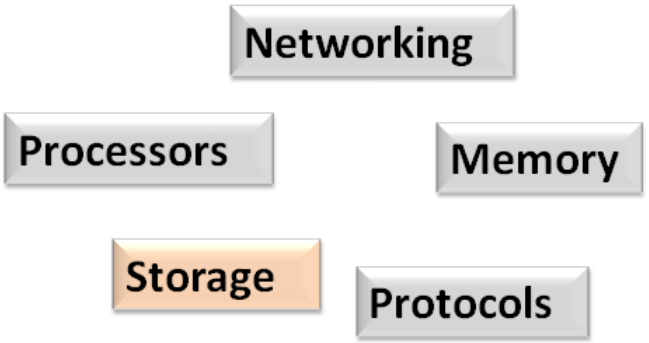


An	Cost ($/MB)	Capacitate (media)
1977	$32,000	16K
1987	$250	640K-2MB
1997	$2	64MB-256MB
2007	$0.06	512MB-2GB+
2017	$0.0091	8GB->...

[http://www.cs.rutgers.edu/~pxk/]

[http://www.statisticbrain.com/average-historic-price-of-ram/]

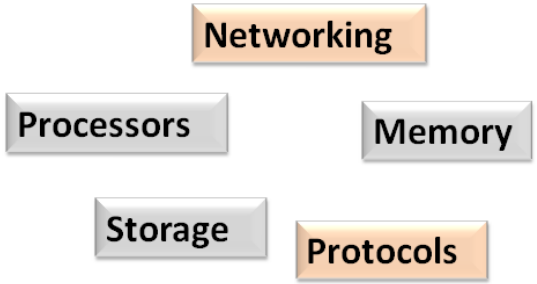
Istorie & Evolutie



- 1977: 310KB floppy drive ~ $1480
- 1987: 40 MB drive ~ $679
- 2008: 750 GB drive ~ $99
- 2017: 3-4TB drive ~ $100
- *"Recording density increased over 60,000,000 times over 50 years"*

[http://www.cs.rutgers.edu/~pxk/]

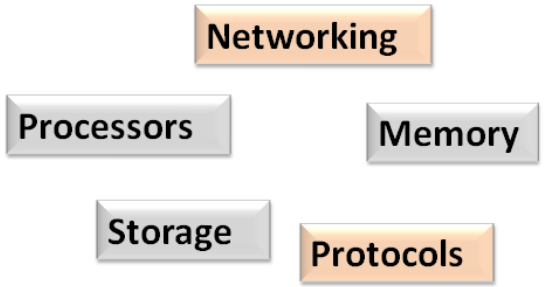
Istorie & Evolutie



1961-1972: primele incercari de comunicare prin schimbare de pachete

- 1961: Kleinrock – propune un model teoretic
- 1967: ARPAnet este proiectat de Advanced Research Projects Agency
- 1969: primul nod operational ARPAnet, retea de 4 calculatoare
- 1972:
  - demonstratie publica a tehnologiilor ARPAnet
  - NCP (Network Control Protocol) primul protocol host-host
  - primul program de posta electronica (e-mail); se introduce simbolul @
  - ARPAnet are 15 noduri

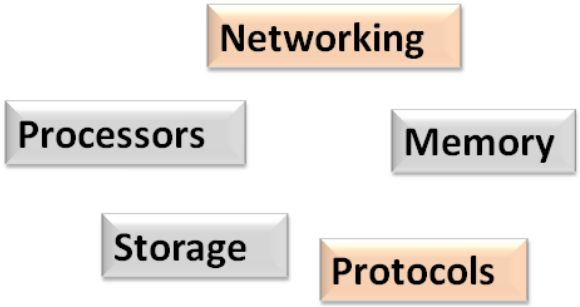
Istorie & Evolutie



1972-1980: Apare conceptul de *Internetworking.* Apar retele aflate in proprietate privata

- 1974: Cerf si Kahn – propun protocolul de comunicare TCP (Transmission Control Protocol)
- 1976 - Robert Metcalf (Hardvard) dezvolta tehnologia Ethernet care permite transferul de date pe cablu coaxial
- 1978: suita de protocoale TCP/IP este standardizata via documentele RFC (Request For Comments)
- La sfirsitul anilor ‘70: arhitecturi proprietare: DECnet, SNA, XNA
- 1979: ARPAnet are 200 de noduri

Istorie & Evolutie



LAN – viteza de transmisie:

- Original Ethernet: 2.94 Mbps
- **1985**: thick Ethernet: 10 Mbps; 1 Mbps with twisted pair networking
- **1991**: 10BaseT - twisted pair: 10 Mbps
- **1995**: 100 Mbps Ethernet
- **1998**: 1 Gbps (Gigabit) Ethernet
- **1999**: 802.11b (wireless Ethernet) standardized
- **2001**: 10 Gbps introduced
- **2005**: 100 Gbps (over optical link)
- **2012**: … Gbps

Cantitati mari de date pot fi transferate intre computere

Istorie & Evolutie

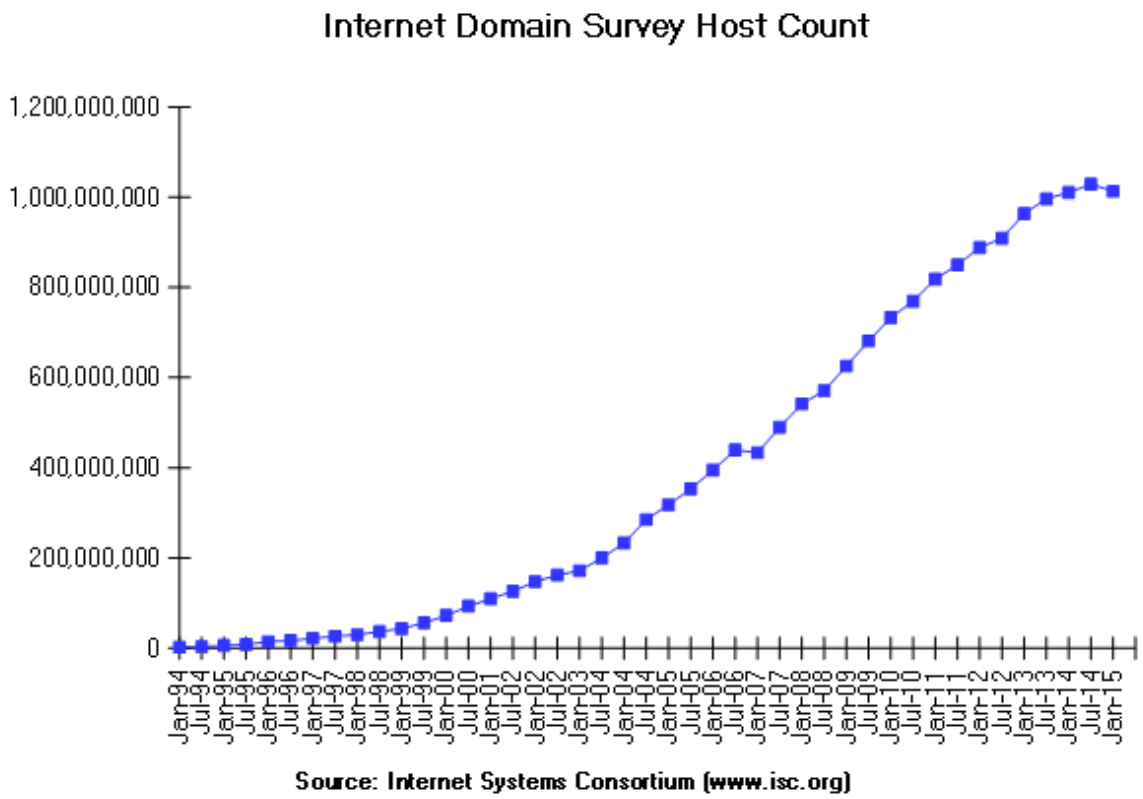
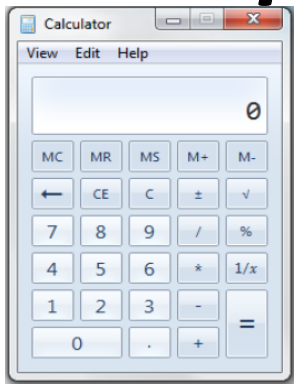


Figura . Cresterea numarului de *host*-uri din Ianuarie 1994 până în Ianuarie 2015

Ianuarie 2015| Sursa: http://www.isc.org/solutions/survey

Ce inseamna *computing?*

- Calcul



- Modul in care gandesti

In domeniul computer science?

- *“we can define computing to mean any goal-oriented activity requiring, benefiting from, or creating computers.”*

… *Computing*?

*"… computing may someday be organized as a public utility just as the telephone system is a **public utility**... The computer utility could become the basis of a new and important industry."*–John McCarthy (a professor of MIT) 1961.

*"As of now, computer networks are still in their infancy, but as they grow up and become sophisticated, we will probably see the spread of **computer utilities** which, like present electric and telephone utilities, will service individual homes and offices across the country."*–L. Kleinrock (one of the chief scientists of the original ARPANET project) 1969

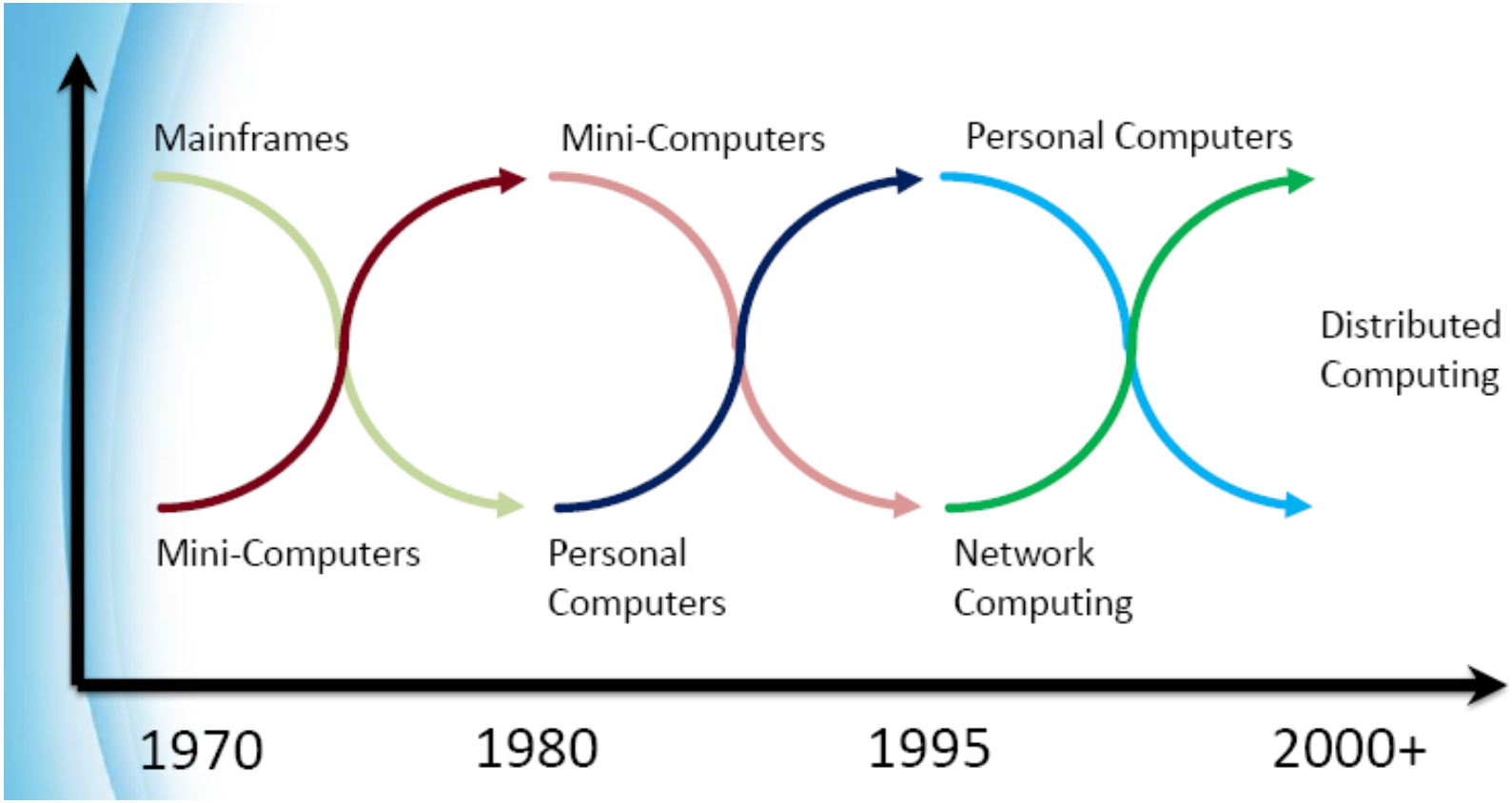
… *Computing*?

"a fost transformat intr-un model format din servicii de larg consum (commodity computing) si care pot fi furnizate intr-un mod similar utilitatilor traditionale "

- a 5-a utilitate -> Utility Computing sau "*Computing as a Utility*"

Trenduri

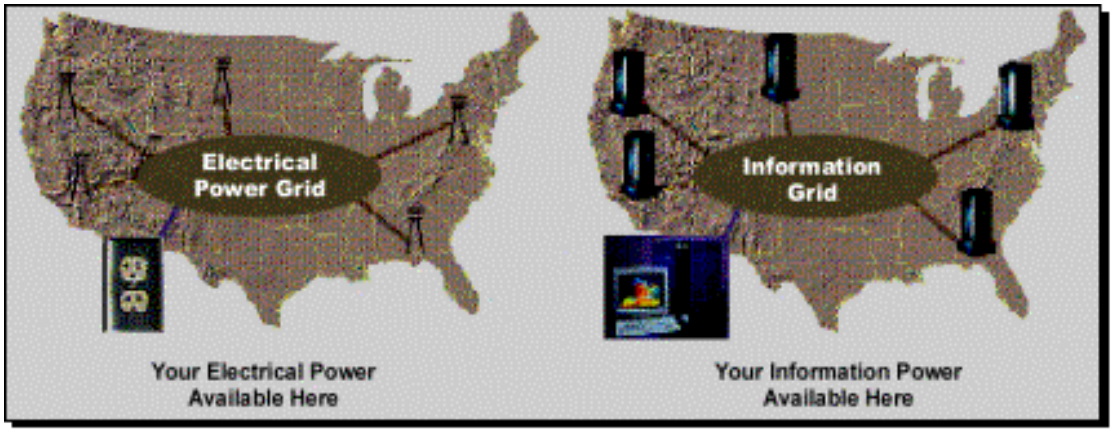
* De la supercomputere la statii de lucru care pot fi conectate intre ele



Grid Computing

Necesitate:

- Utilizarea resurselor neocupate
- aproximativ 90% din puterea unui procesor nu este utilizata
- Posibilitatea de a rezolva o mare varietate de probleme, la un cost rezonabil
- Raportul cost/performanţă în raport cu un super-computer (HPC - high performance computer)



- Termenul de Grid a aparut in anii 90
  - Analogie cu retelele electrice (p*ower grids*)

Grid Computing|Definitii

- Foster and Kesselman (1998): "*A computational grid is a hardware and software infrastructure that provides dependable, consistent, pervasive, and inexpensive access to high-end computational capabilities.*"
- *"The Grid is an emerging infrastructure that will fundamentally change the way we think – and use – computing. The word Grid is used by analogy with the electric power grid, which provides pervasive access to electricity and, like the computer and a small number of other advances has had a dramatic impact on human capabilities and society. Many believe that by allowing all components of our information technology infrastructure – computational capabilities, databases, sensors, and people – to be shared flexibly as true collaborative tools, the Grid will have a similar transforming effect, allowing new classes of application to emerge."* (Foster and Kesselman 2004)

Grid Computing

- Infrastructura de calcul distribuit destinata initial proiectelor stiintifice si mai apoi si celor industriale
- Permite executarea de *task*-uri pe mai multe masini, privite ca un calculator unic
- Partajarea flexibila, sigura & coordonata a resurselor intre colectii dinamice de indivizi, institutii si resurse
- Ofera posibilitatea de a forma organizatii colaborative virtuale (VO - *virtual organizations*) – eventual, constituite dinamic – partajind aplicatii & date intr-un mediu deschis eterogen pentru a rezolva mutual diverse probleme complexe
- Ofera o infrastructura hardware & software care ofera acces permanent, ieftin, de oriunde, in maniera consistenta, la resurse de calcul
- Ofera o modalitatea de a procesa in maniera distribuita informatiile disponibile in Internet

Partajam: *Computing/processing power, Data storage/networked file systems, Communications and bandwidth, Application software, Scientific instruments*

Grid Computing

- Termeni:
  - *Grid middleware* – nivel software care furnizeaza functionalitatile necesare partajarii de resurse eterogene si crearea unei organizatii virtuale
  - *Grid infrastructure* – se refera la combinatia dintre hardware si *Grid middleware* care transforma resurse de calcul disparate, eterogene intr-o infrastructura integrata virtuala care ofera utilizatorului final imaginea unei singure masini
  - *Utility computing* – reprezinta furnizarea de Grid Computing si a aplicatiilor ca un serviciu (e.g. solutii de *hosting* pentru VO, etc)
    - Utility computing este bazat pe modelul de business *pay-per-use*
- Obs. Grid computing rezolva problem de tipul: partajare de resurse, coordonare, *manageability*, performante ridicate
  - Sisteme de tipul: retele, instrumente stiintifice, HPC pot fi componente intr-un Grid

Grid Computing| Arhitectura

- Arhitecturile Grid utilizeaza simultan un numar mare de resurse (hardware, software, logice)
- Resursa – entitate partajabila existenta in cadrul unui Grid
  - De calcul: PC, server, cluster, dispozitive mobile,…
  - De stocare: hard disk, RAID, SAN, …
  - De tip I/O: senzori, retele, imprimante etc.
  - Logice: contoare de timp, …
- O arhitectura Grid se concentreaza pe probleme de interoperabilitate, protocoale de comunicare intre furnizori si utilizarea resurselor cu scopul stabilirii de relatii de partajare

Grid Computing|Arhitectura

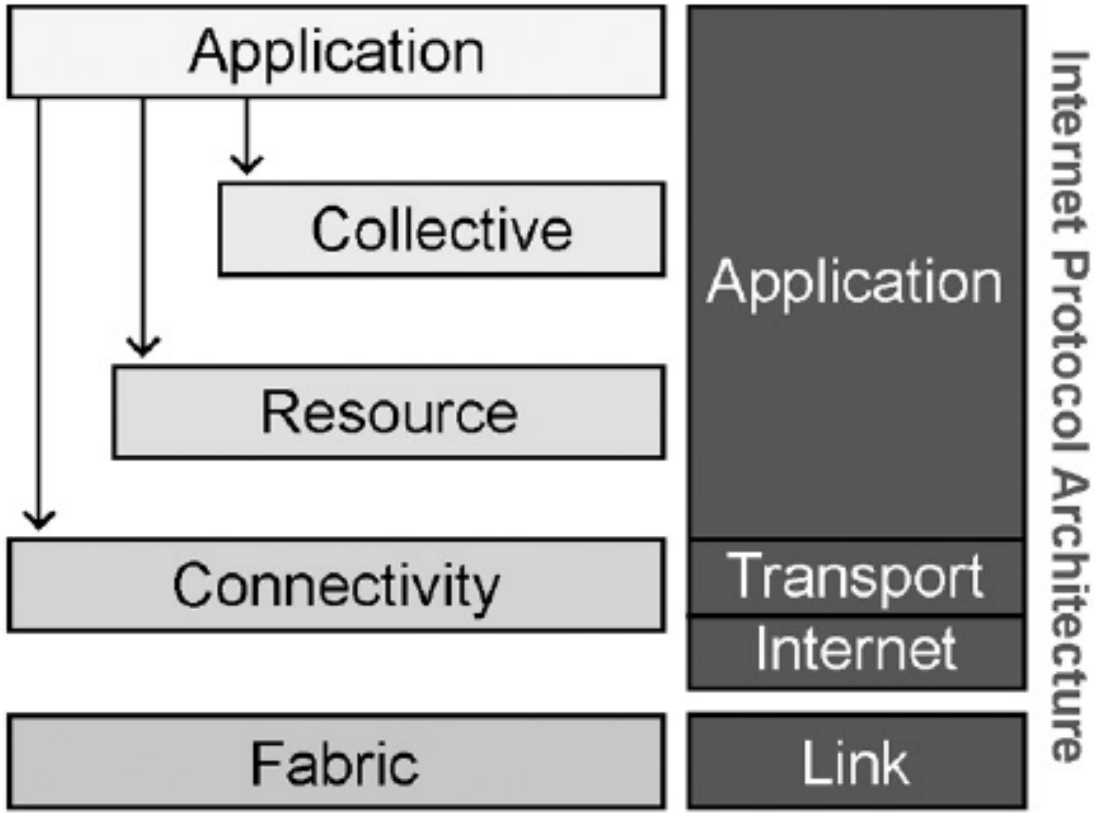
- Arhitectura Grid generica

"Coordinating multiple resources": ubiquitous infrastructure services, app-specific distributed services

"Sharing single resources": negotiating access, controlling use

"Talking to things": communication (Internet protocols) & security

"Controlling things locally": Access to, & control of, resources



Grid Computing | Clasificare

- In raport cu tipul de resurse preponderent administrate
  - Compute Grid – folosit pentru partajarea resurselor computationale (e.g. CPU) - Exemple: procesari grafice intensive
  - Data Grid – concentrat pe stocare, management si partajare de date distribuite si eterogene
  - Application Grid – concentrat pe mangementul aplicatiilor si furnizarea de acces in mod transparent la soft si biblioteci la distanta; Exemplu: grid-uri in domeniul bioinformaticii sau stiintelor pamintului
  - Service Grid – rezultat din convergenta Grid si SOA (Service-oriented Computing), ofera suport pentru partajarea eficienta a serviciilor
- In raport cu domeniul de partajare a resurselor
  - Cluster Grid
  - Enterprise Grid
  - Utility Grid Services
  - Partner/Community Grids

Grid Computing| Evolutie

- Generatia 1 – proiectul Globus (Goble & Foster)
  - **Foloseste tehnologii Internet, dar ignora Web-ul**
  - Aplicatii necesitind putere mare de calcul
  - Include protocoale si instrumente de dezvoltare eterogene
  - Suport pentru accesul si trasferul de fisiere
  - Dezvoltare in medii academice
  - Au urmat…Legion, Condor, Unicore, ….

Grid Computing| Evolutie

- Generatia 2 – OGSA (*Open Grid Services Architecture*)
  - **Are loc convergenta Service-oriented Computing (SOC) si Grid Computing**

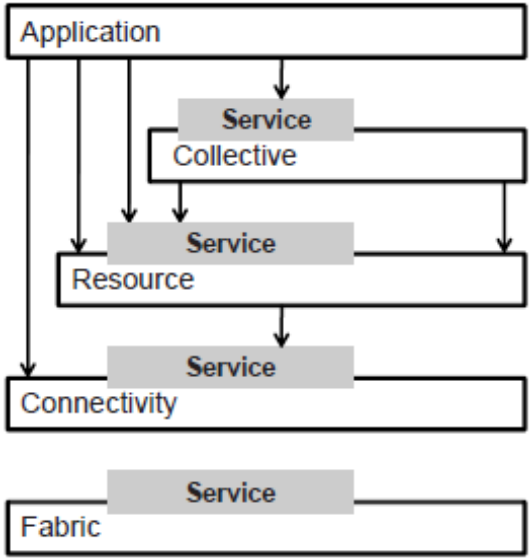
"Service-oriented Computing (SOC) is a new computing paradigm that utilizes services as the basic construct to support the development of rapid, low-cost and easy composition of distributed applications even in heterogeneous environments. The visionary promise of Service-Oriented Computing is a world of cooperating services where application components are assembled with a little effort into a network of services that can be loosely coupled to create flexible dynamic business processes and agile applications that may span organisations and computing platforms." (Papazoglou et al. 2006)

Obs. Viziunea de partajare si interoperabilitatea a SOC la nivel de aplicatie si software versus viziunea Grid Computing preponderenta la nivel hardware

- Generatia 1: arhitectura Grid Computing consta din protocoale, adica din servicii necesare pentru descrierea si partajarea resurselor fizice disponibile
- Prin utilizarea standardelor Serviciilor Web (WSDL, SOAP, BPL4WS,…) protocoalele si serviciile Grid pot fi descrise intr-o maniera standardizata

Grid Computing| Evolutie

- Generatia 2 – OGSA (*Open Grid Services Architecture*)



- Folosind aceleasi standarde => a fost posibila convergenta Grid Computing si SOC => pe langa resursele hardware si de sistem, devin partajabile si aplicatiile

- OGSA:

"Building on concepts and technologies from both the Grid and Web Services communities, OGSA defines a uniform exposed service semantics (the *Grid Service*); defines standard mechanisms for creating, naming, and discovering transient Grid service instances; provides location transparency and multiple protocol bindings for service instances; and supports integration with underlying native platform facilities." (Foster et al. 2002)

Implementari

- Generatia 2 – OGSA (*Open Grid Services Architecture*)

  Serviciile Grid constituite trebuie sa fie:

  – **Dinamice si volatile** – multimi de servicii compuse create, invocate si eliminate “din zbor”
  – **Ad-hoc** – nu exista locatie centrala ori control central
  – **Pe scara larga** – orchestrarea unui numar mare de servicii (>100) trebuie realizata oricind
  – **Disponibile**, potential pe termen lung (e.g. o simulare poate dura saptamini)

  - OGSI (Open Grid Service Infrastructure)
    - Infrastructura pentru OGSA care sa “acomodeze” interactiunea dintre resursele Grid-ului si serviciile Web
  – Model implementat de Globus Toolkit 3.0
    » OGSI a fost inlocuita de WSRF (Web Service Resource Framework): WS- Security, WS- Management si alte standarde a serviciilor Web => Globus 4.0

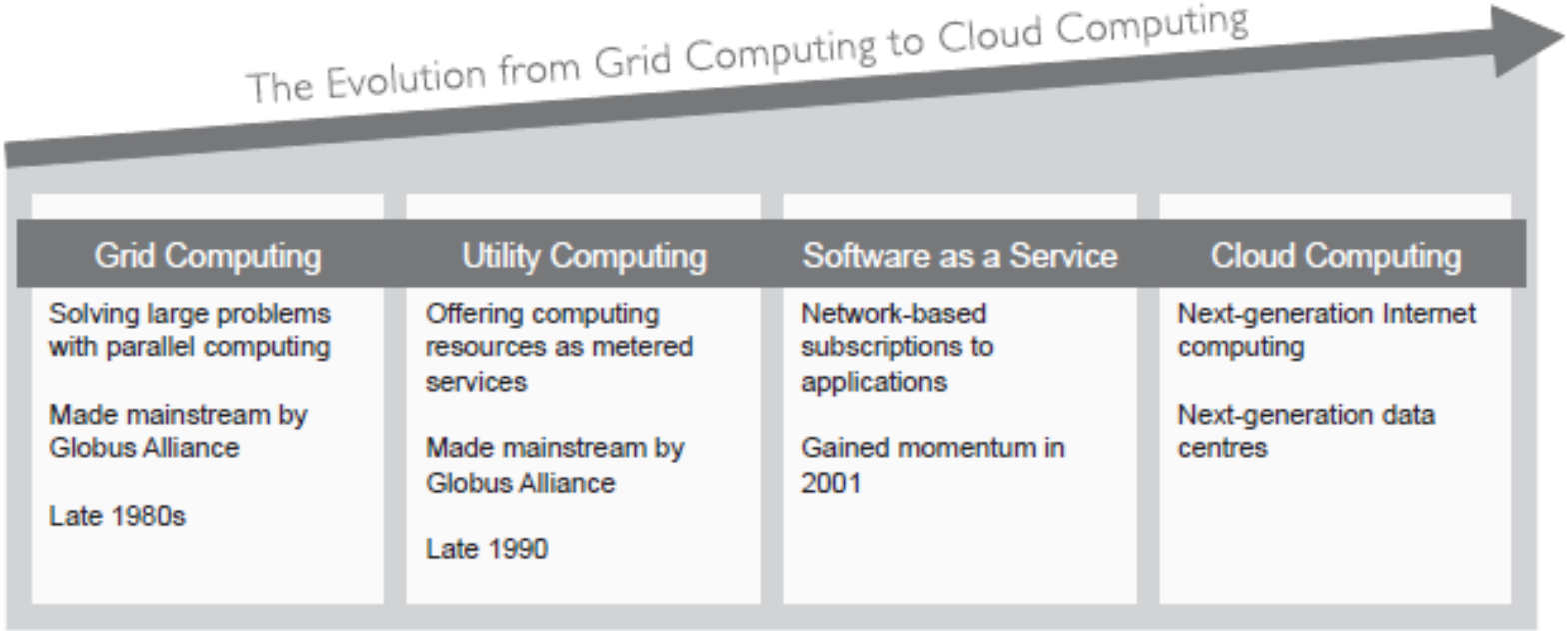
Grid Computing| Evolutie

- Generatia 3 – prezent si viitor
  - *Convergenta Grid Computing si paradigma SaaS (Software-as-a-Service)*
  - Saas
    - Desemneaza software care este detinut, furnizat si gestionat de un furnizor
    - Versus software traditional
      - Utilizatorul plateste functionalitatea pentru timpul de utilizare
      - Utilizatorul nu detine softul, nu a facut investitii in infrastructura, licente etc.
    - Este consumat pe principiul *pay-per-use* via un Web browser sau APIs
    - Istoric: conceptul a aparut in 1998, Application Service Provisioning (ASP)
      - Pas pentru IT outsourcing , vine cu ideea de a furniza aplicatii Web de catre un furnizor central (model de livrare *one-to-many*)
        - Problema principala: incapacitatea de a oferi servicii personalizate, aplicatiile erau oferite la fel pentru orice client
        - Probleme de scalabilitate, robustete, flexibilitate

Grid Computing| Evolutie

- Generatia 3 – prezent si viitor
- Problemele ASP pot fi rezolvate de Grid Computing + Servicii Web
  - Serviciile Web pot contribui la personalizarea serviciilor
  - Tehnologia Grid poate oferi flexibilitate si scalabilitate

  => model de livrare *many-to-many*



The Evolution to Cloud Computing (adapted from IBM 2009)

[Grid and Cloud Computing - A Business Perspective on Technology and Applications, 2010]

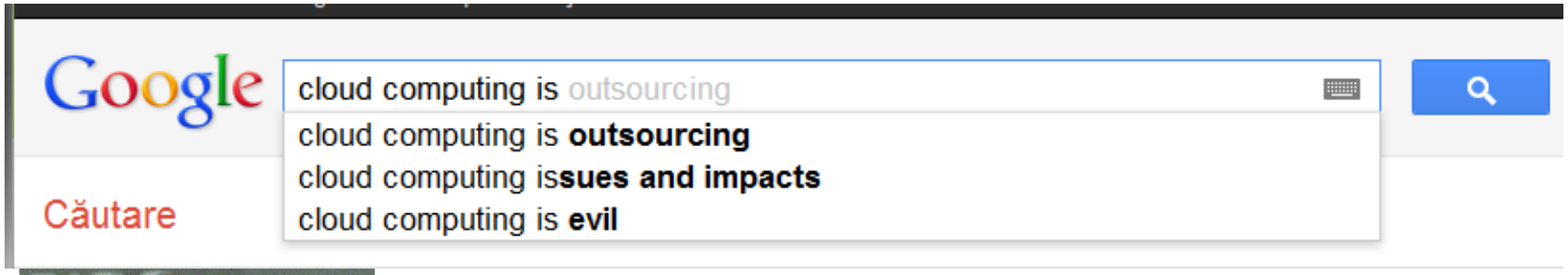
Cloud Computing

Imagine de ansamblu

- Doua directii de evolutie:
  - Grid Computing
    - Tehnologie matura
    - Furnizeaza putere computationala la cerere in stilul *pay-per-use* => noi modele de business pentru *utility computing*
    - Evolutie implusionata de initiative la nivel hardware si sisteme software apartinind: Sun, IBM, etc.
  - Evolutie la nivel software -> SaaS
    - Initiative: Microsoft, SAP etc.
- ? Pasul urmator…
  - Infrastructura fizica scalabila, flexibila, robusta si de incredere
  - Servicii care ofera programatorilor accesul la infrastructura fizica prin manipularea de interfete abstracte
  - SaaS dezvoltat, implementat si care ruleaza pe o infrastructura flexibila si scalabila

Cloud Computing

- Ce este?

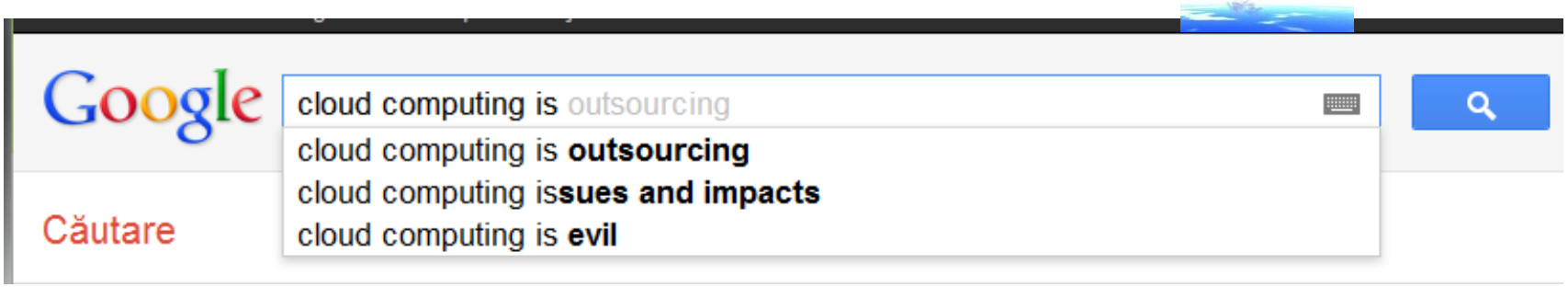


Larry Ellison, founder of Oracle

"We've redefined Cloud Computing to include *everything that we already do.* . . . I don't understand what we would do differently in the light of Cloud Computing other than change the wording of some of our ads."

Cloud Computing

- Ce este?



Richard Stallman
Creatorul GNU

•“cloud computing is evil”
•“I think that marketers like cloud computing because it is devoid of substantive meaning. The term’s meaning is not substance, it’s an attitude: ‘Let any Tom, Dick and Harry hold your data, let any Tom, Dick and Harry do your computing for you (and control it).’ Perhaps the term ‘careless computing’ would suit it better.”

Cloud Computing

Definitie din perspectiva utilizatorului final:

- “the idea of delivering personal (e.g., email, word processing, presentations.) and business productivity applications (e.g., sales force automation, customer service, accounting) from centralized servers” (Merrill Lynch)

Definitie cuprinzind aspecte arhitecturale:

- “a service model that combines a general organizing principle for IT delivery, infrastructure components, an architectural approach and an economic model – basically, a confluence of grid computing, virtualization, utility computing, hosting and software as a service (SaaS)”

Cloud Computing

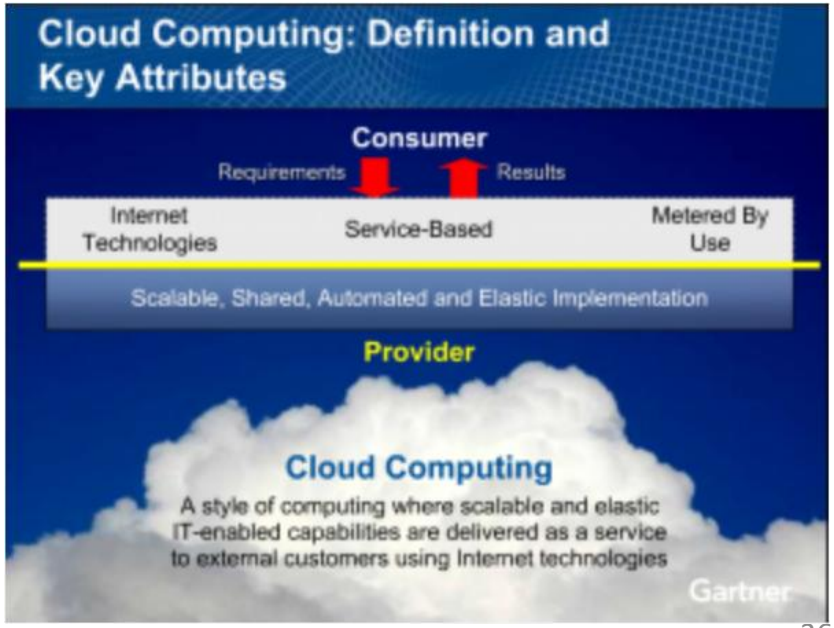
Definitii cuprinzind aspecte arhitecturale dar si de utilizare:

- “Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the datacenters that provide those services. The services themselves have long been referred to as Software as a Service (SaaS). The datacenter hardware and software is what we will call a Cloud. When a Cloud is made available in a pay-as-you-go manner to the general public, we call it a Public Cloud; the service being sold is Utility Computing. We use the term Private Cloud to refer to internal datacenters of a business or other organization, not made available to the general public. Thus, Cloud Computing is the sum of SaaS and Utility Computing, but does not include Private Clouds. People can be users or providers of SaaS, or users or providers of Utility Computing.” (Berkeley Lab, 2009)

Cloud Computing

Definitii cuprinzind aspecte arhitecturale dar si de utilizare:

- "a large-scale distributed computing paradigm that is driven by economies of scale, in which a pool of abstracted, **virtualized**, **dynamically-scalable**, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet." (Foster et al. (2008))
- http://jameskaskade.com/?p=594



- "a style of computing in which massively scalable IT-related capabilities are provided "as a service" using Internet technologies to multiple external customers" (Gartner)

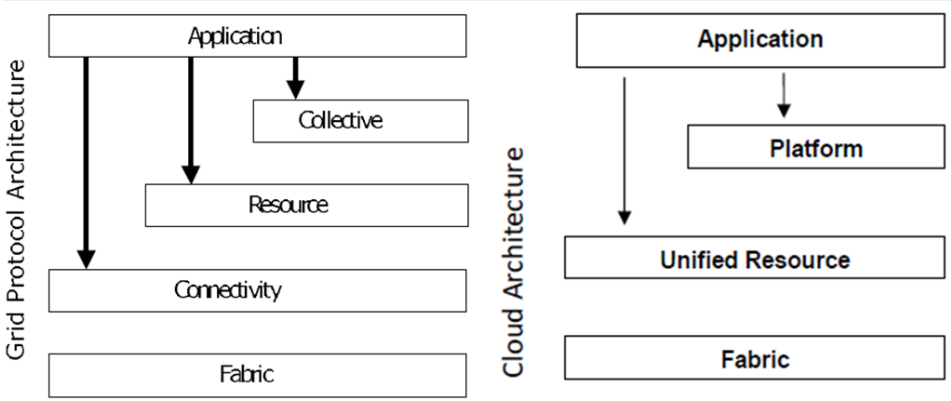
Cloud Computing

Relatia cu Grid Computing:

- “We argue that Cloud Computing not only overlaps with Grid Computing, it is indeed evolved out of Grid Computing and relies on Grid Computing as its backbone and infrastructure support. The evolution has been a result of a shift in focus from an infrastructure that delivers storage and compute resources (such is the case in Grids) to one that is economy based aiming to deliver more abstract resources and services (such is the case in Clouds).” (Foster et al., 2008)

Cloud Computing

Versus Grid Computing

	Grid Computing	Cloud Computing
Modelul de business (Traditional: plata o singura data pentru utilizarea nelimitata a softului)	Grid: orientat pe proiect, negociere, alocarea resurselor in functie de nivelul la care serviciile sunt furnizate	Cloud: plata se face pe baza consumului (calcul, stocare, ..)
Arhitectura 	Nivelul Fabric – e format din resurse, similar ca la Grid Nivelul Unified Resource – resursele care au fost incapsulate (e.g. virtualizare) – cluster sau sistem virtual, sistem de fisiere logic, etc. Nivelul Platform mediu pentru hosting web, dezvoltare de servicii, etc.	

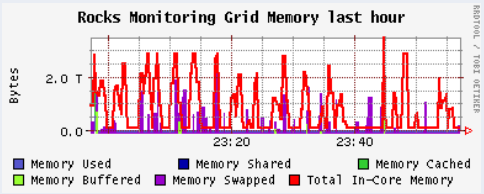
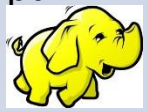
Cloud Computing

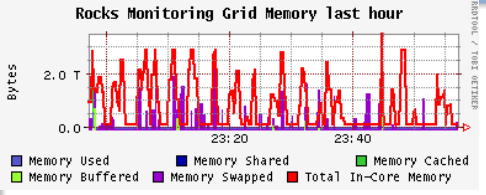
Versus Grid Computing

	Grid Computing	Cloud Computing
Model de calcul	*Batch-scheduled* (*queueing systems*) Alocarea de resurse/servere multiple pentru rezolvarea unui **singur** task	Resurse partajate de utilizatori in mod **simultan**, fata de resurse dedicate Provocare: QoS
Patternul de exploatare	Executarea de programe pentru o perioada limitata de timp	Folosit frecvent pentru "long-running services"
Relatii diferite intre furnizorii de resurse	Are ca scop crerea de VO => angajamente si politici de utilizare (domenii multiple)	Elimina aceasta necesitate (domeniu unic)
Scop diferit	Ofera infrastructura ca si serviciu	Ofera IaaS, PaaS, SaaS
Din punct de vedere al utilizatorului final	Interfetele Grid se bazeaza pe protocoale si API-uri utilizabile de utilizatori experti	Ofera interfete exploatabile din browser sau API-uri

Cloud Computing

Versus Grid Computing

	Grid Computing	Cloud Computing
Localizarea datelor – pentru a obtine o buna scalabilitate datele sunt distribuite pe mai multe computere	Se bazeaza pe sisteme de fisiere distribuite (NFS, GPFS,PVFS, Lustre)	Se bazeaza si pe mecanisme de tipul map-reduce
Monitorizare	Tooluri de monitorizare: Ganglia (http://meta.rocksclusters.org/ganglia/) - **Grid Report for Sun, 19 Feb 2012** 	Greu de realizat un control de granularitate mica datorita virtualizarii (probleme pentru utilizatori si administratori) Viziune: cloud-uri autonome = self-maintained
Model de programare	Face apel la instrumente de control al fluxului pentru a face managementul unor cantitati mari de date si multe task-uri (MPICH-G2, GridRPC, …)	Face apel la modele de tipul map-reduce. Ex. de implementare: Hadoop care foloseste Pig ca limbaj de programare 



ROCKS

Rocks Monitoring Grid Report for Mon, 4 Mar 2013 21:17:15 -0800

Get Fresh Data

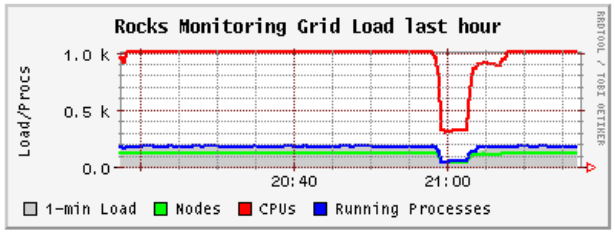
Last hour **Sorted** descending

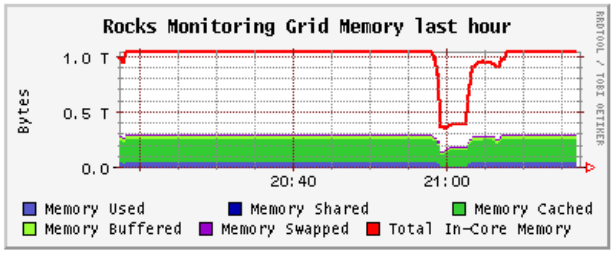
Rocks Monitoring Grid > --Choose a Source

Rocks Monitoring Grid (5 sources) (tree view)

CPUs Total: **1008**
Hosts up: **126**
Hosts down: **5**

Avg Load (15, 5, 1m):
17%, 18%, 18%
Localtime:
2013-03-04 21:17

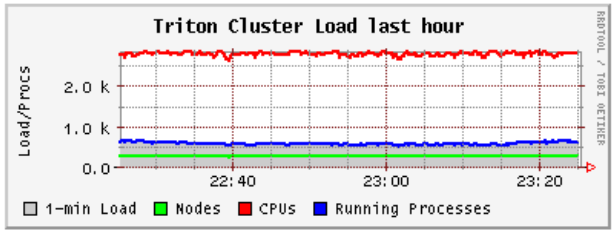


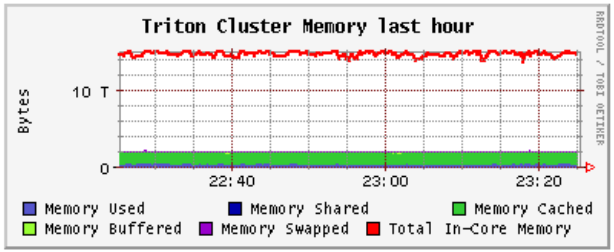


Triton Cluster (physical view)

CPUs Total: **2800**
Hosts up: **268**
Hosts down: **4**

Avg Load (15, 5, 1m):
21%, 22%, 22%
Localtime:
2013-01-04 23:25

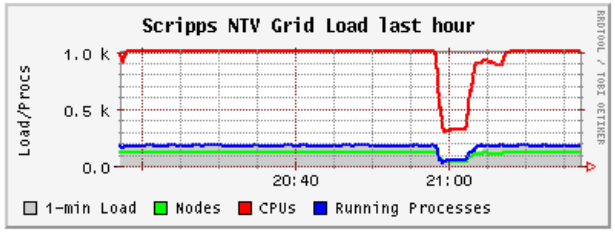


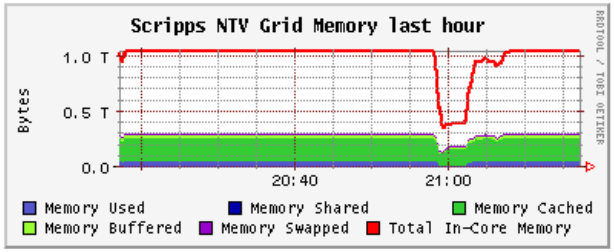


Scripps NTV Grid (tree view)

CPUs Total: **1008**
Hosts up: **126**
Hosts down: **4**

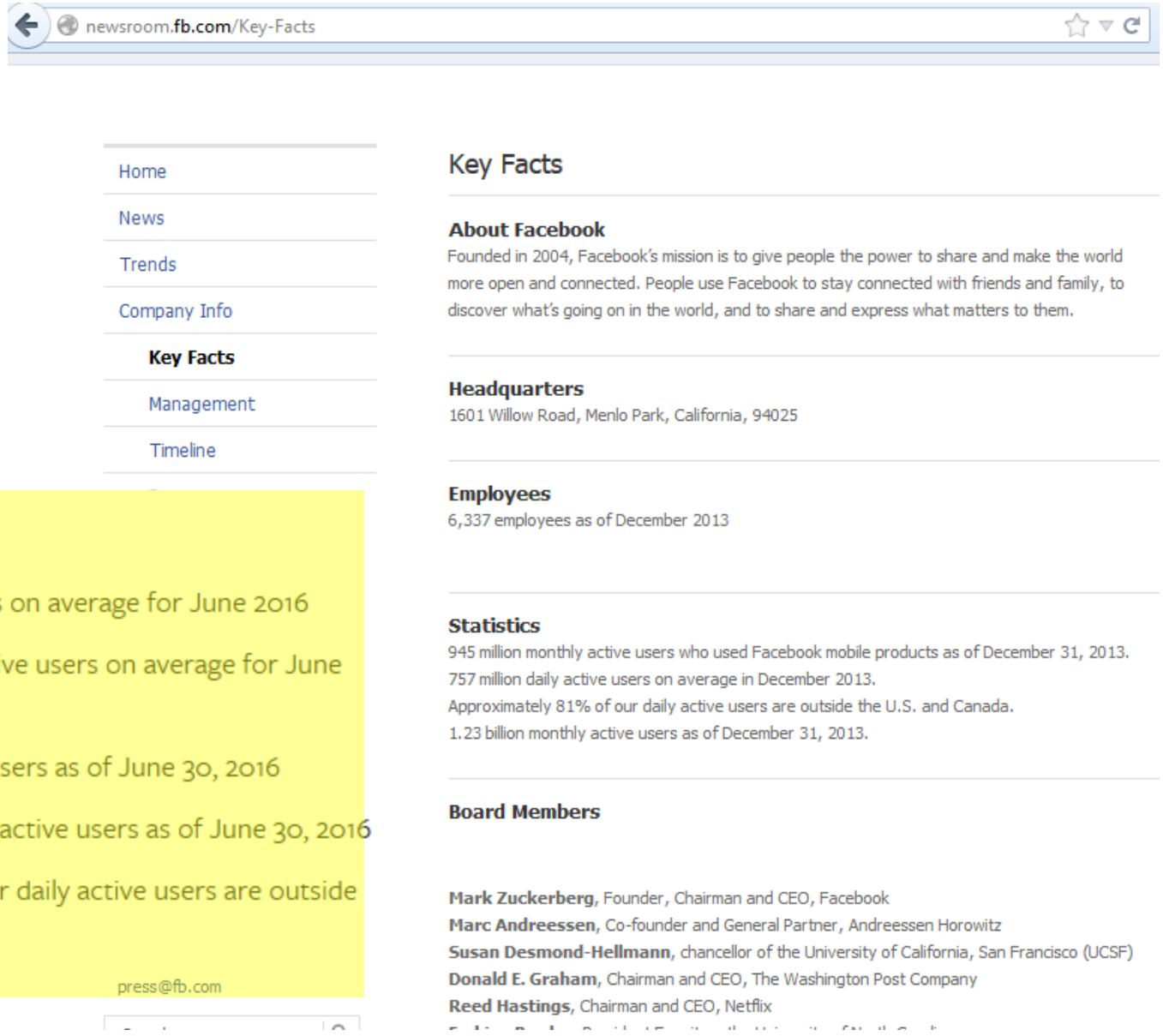
Avg Load (15, 5, 1m):
17%, 18%, 18%
Localtime:
2013-03-04 21:17





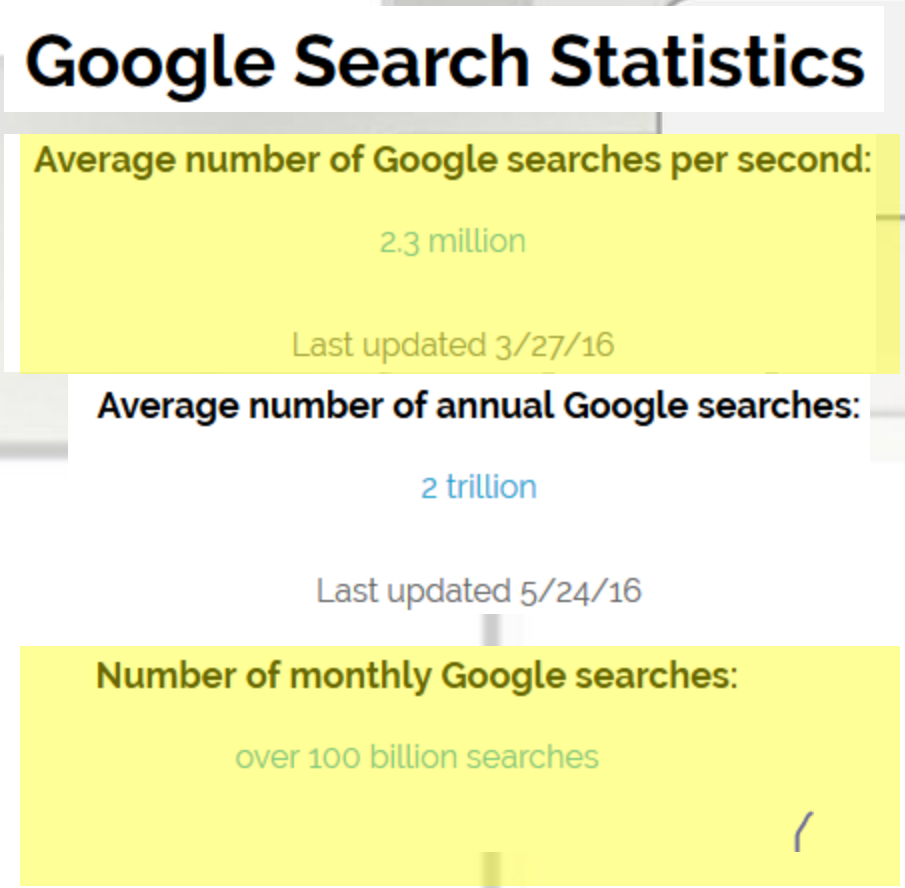
Cloud Computing

- "How big is the Cloud?" ☺



Cloud Computing

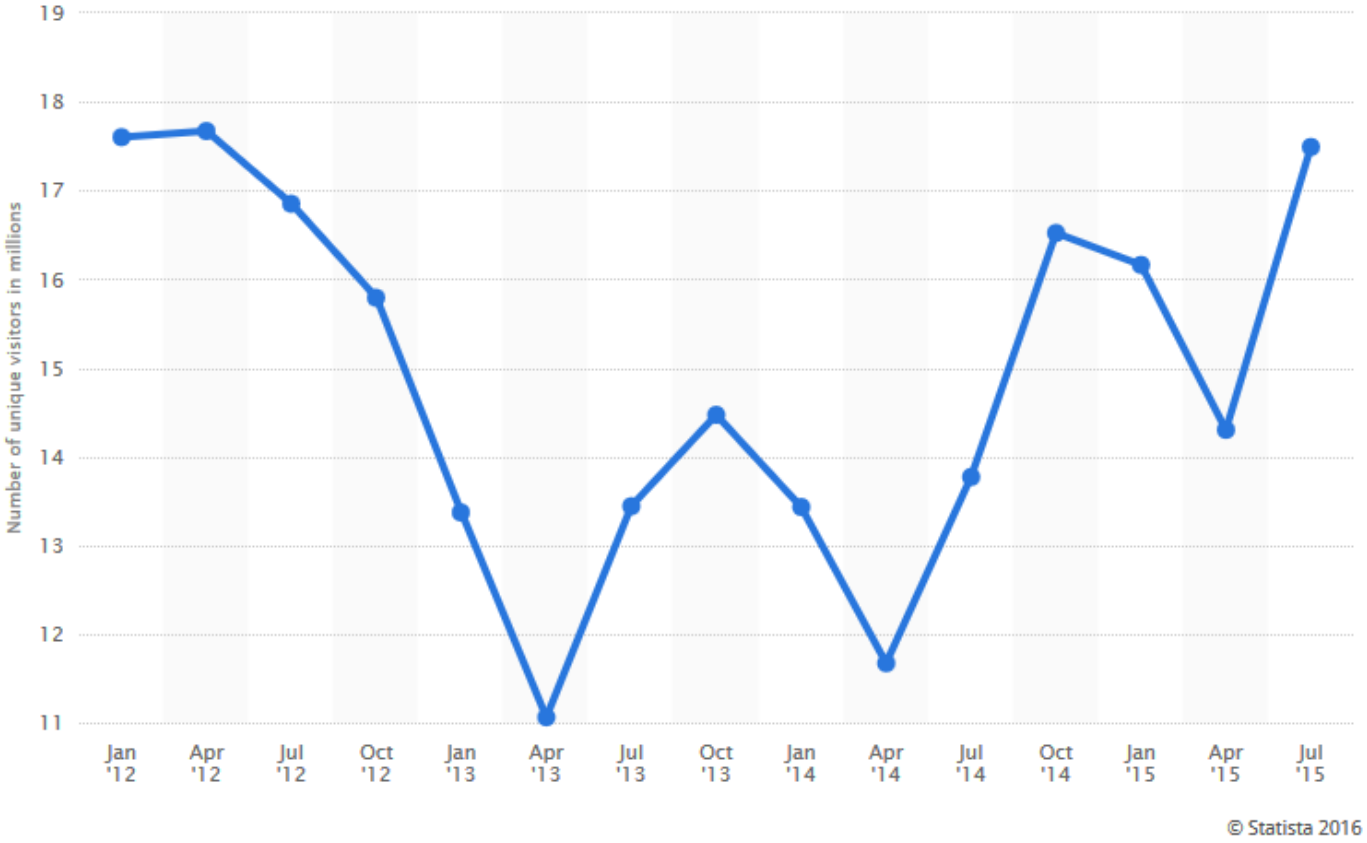
- "How big is the Cloud?" ☺



Cloud Computing

- “Cat de mare este cloud-ul?” ☺

Flickr



Cloud Computing

- Trendul: data-centric computing
  - Big data
- Moneda actuala pe internet?
  - Utilizatorii “platesc” utilizarea Facebook, Google. Flicker … deoarece toate actiunile, legaturile si cautarile sunt inregistrate
  - Datele au si o alta dimensiune in afara de cea economica
    - Se obtin raspunsuri mai corecte la intrebari, validarea ipotezelor asupra diverselor interactiuni sociale,….
    - Exemplu: Online Social Network research

Cloud Computing

- In acest moment nu doar motoarele de cautare sunt “jucatori” Big Data
  - banci, mediul academic, mediul financiar, guvernul, armata, ….

  => totul este posibil datorita unei noi generatii de “*hardware hosting services*” ⇔ cloud si noile modele de programare
    - Algoritmi:
      - Cum recomanda YouTube resurse?
      - Cum gaseste Google pagini relevante pentru o cautare?
      - Cum recunoaste Goggles imagini?
      - Cum se identifica automat daca un email este spam?
      - Cum identifica Facebook cine ar putea fi prietenii tai?

Cloud Computing

- Serviciile din cloud sunt adanc incrustate in societatea actuala
  - Comunicare: Twitter, Facebook, Skype, IM,…
  - Media: iTunes, Netflix,….
  - Market: Amazon, eBay, stock exchanges, advertising,…
  - ….

- *Adevarata intelegere ⇔ intelegerea interactiunilor dintre tehnologie, sisteme, retele si oameni* ⇔ scopul acestui curs ☺

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- Massimo Cafaro, Givani Aloisio, Grids, Clouds and Virtualization, 2011
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Rezumat

- De ce Cloud Computing?
- Istorie & Evolutie
- Grid/Cluster computing – aspecte generale
- Cloud Computing – definitii
- Grid versus Cloud
- Cloud Computing - aspecte

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Întrebări?