Retele de calculatoare
Istoric, Prezent …, Viitor…

Lenuta Alboaie

adria@info.uaic.ro

Cuprins

- Istoric
  - Curs 1
- Prezent…Viitor
  - Curs 1->Curs 13
  - Cloud Computing
  - Grid Computing
  - Grid Computing vs Cloud Computing
  - … -> (Master – Programare Concurenta si Distribuita)

Sisteme distribuite|Aspecte generale

- Un sistem distribuit este format din mai multe calculatoare autonome (sau noduri) care comunică printr-o reţea de calculatoare
- Un sistem distribuit poate avea un obiectiv comun, cum ar fi rezolvarea unei probleme complexe de calcul
- Alternativ, fiecare calculator poate avea propriul utilizator ce il poate utiliza in mod individual, scopul sistemului distribuit fiind cel de a coordona utilizarea resurselor comune sau furnizarea de diferite servicii utilizatorilor

Sisteme Distribuite

- "*A collection of independent computers that appears to the users of the system as a single coherent computer*."
  (**A. Tanenbaum** and **M. Van Steen**, Distributed Systems: Principles and Paradigms, Upper Saddle River, NJ, Prentice-Hall, 2003)
- *"You know you have a distributed system when the crash of a computer you've never heard of stops you from getting any work done."*

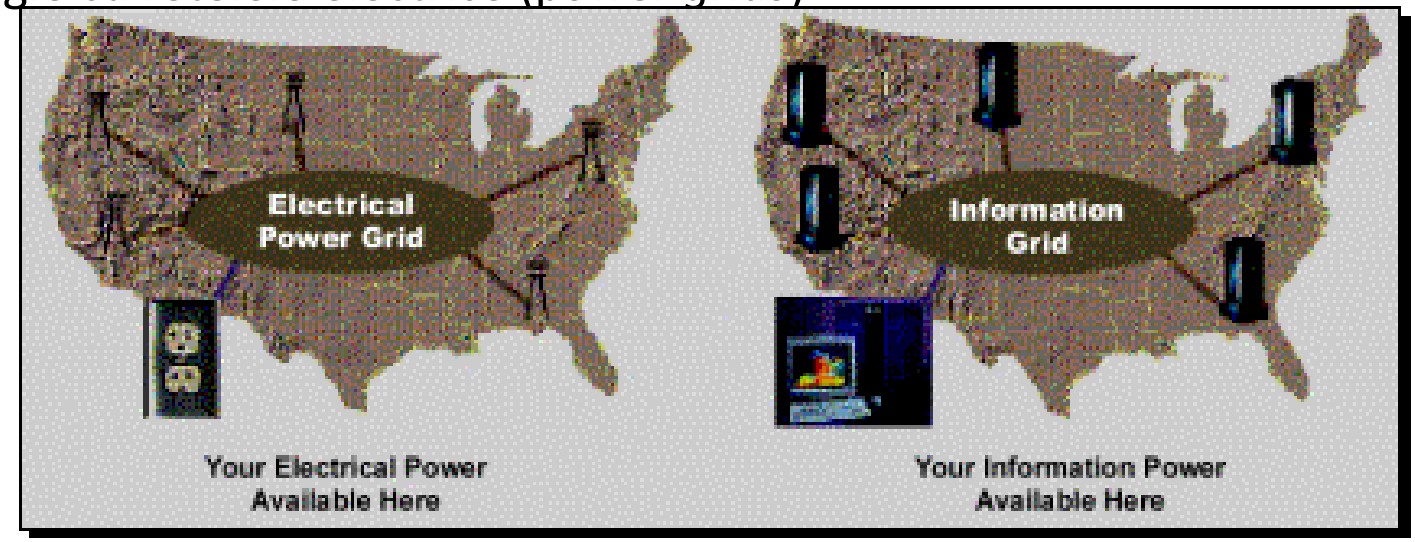
  (**Leslie Lamport**, Distribution email, May 28, 1987, http://research.microsoft.com/users/lamport/pubs/distributed_systems.txt)

Sisteme Distribuite|Utilizare si Caracteristici

- Partajarea si accesibilitatea resurselor
- Accesul la resurse distribuite geografic la distanta
- Imbunatatirea rezistentei *(Enhanced reliability)*
- Cresterea performantelor/cost
- Scalabilitate
- Transparenta (Acces, Localizare, Replicare, Concurenta)
  - ➢Obs. Atentie la gradul de transparenta ☺
- Deschiderea (*openness*)
  - Interoperabilitatea, Portabilitatea, Extensibilitatea

Grid Computing

- 1960: “to enable men and computers to cooperate in making decisions and controlling complex situations without inflexible dependence on predetermined programs.”(Licklider 1960)
- Termenul de Grid a aparut in anii 90
  - Analogie cu retelele electrice (p*ower grids*)



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)

Grid Computing

- 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
- Ofera suport pentru cautarea si regasirea informatiilor, indiferent de localizarea lor fizica
- 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
- Abilitatea 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
- Existenta unei infrastructuri hardware & software care ofera acces permanent, ieftin, de oriunde, in maniera consistenta, la resurse de calcul
- 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: PDA, PC, statie de lucru, server, cluster
  - De stocare: hard disk, RAID, SAN, …
  - De tip I/O: senzori, retele, imprimante etc.
  - Logice: utilizatori, 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

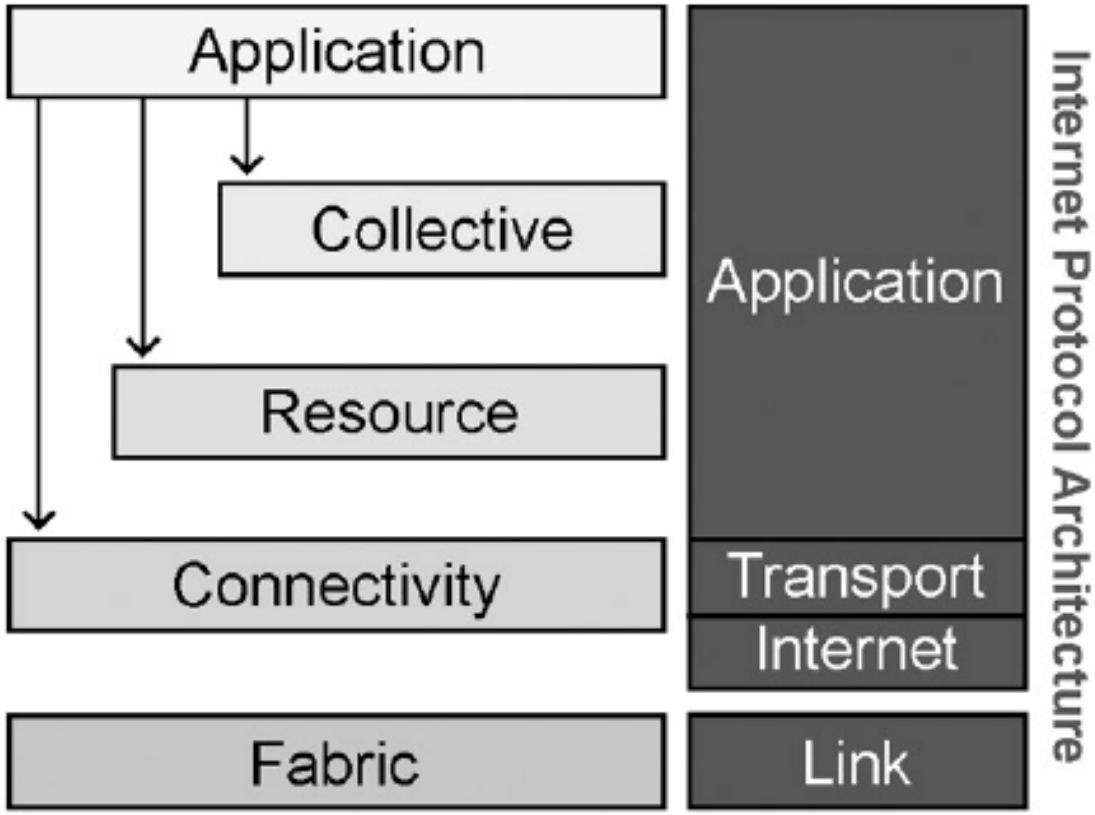
- Arhitectura Grid generica

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

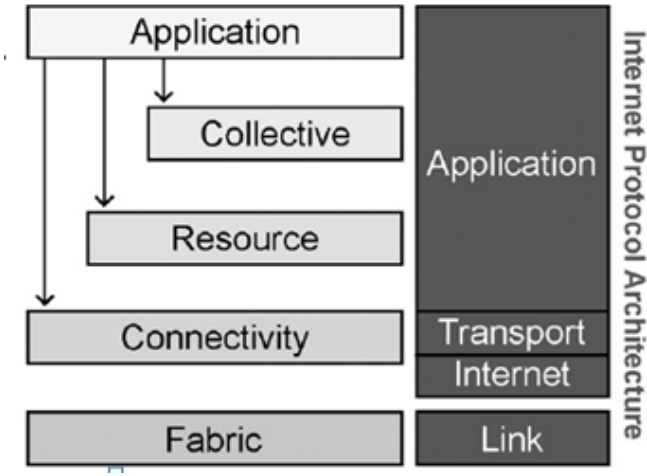
"Sharing single resources": negotiating access, controlling use

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

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

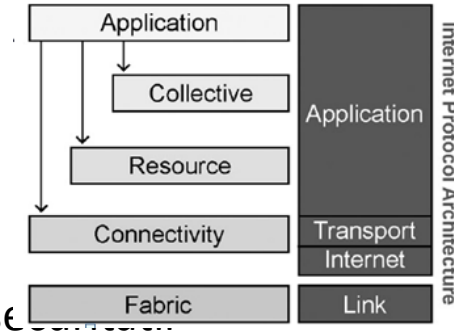


Grid Computing|Arhitectura



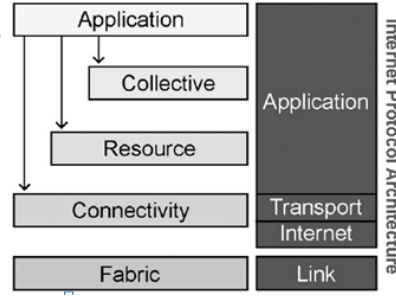
- **Fabric**
  - Furnizeaza resursele fizice (de calcul, de stocare, retea, …) pentru care accesul partajat este mediat de protocoalele Grid-ului
  - Ofera componente care implementeaza operatiile locale, specifice fiecarui tip de resursa
- **Connectivity**
  - Nucleu al protocoalelor de comunicare si de autentificare pentru tranzactiile de retea din interiorul Grid-ului
  - Servicii minimale pentru comunicare: transport, dirijare si numire
  - Solutii de autentificare: suport pentru *single sign on*, delegare, integrarea cu solutii de securitate locala, relatii bazate pe incredere (trust)

Grid Computing|Arhitectura



- **Resource**
  - Scop: utilizarea protocoalelor pentru comunicare si asigurarea se[illegible] (definite in *Connectivity*) pentru negocieri sigure, monitorizare, control, contabilitate si plata a operatiilor de partajare a resurselor individuale,
  - Exemplu de protocoale:
    - GridFTP – acces & transport eficient al datelor
- **Collective**
  - Ofera protocoale si servicii care privesc global resursele Grid-ului
    - E.g. faciliteaza interactiunile dintre seturi de resurse
  - Implementeaza servicii diverse de partajare:
    - Monitorizare si diagnosticare (e.g. supraincarcarea), Cuantificare si plata, …
- **Application**
  - Cuprinde aplicatiile utilizator care opereaza in Grid
    - Medii de programare + biblioteci de nivel inalt
    - Obs. Aplicatii Grid-enable (sau gridified) – > aplicatii proiectate sa ruleze in paralel si sa utilizeze procesoare multiple in Grid

Grid Computing|Arhitectura



- Functionalitati principale oferite de *Grid middleware* (format din cele cinci nivele)
  - Virtualizare si integrarea de resurse autonome eterogene
  - Furnizarea de informatii privind resursele si disponibilitatea lor
  - Management flexibil si dinamic privind alocarea resurselor
  - Securitate (autentificare si autorizare) si incredere
  - Managmentul licentelor
  - Facturare si plata
  - Furnizarea de QoS

- Grid computing funrizeaza avantaje companiilor astfel:
  - la nivel de mangment IT
  - la nivel de *business*

Grid Computing

- Avantaje la nivel de mangment IT:
  - Grid inglobeaza resurse eterogene => disponibilitatea unei puteri mai mare de calcul si utilizarea eficienta a resurselor
  - scaderea costurilor achizitiilor
  - scalabilitatea infrastructurii prin reducerea granitilor intre departamente
  - Eficienta in calcul si acces la resurse datorata: capacitatii de calcul paralel, load balancing => cresterea robustetii si *reliability*
  - In combinatie cu Utility Computing, Grid Computing permite transformarea de cheltuieli de capital pentru infrastructura IT în cheltuieli operaţionale şi oferă posibilitatea de scalabilitate sporită şi flexibilitate
- Avantaje la nivel de business
  - Costuri mai mici si venituri mai mari
  - Posibilitatea mai usoara de colaborare
  - Posibilitatea de a crea VO cu parteneri de afaceri

Grid Computing

- Riscuri si provocari :
  - O administrare potrivita va evita probleme de tipul “Sever hugging” (e.g. partajarea de resurse ce nu trebuie partajate)
  - Ajustarea aplicatiilor existente a.i. sa functioneze in Grid
  - Lipsa de standarde in Grid Computing conduce la decizii grele privind tehnologiile utilizate
  - Desi Grid este destinat sa functioneze pe baza de resurse eterogene, aceasta implicind costuri mari in ceea ce priveste integrarea acestora, se ia in calcul si posibilitatea respectarii unui standard a resurselor fizice => afectarea completa a infrastructurii IT

Initiative

- GridPP (UK Computing Grid for Particle Physics)
  - Parte integranta a celui mai mare Grid din lume: LCG (LHG Computing Grid)

    LHG = Large Hadron Collinder (CERN, din 2007)
  - LCG este compus din peste 5200 CPU-uri, 4000 TB de memorie, rulind peste 5000 de *task*-uri simultan
  - Face parte din cadrul proiectului EuroGrid
  - www.dridpp.ac.uk
- Fraunhofer Grid Alliance
  - Scop: oferirea unui Grid computational pentru acces facil la resursele Grid-ului via un portal Web
  - Bazat pe Globus Toolkit
  - Functioneaza in mediul academic si industrial
  - www.fhrg.fhg.de

Initiative

- Jgrid
  - Framework pentru Grid-uri compuse din componente hardware/software vazute ca servicii
  - Se bazeaza pe tehnologia Jini – infrastructura & model programatic pentru crearea de sisteme distribuite dinamice in Java
  - Aplicatiile jGrid pot fi dezvoltate via P-Grade (mediu de dezvoltare grafic)
  - http://jgrid.jini.org
- Alchemi
  - Sistem Grid bazat pe .NET Framework
  - Asigura interoperabilitatea cu alte sisteme Grid via Gridbus Grid Service Broker

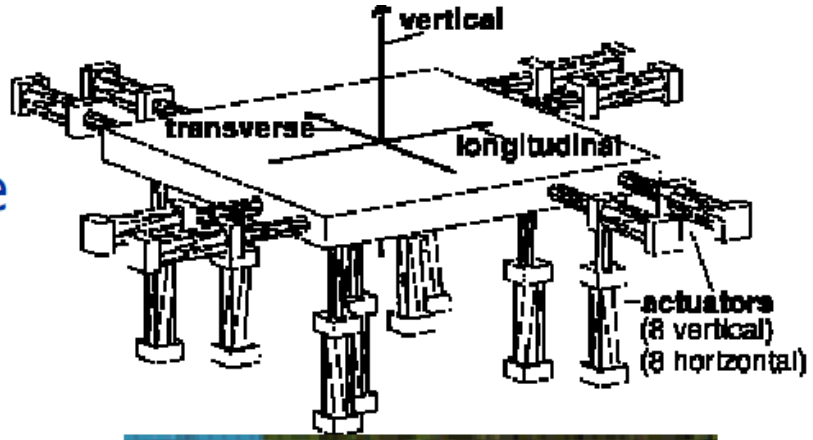
Aplicatii

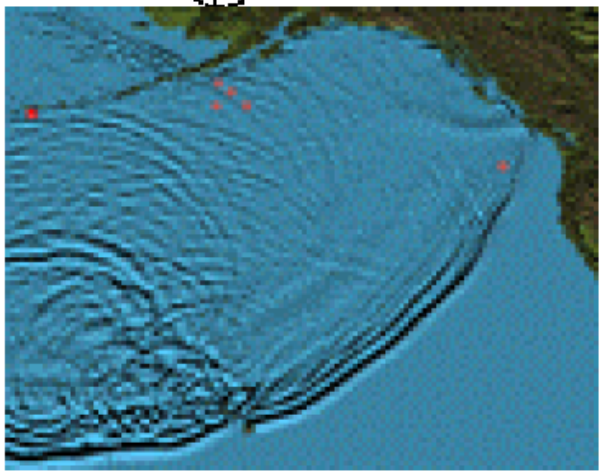
- Exemple de aplicatii
  - Vizualizarea 3D fotorealistica
    - Renderizare prin POV-Ray (Persistence of Vision Raytracer)
  - Chirurgie vasculara virtuala
    - CrossGrid
    - http://www.crossgrid.org
  - Rezolvarea problemelor de optimizare
    - Proiectul TRACER (foloseste arhitecturi ca Globus, Condor, Legion, Sun Grid Engine)
    - http://neo.lcc.uma.es/

Aplicatii

- Exemplu: Earthquake Engineering Simulation

  - NEESgrid: national infrastructure to couple earthquake engineers with experimental facilities, databases, computers, & each other
  - On-demand access to experiments, data streams, computing, archives, collaboration





NEESgrid: Argonne, Michigan, NCSA, UIUC, USC

[http://www.nesc.ac.uk/talks/talks/Grids_and_Globus.pdf]

Aplicatii

- Exemplu: Home Computers evaluate AIDS Drugs

- Community =
  - 1000s of home computer users
  - Philanthropic computing vendor (Entropia)
  - Research group (Scripps)
- Common goal= advance AIDS resear

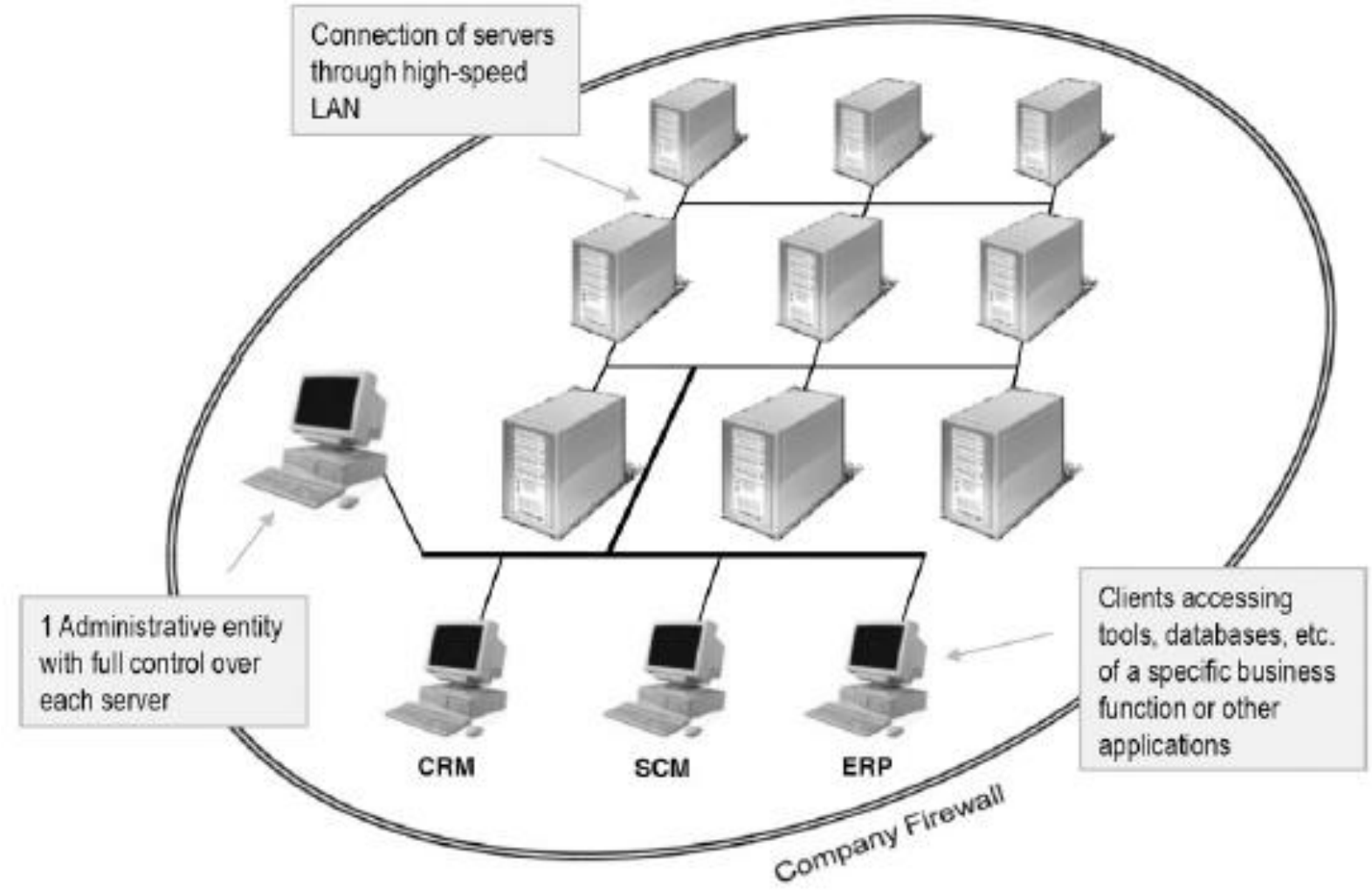
[http://www.nesc.ac.uk/talks/talks/Grids_and_Globus.pdf]

Grid Computing

- Clasificari
  - 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 mangmentul 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 SOC (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**

Tipuri

- **Cluster Grid**



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

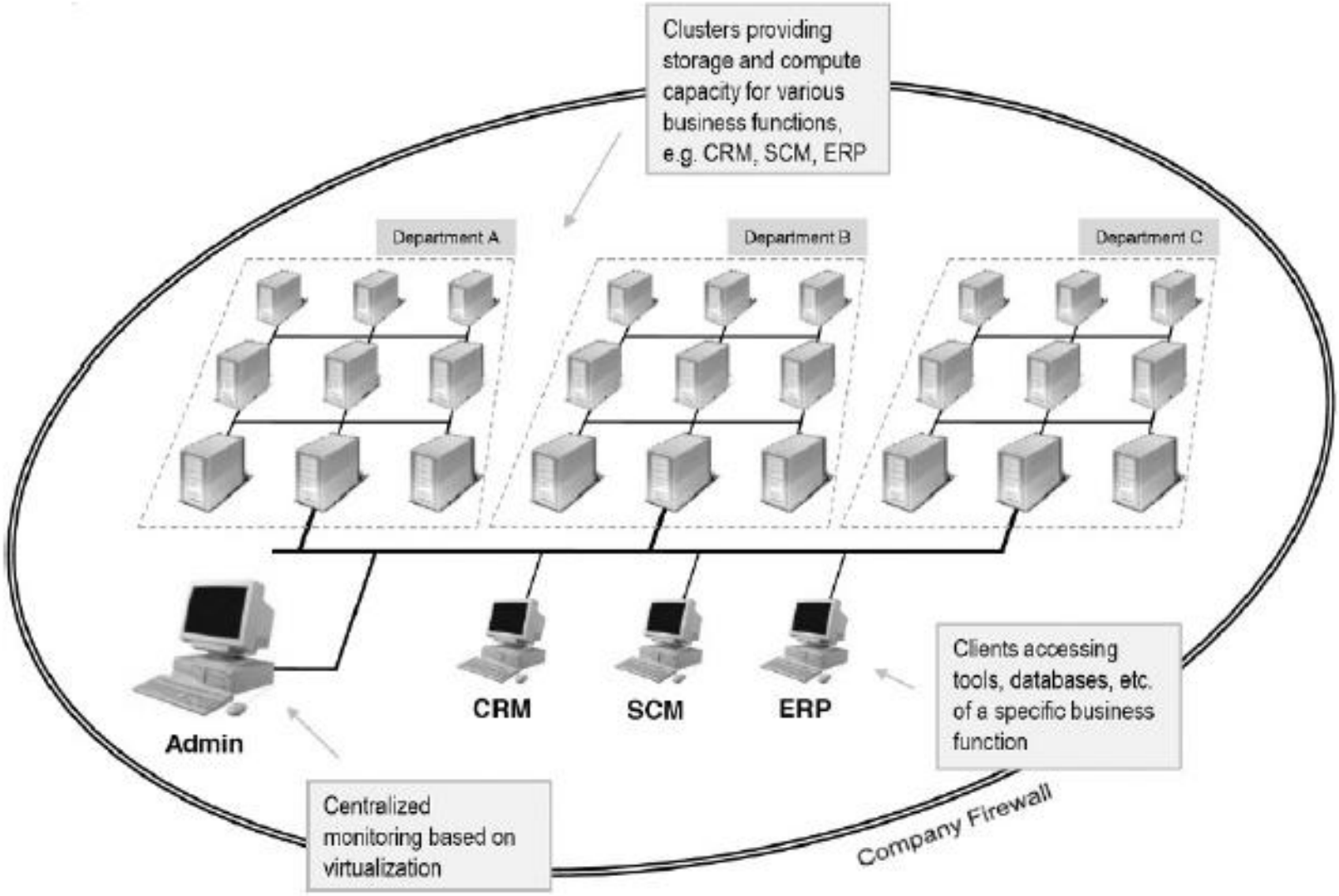
Tipuri

- **Cluster Grid**
  - Reprezinta o colectie de calculatoare interconectate folosite (si vazute) ca o resursa unica la nivel de departament/grup
    - *Departamental grid* (Sun)/ *infra grid* (IBM)
  - Face posibila utilizarea la maxim a resurselor colectiei de calculatoare

    (*mainframe*-uri, PC-uri, laptop-uri, *smartphone*-uri, ...)
  - Cluster = ansamblu de calculatoare – dintr-un LAN – care formeaza o resursa unica de calcul
  - Obs. Clusterele nu ofera implicit partajare de resurse (imbunatateste capacitatea de calcul si de stocare), dar poate fi considerat primul pas spre Grid Computing

Tipuri

- **Enterprise Grid**



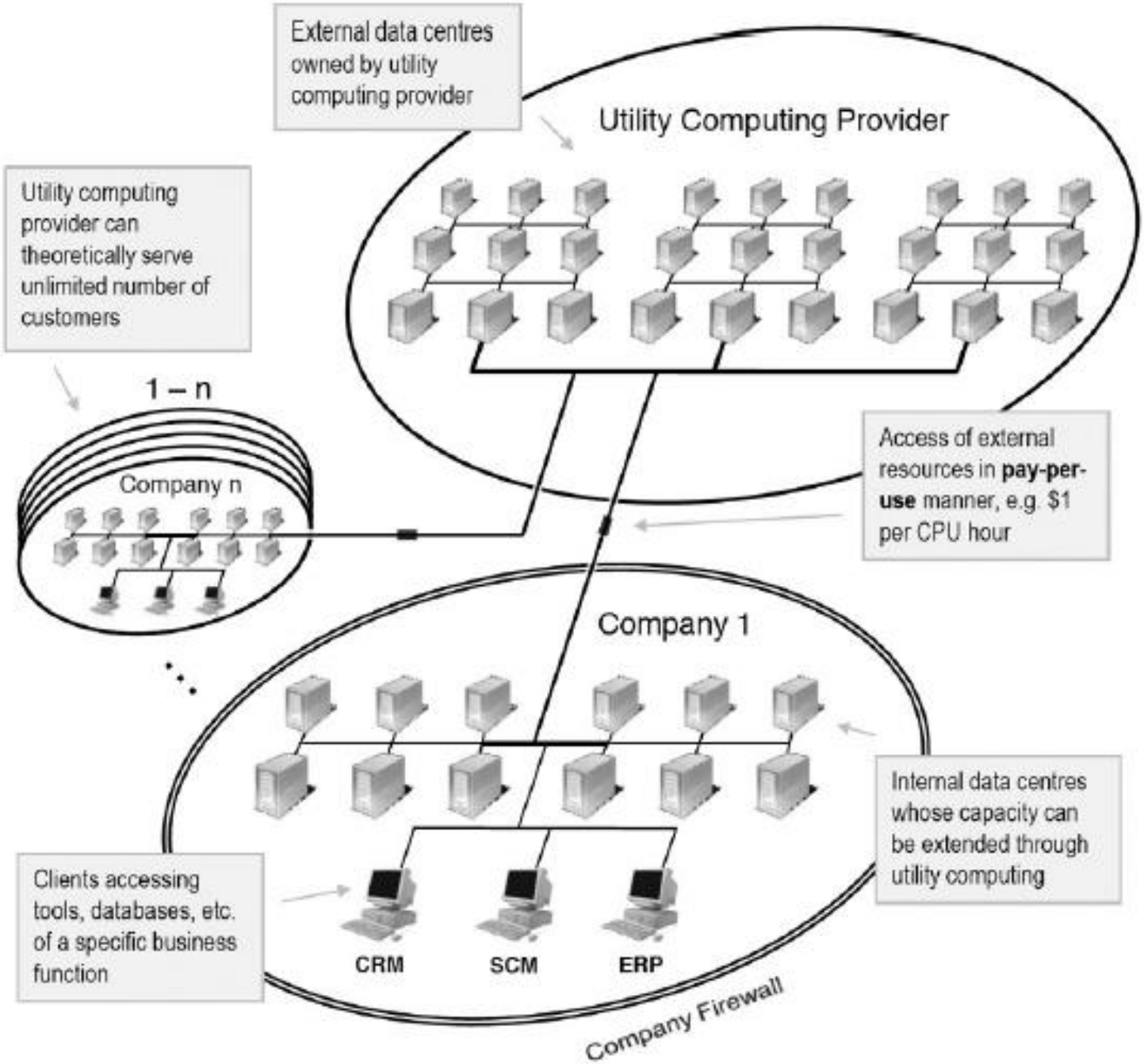
[Grid and Cloud Computing - A Business Perspective on Technology and Applications, 2010]

Tipuri

- **Enterprise Grid**
  - Faciliteaza partajarea de resurse intre mai multe departamente si colective din cadrul unei organizatii (virtuale)
    - Politici de management a resurselor
  - Numit si *intra grid* ori *campus grid*
  - Exemplu: Compania Farmaceutica Novartis
    - Detinea in 2003: 65000 de PC-uri desktop
    - Initial Grid Pilot: 2003, Basel (Elvetia), 50 *PC*-uri "*Grid enabled*" conectate la nodurile existente (Scop: determinarea structurii proteinelor)
      - In fiecare nod exista un agent care verifica incarcarea sistemului
      - => rezultat: o saptamana de rulare in Enterprise Grid a condus la rezultate care se puteau obtine in 3,18 ani
    - 2700 PC-uri (Basel, Viena, Cambridge)

Tipuri

- **Utility Grid**



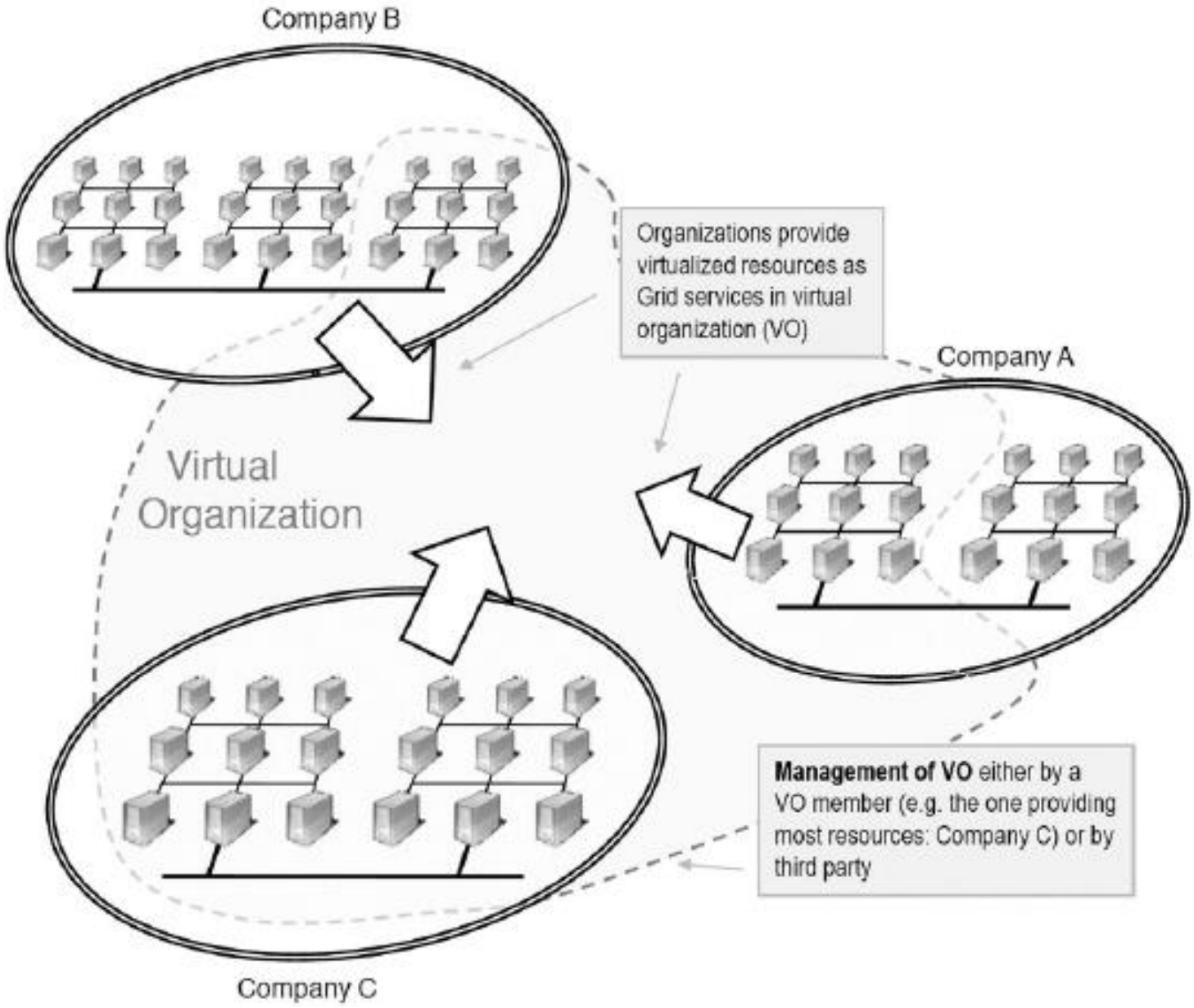
[Grid and Cloud Computing - A Business Perspective on Technology and Applications, 2010]

Tipuri

- **Utility Grid**
  - Este un Grid dezvoltat si administrat de un furnizor de servicii, si utilizarea capacitatii de calcul si/sau stocare se face in maniera *pay-per-user*
  - Functionalitate: utilizatorul nu detine un astfel de Grid si nu detine controlul asupra operatiilor; sunt transmise datele si cereri de calcul si apoi se asteapta rezultatul;
    - => probleme de securitate si *privacy*
    - => nu sunt necesare investitii in infrastructura IT
    - => Utility Computing ofera scalabilitate si flexibilitate la cerere
  - Exemple:
    - Sun Grid Compute Utility din 2006
      - *Pay-per-use*: 1$/CPU – ora
    - HP Labs ofera Utility Computing companiei DreamWorks

Tipuri

- **Partener/ Community Grid**



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

Tipuri

- **Partener/Community Grid**
  - Ofera suport pentru construirea de VO bazata pe infrastructura IT de partajare de resurse
  - Arhitectura poate fi vazuta ca o colectie de resurse independente (e.g. Cluster Grids) interconectate de un Grid middleware global
  - Partener grids – se stabilesc intre companii sau universitati ce au un scop comun
    - Se definesc politici de partajare de resurse
  - Community Grids – se bazeaza pe donatia de resurse (deseori de la persoane private)
    - Exemplu: SETI@HOME

- **Viziune: Open Global Grid**
  - Reprezinta o colectie de Grid-uri eterogene, plus alte resurse distribuite geografic pe o arie larga – continet sau planeta
    - Politica de utilizare globala
    - Protocoale generale de partajare a resurselor
    - => nu este necesara o configuratie suplimentara pentru acces

Grid Computing| Evolutie

- **Generatia 1** – proiectul Globus (Goble & Foster)
  - Dezvoltare in medii academice
  - Aplicatii necesitind putere mare de calcul
  - Include protocoale (LDAP, FTP) si instrumente de dezvoltare eterogene
  - Suport pentru accesul si trasferul de fisiere
  - Foloseste tehnologii Internet, dar ignora Web-ul
  - Partajarea resurselor se realizeaza via GridFTP
  - Au urmat…Legion, Condor (HTCondore – 2012), Unicore (http://www.unicore.eu/testgrid/), ….

Grid Computing| Evolutie

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

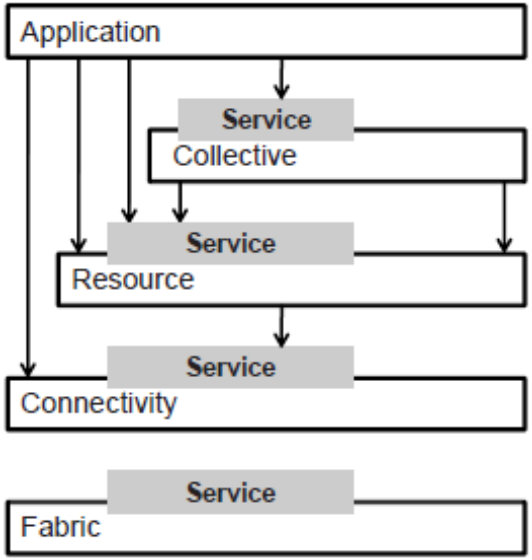
> "Service-oriented Computing (SOC) is a new computing paradigm that utilizes services as the basic construct to support the development of rapid, low-cost and easy composition of distributed applications even in heterogeneous environments. The visionary promise of Service-Oriented Computing is a world 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 acelasi standarde => a fost posibila convergenta Grid Computing si SOC => pe langa resursele hardware si de sistem, devin partajabile si aplicatiile rulind pe acestea

- 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)

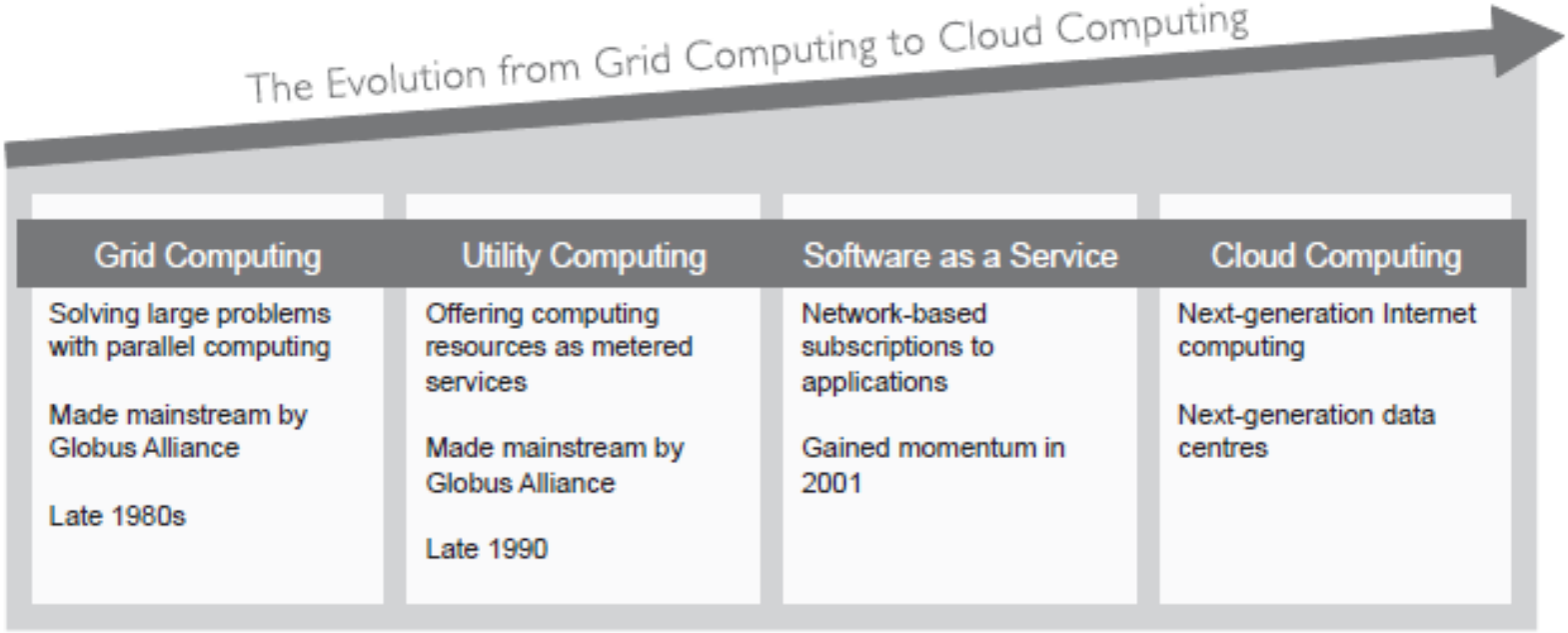
Grid Computing| Evolutie

- **Generatia 3** – prezent si viitor
  - Convergenta Grid Computing, SOC si paradigma SaaS (***Software-as-a-Service***)
  - **SaaS**
    - Desemneaza software care este detinut, furnizat si gestionat de un furnizor
    - Este consumat pe principiul *pay-per-use* via un Web browser sau APIs
    - Versus software traditional
      - Utilizatorul plateste functionalitatea pentru timpul de utilizare
      - Utilizatorul nu detine softul, nu a facut investitii in infrastructura, licente etc.
    - Istoric: conceptul a aparut in1998, 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, incredere

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*



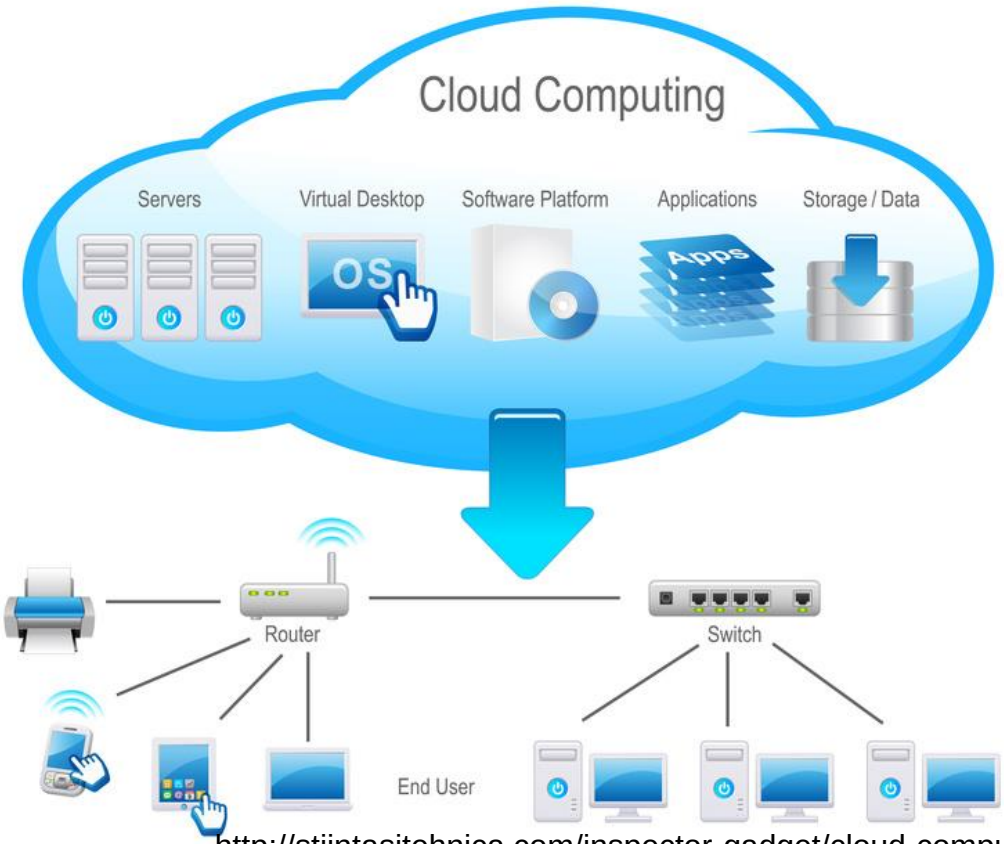
The Evolution to Cloud Computing (adapted from IBM 2009)

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

Cloud Computing

-> Master ☺

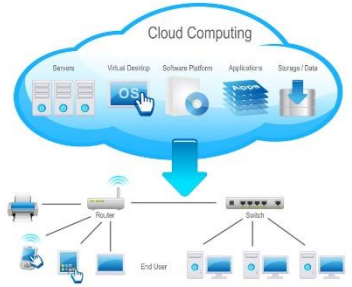
Cloud Computing



http://stiintasitehnica.com/inspector-gadget/cloud-computing-procesarea-intangibila

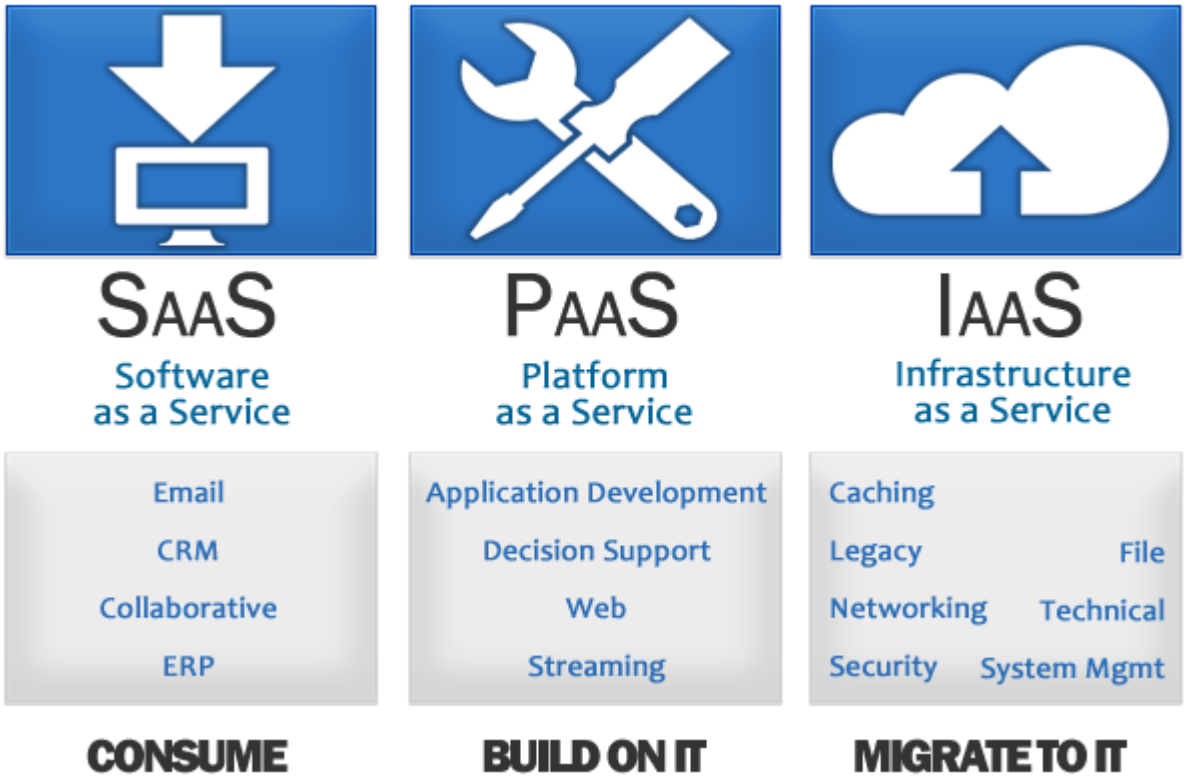
- Concept care reflecta seria de transformari in IT catre o economie bazata pe servicii
- Companiile sunt dispuse sa plateasca serviciile si mai putin produsele

Cloud Computing

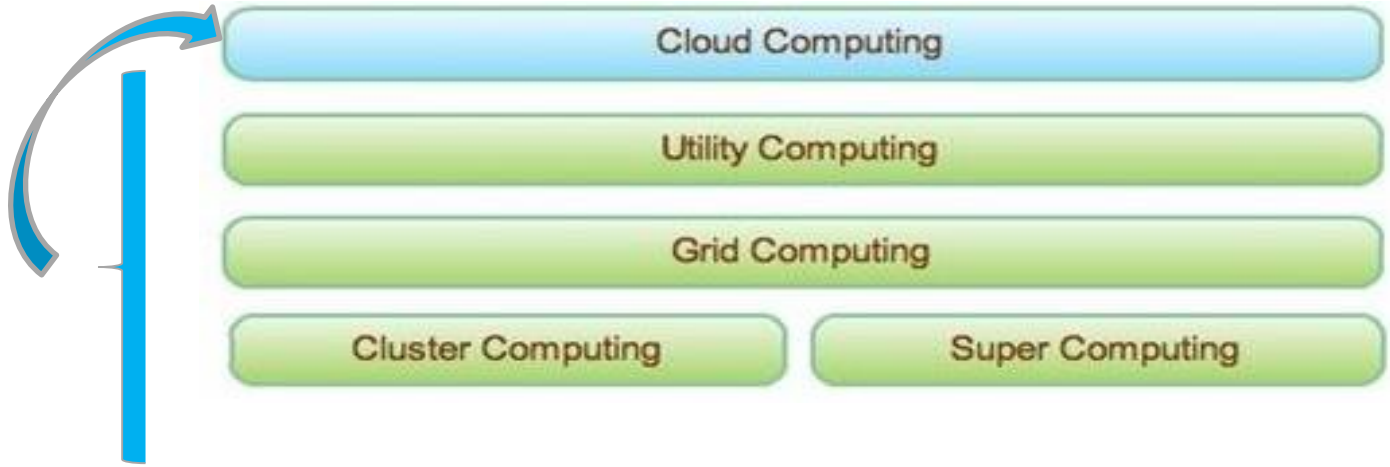


- *"a new generation of computing that utilizes distant servers for data storage and management, allowing the device to use smaller and more efficient chips that consume less energy than standard computers"*
- *"Cloud Computing is a computing paradigm in which tasks are assigned to a combination of connections, software and services accessed over the Internet. This network of servers and connections is collectively known as "the cloud."*
- Asigura utilizatorilor sansa de a dispune de putere de calcul
  - E.g. Photosopul accesat de pe un telefon mobil ☺

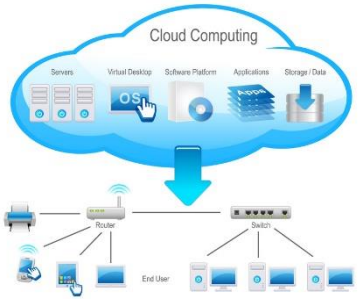
Cloud Computing



… pasii care
au condus catre



Cloud Computing



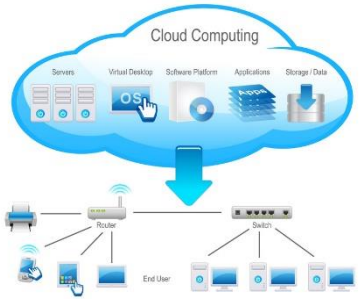
- Tipuri de servicii:
  - **Infrastructure-as-a-Service** (IaaS)
    - E.g. Amazon Web Services furnizeaza instante de servere virtuale cu adresa IP unica si spatiu de stocare, la cerere prin intermediul unui API;

      Se permite platirea serviciilor in functie de resursele consumate

      (modelul de consum al electricitatii, apei,…) => utility computing
  - **Platform-as-a-Service** (PaaS)
    - Partea software si instrumentele gazduite de furnizorul de infrastructura
    - Dezvoltatorii pot utiliza API-uri, portaluri pentru dezvoltarea de aplicatii
    - Exemple: Force.com, GoogleApps
    - Obs. Unii furnizori nu permit mutarea softului creat pe alte platforme
  - **Software-as-a-Service** (SaaS)
    - Serviciile pot fi “orice”: email, procesari de baze de date, …

Avantaj: Furnizorul detine si aplicatia si datele => *end-user* le poate accesa de oriunde

Cloud Computing

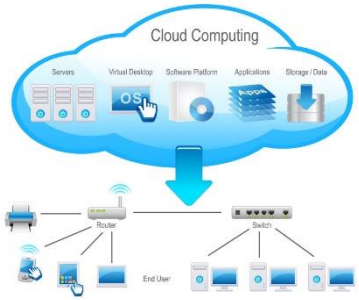


Obs. Un serviciu cloud difera de un serviciu de *hosting* obisnuit

- Este vindut la cerere (minute, ore)
- Flexibilitate - posibilitatea de a accesa un serviciu in functie de preferinte
- Serviciul este manipulat in totalitate de furnizor (utilizatorul are nevoie doar de un computer personal si acces la Internet)

- Clasificare
  - Cloud public – vinde servicii oricui in internet (e.g. Amazon Web Services)
  - Cloud privat – disponibil pentru un numar limitat de persoane
  - Cloud hibrid

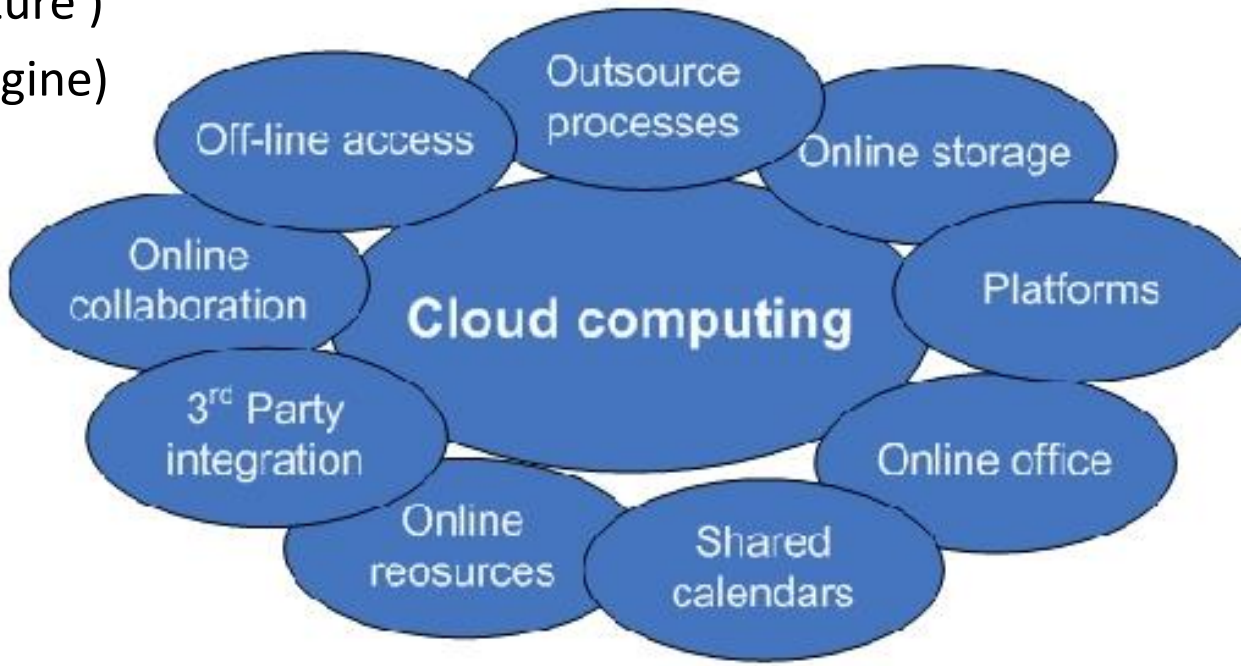
Cloud Computing



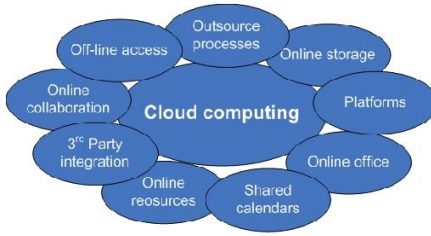
- **Aspecte**
  - *Self-healing – failover*
    - Resurse interschimbabile (servere, sisteme de stocare, retele)
  - *Service Level Agreements-driven*
  - *Multi-tenancy*
    - Partajarea infrastructurii, fara afectarea securitatii sau a confidentialitatii
  - Virtualizare
    - Aplicatii multiple pot rula pe un singur calculator sau mai multe calculatoare pot fi folosite pentru a executa o aplicatie (*grid computing*)
  - Scalabilitate Liniara – comportamentul sistemului va putea fi predictibil odata cu cresterea cererilor pentru o aplicatie
  - Aplicatii (si instrumente de dezvoltare a acestora) corespunzatoare

Cloud Computing

- Furnizori:
  - Amazon.com
  - Microsoft (Windows Azure)
  - Google (Google App Engine)
  - OpenStack
  - Salesforce
  - Eucalyptus
  - …
- Parteneriate
  - SAP si IBM
  - HP, Intel si Yahoo!
  - IBM si Amazon
  - Yahoo! si Computational Research Laboratories



Cloud Computing



- **Provocari:**
  - Reducerea costurilor de infrastructura
  - Management eficient
  - … altfel spus se urmaresc castiguri in 3 directii
    - Timp/eficienta
    - Mobilitate
    - Bani

mecanisme de baza a unei afaceri competitive

Cloud Computing

.....☺

Trecut…(statistici)

Worst Performing Industries In The Past Decade (2000-2009)

Rank	Worst Performing	Growth
1	Men's & Boys' Apparel Manufacturing	-89.1%
2	Clothing Accessories Manufacturing	-76.2%
3	Money Market & Other Banking	-73.3%
4	Broad Woven Fabric Mills	-72.7%
5	Women's & Girls' Apparel Manufacturing	-71.4%
6	Apparel Knitting Mills	-70.9%
7	Leather Tanning & Finishing	-70.0%
8	Manufactured Home Dealers	-67.4%
9	Circuit Board & Electronic Component Manufacturing	-63.9%
10	Recordable Media Manufacturing	-63.7%

[http://smallbiztrends.com/2009/12/top-10-industries-of-the-decade.html]

Prezent&Viitor…(statistici)

Worst Performing Industries In The Coming Decade (2010-2019)

Rank	Worst Performing	Growth
1	Wired Telecommunications Carriers	-52.0%
2	Tank & Armored Vehicle Manufacturing	-51.9%
3	Vacuum, Fan & Small Household Appliance Manufacturing	-34.4%
4	DVD, Game & Video Rental	-32.8%
5	Photofinishing	-31.5%
6	Lighting & Bulb Manufacturing	-26.8%
7	Telecommunications Resellers	-26.4%
8	Laminated Plastics Manufacturing	-25.3%
9	Synthetic Fiber Manufacturing	-24.6%
10	Wire & Spring Manufacturing	-24.5%

[http://www.inc.com/news/articles/2010/01/best-and-worst-industries.html]

Trecut…(statistici)

Best Performing Industries In the Past Decade (2000-2009)

Rank	Best Performing	Growth
1	Voice Over Internet Protocol Providers (VoIP)	See Note
2	Search Engines	1655.9%
3	eCommerce & Online Auctions	468.9%
4	Online Dating & Matchmaking	248.8%
5	Tank & Armored Vehicle Manufacturing	244.7%
6	Petrochemical Manufacturing	221.2%
7	Mining Support	186.7%
8	Wireless Telecommunications Carriers	183.4%
9	Biotechnology	182.1%
10	Warehouse Clubs and Supercenters	146.5%

[http://smallbiztrends.com/2009/12/top-10-industries-of-the-decade.html]

Prezent&Viitor…(statistici)

Best Performing Industries In The Coming Decade (2010-2019)

Rank	Best Performing	Growth
1	Voice Over Internet Protocol Providers (VoIP)	149.6%
2	Retirement & Pension Plans	133.7%
3	Biotechnology	127.6%
4	eCommerce & Online Auctions	124.7%
5	Environmental Consulting	120.3%
6	Video Games	112.9%
7	Trusts & Estates	105.7%
8	Search Engines	100.9%
9	Recycling Facilities	80.9%
10	Land Development	72.7%

[http://www.inc.com/news/articles/2010/01/best-and-worst-industries.html]

Prezent&Viitor…(statistici)

- Top 5 joburi (2014 ->…)
  - Ethical Hacker
  - Logistician
  - Actuary
  - Epidemiologist
  - Front-End Engineer (front-end web developers)

http://www.businessinsider.com/high-paying-jobs-of-the-future-2014-1

Cuprins

- Istoric
  - Curs 1
- Prezent…Viitor
  - Curs 1->Curs 13
  - Cloud Computing
  - Grid Computing
  - Grid Computing vs Cloud Computing

    - Anul III, Semestrul II – Cloud Computing
    - Master, Semestrul II – Programare Concurenta si Distribuita

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“Little by little, one travels far.”
(J. R. R. Tolkien)