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Virtualization and Clouds
Lecture 3
**Unweaving Clouds:
Principles and Practices**

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CERN

Inverted CERN School of Computing, 3-4 March 2011

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What is Cloud Computing?

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What is Cloud Computing?

- **Cloud Computing definitions?**
  - Cloud Computing is a style of computing where scalable and elastic IT-enabled capabilities are delivered as a service to external customers using Internet technologies. *Thomas Bittman - Gartner*

  - Cloud Computing is an emerging IT development, deployment and delivery model, enabling real-time delivery of products, services and solutions over the Internet. *Frank Gens - IDC*
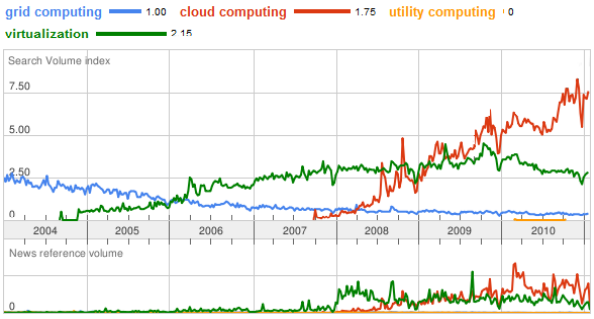
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Cloud Computing hype?

grid computing — 1.00   cloud computing — 1.75   utility computing — 0
virtualization — 2.15

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Cloud Computing hype?

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Cloud Computing hype?

Source: Gartner (August 2010)

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Cloud Computing hype?

- **IT spending on cloud computing**
  - The most important significant change in the IT priorities of ESG's 2011 survey is the increased importance attached to cloud computing services. – *ESG Research*.
  - 66% of midsize firms surveyed have cloud computing projects in progress or in planning stage. - *IBM, "Inside the Midmarket: a 2011 prespective"*.
  - 65% or more of new enterprise IT spending to be cloud-based by 2015. – *Saugatuck Technology Inc.*

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Cloud Computing hype?

- **Some companies with "cloud" solutions**

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Cloud Computing hype?

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What is Cloud Computing?

- **Cloud Computing definition?**
  - Cloud computing is about the evolution of dynamic virtualized infrastructure that allows us to think more in terms of resource pools than individual IT components. (…) *Dale Vile - Freeform Dynamics*

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What is Cloud Computing?

Some history and background

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Some history and background

- **70's – 80's: Mainframe Era**
  - powerful computers used mainly by large organizations for critical applications;
  - centralized computing;
  - no communication with outside;
  - virtualization;

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Some history and background

- **90's – 2000's: Client Server Era**
  - maybe there is more than one computer in the world;
  - common hardware becomes more powerful;
  - distributed computing;

Some history and background

- **2010 – beyond: Cloud Era?**
  - increased network bandwidth and reliability;
  - no need to invest large amounts of money in hardware;
  - large data centers
  - high service availability;

What is cloud computing?

- **Cloud Computing definition?**
  - Cloud computing describes 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. *Dan Kusnetzky, Rachel Chalmers - 451 Group*

Cloud vs Utility Computing

- **Utility Computing**
  - renting of computing resources such as hardware, software and network bandwidth on an as-required, on-demand basis;
  - what were earlier considered products, are treated as services.

Cloud vs Utility Computing

- **Is utility computing, cloud computing?**

no

Maybe they share some characteristics, but they are different concepts;

Cloud vs Server Virtualization

- **Server Virtualization**
  - utilization of a software application to divide one physical server into multiple isolated virtual environments;
  - its able to run multiple and different operating systems in a single server.

Cloud vs Server Virtualization

- **Is server virtualization, cloud computing?**

no

Maybe they share some characteristics, but they are different concepts;

Cloud vs Grid Computing

- **Grid Computing**
  - use of computer resources from multiple administrative domains to reach a common goal;
  - allowed single authorization to all resources;
  - distributed system;
  - loosely coupled, heterogeneous, and geographically dispersed resources;
  - uses a software layer to interact with the resources;

Cloud vs Grid Computing

- **Is grid computing, cloud computing?**

no

Maybe they share some characteristics, but they are different concepts;

What is cloud Computing?

- **Cloud Computing definition?**
  - Cloud computing is the next stage in the evolution of the Internet. The cloud in cloud computing provides the means through which everything — from computing power to computing infrastructure, applications, business process to personal collaboration — can be delivered to you as a service wherever and whenever you need. (…)
    There are three models for Cloud: Infrastructure as a Service, Platform as a Service, and Software as a service.
    Cloud Computing for Dummies by Wlley

How are clouds classified?

VERTICAL CLOUDS, ELASTIC CLOUDS, YOU NEVER KNOW WHICH WAY TO LOOK THESE DAYS!

How are clouds classified?

- **Most popular cloud services:**
  - SaaS - Software as a Service;
  - PaaS - Platform as a Service;
  - IaaS - Infrastructure as a Service;

SaaS
PaaS
IaaS

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How are clouds classified?

- **IaaS – Infrastructure as a Service**
  - provide access to collections of virtualized computer hardware resources (machines, network, storage);
  - users assemble their own virtual cluster on which they are responsible for maintaining;
  - typically billed on a utility computing basis;

  - Examples:
    - Amazon EC2;
    - Rackspace cloud servers;
    - GoGrid

How are clouds classified?

- **PaaS – Platform as a Service**
  - users develop, test deploy, host and maintain their own applications within an environment offered by the service provider;
  - environment with scalable compute and data structures embedded in it;

  - Examples:
    - Google App Engine;
    - Microsoft Azure;
    - force.com;
    - heroku;
    - Engine Yard;

How are clouds classified?

- **SaaS – Software as a Service**
  - easy access to hosted applications over the network. Most likely using a browser;
  - no local server installation. Controlled and executed on the provider's infrastructure;
  - system maintenance often included in the service;

  - Examples:
    - Google Docs;
    - ZoHo CRM
    - Salesforce.com

How are clouds classified?

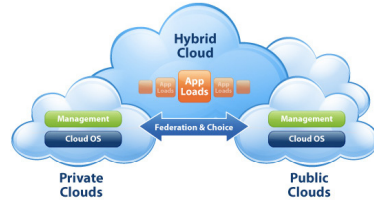iCSC 2011   3 - 4 March 2011, CERN

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How are clouds classified?

- **Most popular cloud types:**
  - Public cloud;
  - Private cloud;
  - Hybrid cloud;

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How are clouds classified?

- **Public cloud**
  - infrastructure is owned by a single organization and made available to other organizations / users;
  - customer's rent access to resources as needed on a pay-as-you-go basis;
  - offer access to large pools of scalable resources on a temporary basis;

  - Examples:
    - Commercial cloud providers;
    - Community public clouds – enable scientific and educational projects;

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How are clouds classified?

- **Private cloud**
  - Infrastructure is owned by a single organization and made available only to the organization;
  - Is subject to the organization's physical, electronic, and procedural security measures;
  - Improve data center efficiency while reducing operational expense;

  - Examples:
    - Optimize and simplify internal operation;
    - IT consolidation within large organizations;

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How are clouds classified?

- **Hybrid cloud**
  - combines computing resources drawn from one or more public clouds and one or more private clouds at the behest of its users;

  - Examples:
    - Cloudbursting to address peak demands;
    - Cloud Federation to share infrastructure with partners;
    - Cloud Aggregation to provide a larger resource infrastructure;

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What is Cloud Computing?

- **Cloud Computing definition?**
  - Cloud computing is nothing more than a service model where business workloads are deployed, transparently executed internally or somewhere on the Internet, and businesses only pay for what they consume. Rather than purchase servers, storage, and other pieces of IT equipment, businesses simply purchase a set of dials and indicators that finely-tune and adjust IT performance, availability, data protection, and security based on business requirements regardless of the actual physical location of the applications and data. *Mark Bowker, Steve Duplessie - Enterprise Strategy Group*

Cloud standards

- **How important are they?**
  - A standard is an established norm or requirement about technical systems;
    - Interoperability;
    - Measurement;

  - Standards for configuration and management of cloud services are lacking;

Cloud standards

Occi
Open Cloud Computing Interface

- **Open Cloud Computing Interface**
  - set of open community-lead specifications delivered through the OGF – Open Grid Forum;
  - protocol and API for the management of a cloud;
  - serve many models as IaaS, PaaS and SaaS;

Cloud standards

amazon
web services™

- **Amazon Elastic Compute Cloud (EC2) and Simple Storage Service (S3)**
  - today the market-leading infrastructure-as-a-service APIs;
  - doesn't necessarily equate to a long-term standard;

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What is Cloud Computing?

- **Cloud Computing definition?**
  - Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction. *National Institute of Standards and Technology, Information Technology Laboratory .*

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Cloud Computing Risks

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Cloud Computing Risks

- **"Is Cloud Computing Secure?"**
  - the use of the internet makes it open to attackers worldwide;
  - are isolated data centers immune to attacks?
  - where is my data?

  - perhaps we should look more closely into the providers;
- **"Can I trust my cloud provider?"**
  - with so many companies offering "cloud services" careful is needed choosing the cloud provider;
  - but, is this process different from selecting a vendor or a provider of any service?

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Cloud Computing Risks

- **Where is my data? Some considerations…**
  - critical data distributed between different locations allows better reliability;

  - critical data distributed between different countries
    - Country X legislation can change and allows access to all data within its geographical borders;
    - US officials could access information about citizens of others countries "if that information is physically within the United States";

  - if data protection and privacy is a major concern maybe a private cloud should be considered;

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Cloud Computing Risks

- **Is Cloud Computing risk free?**
  - Security;
  - Compatibility;
  - Availability;
  - Compliance;
  - Monitoring;
  - Lock in;
  - Standardization;

What is Cloud Computing?

"Consensus" characteristics about

Cloud Computing

What is Cloud Computing?

- **On-demand self-service:** A consumer can unilaterally provision computing capabilities as needed automatically without requiring human interaction with each service's provider;

- **Broad network access:** Capabilities are available over the network and accessed through standard mechanisms.

- **Resource pooling:** The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model. There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided resources.

What is Cloud Computing?

- **Rapid elasticity:** Capabilities can be rapidly and elastically provisioned, to quickly scale out and rapidly released to quickly scale in. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be purchased in any quantity at any time.

- **Measured Service:** Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service. Resource usage can be monitored, controlled, and reported providing transparency for both the provider and consumer of the utilized service

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Cloud Computing in practice

- **How to provision a machine in a public cloud?**
  - different solutions/vendors/prices …

Amazon EC2

Rackspace Cloud Servers

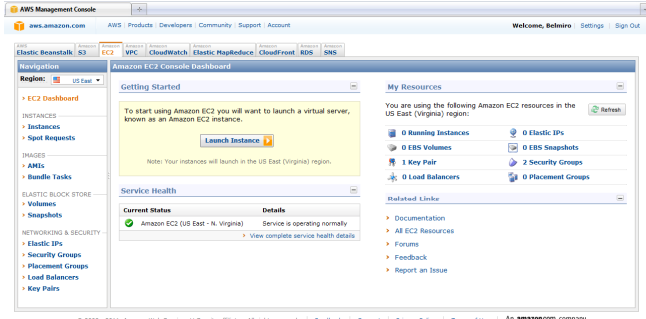# Cloud Computing in practice

- **How to provision a machine using Amazon EC2?**

  1. Create your account on Amazon (if you do not already have one) and setup your keys;

  2. Install Amazon EC2 API Tools or use the AWS console;

  3. Instantiate your images(s);

  4. Configure your instance;

Cloud Computing in practice

- **How to provision a machine using Amazon EC2?**

Amazon Web Services Console

Cloud Computing in practice

- **Using the AWS EC2 API tools to instantiate an image**

```
export EC2_PRIVATE_KEY=$HOME/<where your private key is>/pk-XXXX.pem
export EC2_CERT=$HOME/<where your certificate is>/cert-XXXX.pem
```

```
ec2-describe-images -o amazon

IMAGE     ami-225fba4b       ec2-public-images/fedora-core4-apache-mysql-
v1.07.manifest.xml   amazon     available public          i386       machine
                                instance-store     paravirtual
IMAGE     ami-25b6534c       ec2-public-images/fedora-core4-apache-
mysql.manifest.xml   amazon     available public          i386       machine
                                instance-store     paravirtual
IMAGE     ami-2e5fba47       ec2-public-images/fedora-core4-apache-
v1.07.manifest.xml   amazon     available public          i386       machine
                                instance-store     paravirtual
IMAGE     ami-23b6534a       ec2-public-images/fedora-core4-apache.manifest.xml
          amazon     available public          i386       machine
                                instance-store     paravirtual

(…)
```

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Cloud Computing in practice

- **Using the AWS EC2 API tools to instantiate an image**

```
ec2-add-keypair ec2-keypair > ec2-keypair.pem
```

```
ec2-run-instances ami-ccf405a5 -k ec2-keypair -t m1.small

RESERVATION        r-6cb76c01        980927233206        defaultINSTANCE     i-
8de9aae1 ami-ccf405a5                          pending   ec2-keypair        0
            m1.small 2011-02-17T08:09:38+0000     us-east-1c           aki-
407d9529                   monitoring-disabled
        ebs                                              paravirtual
```

```
ec2-authorize default -p 22
```

```
ec2-describe-instances

RESERVATION        r-6cb76c01          980927233206        defaultINSTANCE     i-
8de9aae1 ami-ccf405a5        ec2-50-16-58-182.compute-1.amazonaws.com         ip-10-
203-55-143.ec2.internal      running  ec2-keypair        0
        m1.small 2011-02-17T08:09:38+0000us-east-1c      aki-407d9529
                monitoring-disabled 50.16.58.182          10.203.55.143
                ebs                                              paravirtual
```

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Cloud Computing in practice

- **Using the AWS EC2 API tools to instantiate an image**

```
ssh -i <where is your keypair> ec2-user@ ec2-50-16-58-182.compute-1.amazonaws.com
```

```
Linux ip-10-203-55-143 2.6.35-24-virtual #42-Ubuntu SMP Thu Dec 2 05:01:52 UTC 2010
i686 GNU/Linux
Ubuntu 10.10
Welcome to Ubuntu!

ubuntu@ip-10-203-55-143:~$
```

```
ec2-terminate-instances i-8de9aae1
INSTANCE  i-8de9aae1        running   shutting-down
```

```
ec2-describe-instances
RESERVATION        r-6cb76c01          980927233206        defaultINSTANCE     i-
8de9aae1 ami-ccf405a5                        terminated            ec2-keypair
        0                m1.small 2011-02-17T08:09:38+0000     us-east-1c
        aki-407d9529                   monitoring-disabled
                ebs                                              paravirtual
```

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CERN internal cloud – "lxcloud"

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CERN internal cloud – "lxcloud"

- **CERN batch Farm "lxbatch"**
  - about 4000 physical nodes;
  - about 28400 intel cores;
  - about 4400 amd cores;
  - about 80 queues;
  - average throughput of 180000 jobs per day;
  - 25 different resource pools;

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CERN internal cloud – "lxcloud"

- **"lxbatch" on "lxcloud" motivation**
  - How to provide the right mix of environments matching needs?
  - How to resolve conflicts between new hardware and old OS?
  - How to manage intrusive interventions in a fragmented setup?
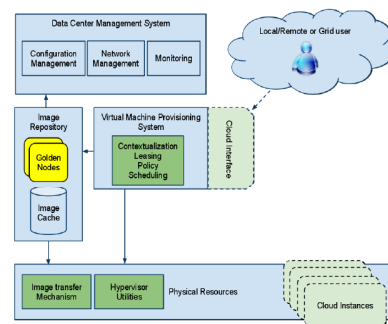

CERN internal cloud – "lxcloud"

- **"lxbatch" - virtual batch nodes**
  - Clones of real worker nodes but not managed by Quattor;
  - Instantiated proactively depending on demand;
  - Can coexist with physical worker nodes;
  - Dynamically join de batch farm as worker nodes;
  - Limited life time;

CERN internal cloud – "lxcloud"

- **"lxcloud" - architecture**

CERN internal cloud – "lxcloud"

- **"lxcloud" - architecture characteristics**
  - Image repository with "golden nodes";
  - Image distribution using bittorrent protocol;
  - Hypervisors fully Quattor managed;
  - VM instances Not Quattor managed have finite lifetime;
  - Specific IP/MACs are pinned to hypervisors;

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CERN internal cloud – "lxcloud"

- **"lxcloud" - image creation**
  - Derived from a centrally managed "golden node";
  - "golden node" is Quattor managed and always up to date;
  - Stored in an image repository and pushed to the hypervisors in case of an update;
  - Staged on hypervisors to speed up instance creation;
  - Different image flavors;
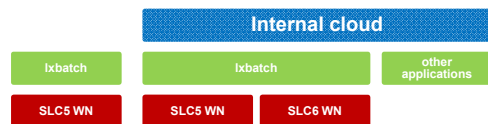

CERN internal cloud – "lxcloud"

- **"lxcloud" - image distribution**
  - Bittorrent protocol
    - Several implementation were tested, rtorrent was selected;
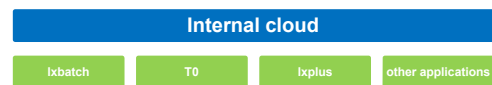 - A CERN developed software manages the images in the hypervisors;

CERN internal cloud – "lxcloud"

- **Present:**

Internal cloud		
lxbatch	lxbatch	other applications
SLC5 WN	SLC5 WN	SLC6 WN

- **(near?) Future?:**

Internal cloud			
lxbatch	T0	lxplus	other applications

CERN internal cloud – "lxcloud"

- **Management and provision systems:**
  - Platform ISF
    - Proprietary product provided by Platform Computing;

  - OpenNebula
    - Open Source product;

  - OpenStack "nova"
    - Open Source product;

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CERN internal cloud – "lxcloud"

- **Virtualization as cloud enabler**
  - KVM hypervisor;
    - Open source hypervisor;
    - Lightweight hypervisor module that comes with the mainstream Linux kernel;
    - Supported by Red Hat;

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Thank you

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