outline

- Cloud computing: Approach and vision
- Resource Provisioning in Cloud systems:
- Cloud Systems: IaaS, PaaS, SaaS
- Using Cloud Systems in practice
- Cloud system providers
- Open source Cloud middleware
What is Cloud Computing?

Cloud Computing is an Evolution in IT

Grid Computing
- Solving large problems with parallel computing
- Made mainstream by Globus Alliance

Utility Computing
- Offering computing resources as a metered service
- Introduced in late 1990s

Software as a Service
- Network-based subscriptions to applications
- Gained momentum in 2001

Cloud Computing
- Next-Generation Internet computing
- Next-Generation Data Centers

At Your Service
What is the cloud

• IT as a **service**
• Cloud allows **access to services** without user **technical knowledge** or control of supporting infrastructure
• Best describe in terms of what happened to electrical power over 100 years ago
• Now computers are simple devices connected to the leader cloud

Data processing, storage and software application that used to run locally are now being supplied by big central computing station, They are becoming in essence **computing utilities**
Traditional ways of provisioning resources
Expand your Infrastructure!
Buy new servers, increase your software costs, provision more datacenter capacity!!
Look to the cloud!
Pay for the bandwidth and server resources that you need.
When your push is done then turn the whole thing off!

• The Three Reasons to Cloud Compute: http://www.youtube.com/watch?
  annotation_id=annotation_308603&feature=iv&src_vid=SgujalzkwrE&v=OlbkMjrdjQ
What is Cloud Computing?

A style of computing where massively scalable IT-enabled capabilities are provided "as a service" over the network.

- **Acquisition Model**
  - Service based
  - "I only care about results, not how IT capabilities are implemented"

- **Business Model**
  - Usage based
  - "I want to pay for what I use, like a utility"

- **Access Model**
  - Internet, Intranet
  - "I can access services from anywhere, from any device"

- **Technical Model**
  - Dynamic, flexible
  - "I can scale up or down capacity, as needed"
Elastic approach to resource provisioning
Utility based usage metric

Cloud Computing Characteristics
Consumer Perspective

- **Single Point of Access**: Self service with rich user experience
- **Virtualization**: Increased system utilizations
- **Automation**: Automated service request and fulfillment
- **Agility**: Rapid service provisioning
- **Flexibility**: Massive scaling of IT services as needed
- **Usage Accounting**: Utility based usage metrics
- **Service Management**: Modular services managed across infra/platform/application/business stacks.
- **Security**: Shared services delivered across trusted domains
- **Cost Efficiency**: Reduced CapEx with minimal to no asset ownership
**Delivery Models**

*Cloud Delivery Models*

**Enterprise Internal Cloud** – Security sensitive Cloud services delivered behind the firewall.

**Public Cloud** – General Cloud Services delivered over the Internet.

**Hybrid Cloud** – Combination of internal and external cloud services.

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**Innovative Business Models**

- **Core Products**
  - Service Integration
    - Enterprise IT
      - Traditional data centers evolving to improve efficiency

- **Innovative Products**
  - Service Integration
    - Enterprise Cloud
      - Greenfield enterprise clouds for innovative solutions behind the firewall

- **Innovative Services**
  - Service Integration
    - Public Clouds
      - Clouds providing general consumer / business services outside the firewall

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• Cloud computing: Approach and vision
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  • Cloud Systems: IaaS, PaaS, SaaS
• Using Cloud Systems in practice
A new consumption Model for IT

Self Service
Instantly Provisioned
Pay For Use
Efficient
Scale Up & Down
Enabling Cloud

Software

Monolithic Applications

Distributed Services

Platform

Loosely Connected, Discrete Resources

Virtualized Fabric Of Resources
Abstract, Pool, automate
Abstract, Pool, automate
Grid middleware

Server

RAID – SAN/NAS

Disk
Everything-as-a-Service
Relation between IaaS, PaaS, SaaS
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Example of the elasticity and scalability (IaaS)

- To test the possibilities and performance of Grid on Demand a Biomedical Application and a workflow manager are used

- Biomedical Application: WAVE
  - Parallel (MonteCarlo simulation) application

- Workflow Manager
  - A (graphical) tool to assist complex e-Science application creation
  - Creates a series of jobsubmissions
  - WS-VLAM created by UvA SNE Group
  - Connects to Globus Grid Interface
Example of the elasticity and scalability (IaaS)

demand compared to a 32 node physical UvA cluster (DAS3) Globus Grid interface

<table>
<thead>
<tr>
<th>Resource provisioning</th>
<th>Jobs</th>
<th>Total execution time</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAS3</td>
<td>28</td>
<td>00:42:58</td>
</tr>
<tr>
<td>Grid on Demand</td>
<td></td>
<td>00:46:22</td>
</tr>
<tr>
<td>DAS3</td>
<td>98</td>
<td>02:46:36</td>
</tr>
<tr>
<td>Grid on Demand</td>
<td></td>
<td>00:52:26</td>
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</tbody>
</table>
Example of the elasticity and scalability
**Example of successful MSc project**

[Image: ws-vlam](https://example.com/ws-vlam)

**Building a grid-enabled cluster in the Amazon cloud**

**FEATURE | JANUARY 12, 2011**

Can grid computing be offered as a cloud service?

Willem Toorop and Alain van Hoof of the University of Amsterdam sought to find out for a research project called "Grid on Demand." ([Click here for the full report](https://example.com/report)).

The project sought to combine the distributed resource model of grid computing with cloud computing's ability to quickly (but temporarily) cope with sudden demands for massive amounts of computing power, or what is known as "urgent computing."

An "on-demand grid" could provide this ability, thus helping to support current or newly developed e-Science applications.

To test this prospect, the team created an Amazon Machine Image (AMI) to operate as a grid-on-demand and made it publicly available in most regions as a community AMI for 32-bit, 64-bit and cluster instance types. Due to issues with upper and lowercase hostnames the image cannot yet run in the eastern region of the US, and therefore the cluster instance type is not supported either. Otherwise, the AMI runs off-the-shelf and does not need external support services.

The AMI contains Ubuntu (Lucid) Linux with Torque Resource Manager 2.6.8 (Torque) as cluster software and Globus Toolkit 4.2.1 (GT) for grid participation. An initial instance operates as the cluster's head node and first compute node. A new Certificate Authority (CA) is created with which an initial host and grid-user certificate are generated. A just-launched instance can immediately be used as a grid resource.

Further configuration of the instance is offered through a web interface, to among other things authorize additional Grid EECS to use the resource.

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<table>
<thead>
<tr>
<th>Job#</th>
<th>Performance on DAS3 - 100 Jobs</th>
<th>Performance on Grid on Demand - 100 Jobs</th>
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<tbody>
<tr>
<td></td>
<td>Running time</td>
<td>Pending time</td>
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<tr>
<td>0</td>
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<td>100</td>
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<table>
<thead>
<tr>
<th>Cloud Marketplace</th>
<th>AppDirect</th>
<th>YX Appirio</th>
<th>Ingram Micro</th>
<th>myGravitant®</th>
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<tbody>
<tr>
<td>Cloud Broker Platform</td>
<td>cloudMatrix™</td>
<td>jamcracker.</td>
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<td>Netsuite</td>
<td>Salesforce</td>
<td>Taleo</td>
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<td>SaaS, PaaS, and IaaS</td>
<td>Azure</td>
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<td>Google</td>
<td>heroku</td>
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<td>enomaly</td>
<td>flexiant</td>
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<td>Eucalyptus</td>
<td>flexiant onapp</td>
<td>openstack</td>
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<td>Virtualization Software/Mgmt</td>
<td>Parallels</td>
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<td>Xen</td>
<td>Citrix</td>
<td>Hyper-V</td>
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<td>IBM</td>
<td>Dell</td>
<td>Oracle</td>
<td>HP</td>
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</tr>
</tbody>
</table>
### Infrastructure as a Service (IaaS).

<table>
<thead>
<tr>
<th>Provider</th>
<th>Products/Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amazon</td>
<td><strong>S3</strong> (Data storage/file system), <strong>SimpleDB</strong> (non-relational database) <strong>EC2</strong> (computing servers).</td>
</tr>
<tr>
<td>Rackspace</td>
<td><strong>Cloud Drive</strong> (Data storage/file system), <strong>Cloud Sites</strong> (web site hosting on cloud) <strong>Cloud Servers</strong> (computing servers).</td>
</tr>
<tr>
<td>GoGrid</td>
<td><strong>Cloud Hosting</strong> (web site hosting on cloud) <strong>Cloud Storage</strong> (Data storage/file system).</td>
</tr>
<tr>
<td>IBM</td>
<td><strong>Smart Business Storage Cloud Computing on Demand</strong> (CoD)</td>
</tr>
</tbody>
</table>
Platform as a Service (PaaS).

<table>
<thead>
<tr>
<th>Company</th>
<th>Platform</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Googles</td>
<td><strong>AppEngine</strong></td>
<td>is a development platform based upon Python and Java</td>
</tr>
<tr>
<td>force.com</td>
<td><strong>Apex</strong></td>
<td>a development platform based upon a proprietary programming language</td>
</tr>
<tr>
<td>Microsoft</td>
<td><strong>Azure</strong></td>
<td>provides a development platform based upon .Net.</td>
</tr>
</tbody>
</table>
# Software as a Service (SaaS)

<table>
<thead>
<tr>
<th>Company</th>
<th>Product Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Google</td>
<td>Google Docs, GMail, Google Calendar and Picasa</td>
</tr>
<tr>
<td>IBM</td>
<td><strong>LotusLive iNotes</strong>, a web based email service that provides messaging and calendaring capabilities to business users</td>
</tr>
<tr>
<td>Zoho</td>
<td>has vast suite of online products similar to Microsoft office suite.</td>
</tr>
</tbody>
</table>
Software as a Service (SaaS) applications processing

- Photo editing software
- Online file storage
- Twitter related applications
- Digital Video
- Photo Album
- Editing documents, spreadsheets and powerpoints
- Navigation: google Maps, Yahoo maps, …
- e-commerce software
- …
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OpenNebula
OpenNebula

- OpenNebula provides different interfaces to interact and manage physical and virtual resources.
OpenStack

• The OpenStack Open Source Cloud Mission:
  “to produce the ubiquitous Open Source Cloud Computing platform that will meet the needs of public and private clouds regardless of size, by being simple to implement and massively scalable. ”

• Originated by Rackspace and NASA In 2010