Module 6.1
Views of Cloud Computing

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Spring 2021
The Cloud is the Computer
- IEEE Spectrum, 2008

Datacenter as a Computer
- Barroso and Hölzle, 2009

The Network is the Computer
- Sun Microsystems, early 1990s
Cloudwashing

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NIST Cloud Computing 3-4-5 Definition

5 Essential Characteristics

2009-2011
16 versions

3 Service Models

4 Deployment Models
NIST Cloud Computing 3-4-5 Definition

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2009-2011
16 versions

3 Service Models
- Software as a Service (SaaS)
- Platform as a Service (PaaS)
- Infrastructure as a Service (IaaS)

4 Deployment Models
NIST Cloud Computing 3-4-5 Definition

5 Essential Characteristics

- On-demand self service
- Broad network access
- Resource pooling (multi-tenant)
- Rapid elasticity
- Measured service

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2009-2011
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Software as a Service (SaaS)
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4 Deployment Models
Public
Private
Community
Hybrid

World-Leading Research with Real-World Impact!
NIST Cloud Computing 3-4-5 Definition

5 Essential Characteristics

On-demand self service
Broad network access
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Rapid elasticity
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2009-2011
16 versions

Other Common Characteristics

Geographic distribution
Homogeneity
Resilience
Massive scale
Virtualization
Security

3 Service Models

Software as a Service (SaaS)
Platform as a Service (PaaS)
Infrastructure as a Service (IaaS)

4 Deployment Models

Public
Private
Community
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“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.”

I don’t think so
Cloud and Grid: Foster et al 2008

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Scale

Distributed Systems

Supercomputers

Grids

Clusters

Clouds

Web 2.0

Application Oriented

Services Oriented

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World-Leading Research with Real-World Impact!
1. Coordinates resources that are not subject to centralized control
   - Virtual Organization (VO)
2. Uses standard, open, general-purpose protocols and interfaces
   - Globus toolkit
3. Delivers non-trivial qualities of service
Grid versus Cloud

1. Coordinates resources that are not subject to centralized control
   - Virtual Organization (VO)
2. Uses standard, open, general-purpose protocols and interfaces
   - Globus toolkit
3. Delivers non-trivial qualities of service
   - Yes

Grid

- On-demand self service
- Broad network access
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- Rapid elasticity
- Measured service

Cloud

- Geographic distribution
- Homogeneity
- Resilience
- Massive scale
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- Security

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World-Leading Research with Real-World Impact!
## Grid versus Cloud Drivers

<table>
<thead>
<tr>
<th>Cloud</th>
<th>Grid</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Commercially developed</td>
<td>- DoD funded, no commercial traction</td>
</tr>
<tr>
<td>- Little or no academic input</td>
<td>- Mainly academic driven</td>
</tr>
<tr>
<td>- Pay-per-use</td>
<td>- Pay-per-seat (one-time payment)</td>
</tr>
<tr>
<td>- Payment driven</td>
<td>- Project oriented, proposal driven</td>
</tr>
<tr>
<td>- Centrally owned hardware</td>
<td>- Multiply owned hardware</td>
</tr>
<tr>
<td>- Centrally scheduled</td>
<td>- Distributed scheduling</td>
</tr>
<tr>
<td>- Single point of trust</td>
<td>- Multiple trust points</td>
</tr>
<tr>
<td>- Simple security</td>
<td>- Complex PKI based security</td>
</tr>
<tr>
<td>- Interactive</td>
<td>- Batch</td>
</tr>
<tr>
<td>- Commodity computing</td>
<td>- High performance computing</td>
</tr>
<tr>
<td>- Small and medium businesses</td>
<td>- High end organizations</td>
</tr>
<tr>
<td>- Virtualization essential</td>
<td>- Virtualization often not used</td>
</tr>
<tr>
<td>- Not so predictable performance</td>
<td>- Predictable performance</td>
</tr>
</tbody>
</table>
Figure 1. Users and providers of cloud computing. We focus on cloud computing's effects on cloud providers and SaaS providers/cloud users. The top level can be recursive, in that SaaS providers can also be SaaS users via mashups.
Not IaaS or PaaS but classes of utility computing
Cyber Security: What is Different in the Cloud?

Risk = \( f(\text{Threats, Vulnerabilities, Impact}) \)

- Threats
- Vulnerabilities
- Impact
Cyber Security: What is Different in the Cloud?

- Multi-Tenancy
- Security and Privacy
- Compliance and Forensics
- Cloud Service Provider