I·C·S
The Institute for Cyber Security

C·SPECC
Center for Security and Privacy
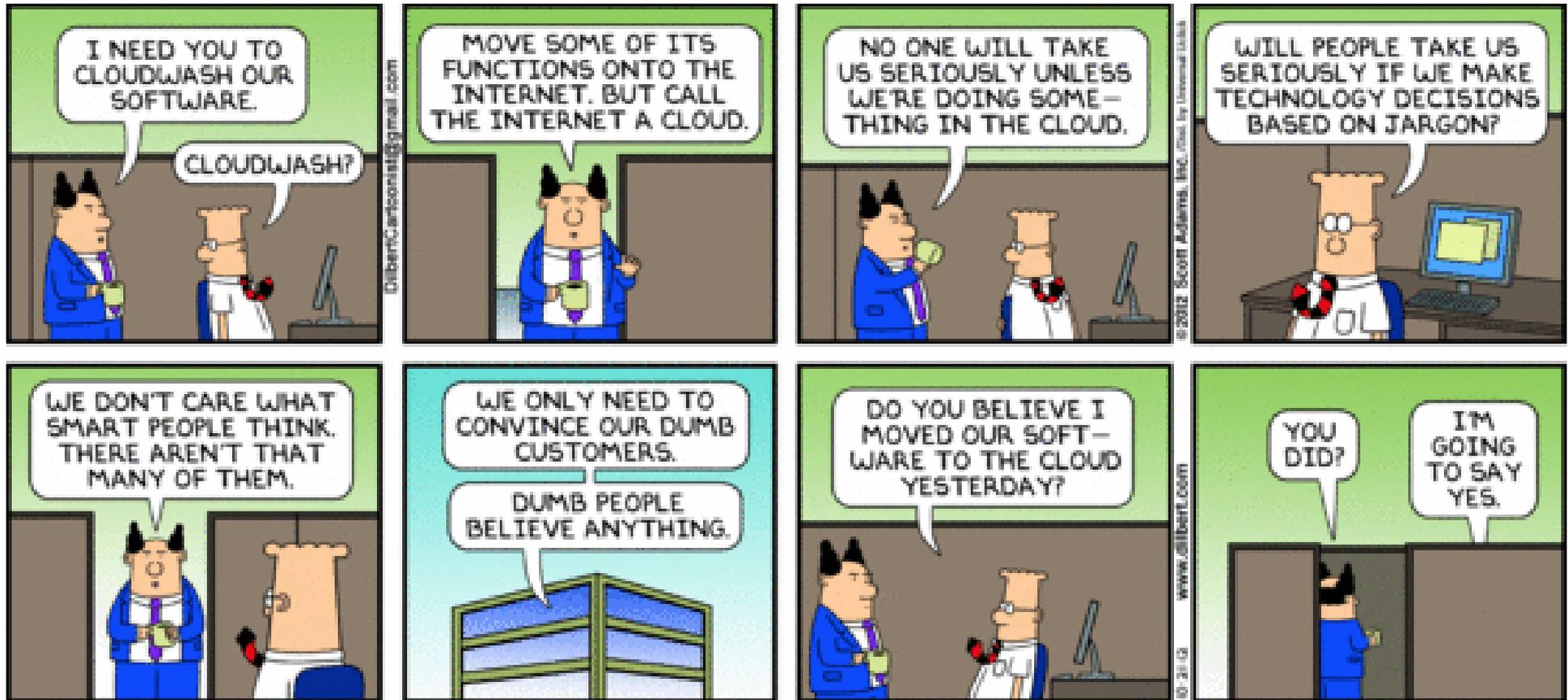Enhanced Cloud Computing

Module 6.1
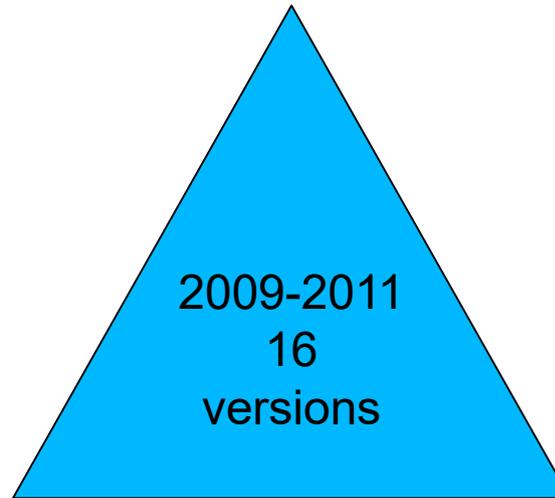# Views of Cloud Computing

Ravi Sandhu

Spring 2021

UTSA
Computer Science

The Cloud is the Computer
- IEEE Spectrum, 2008
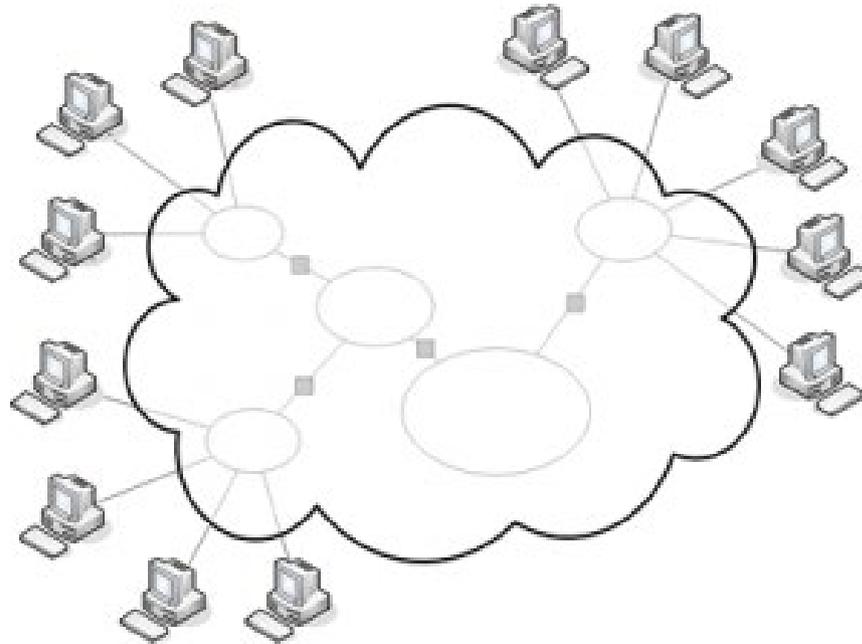
The Network is the Computer
- Sun Microsystems, early 1990s

Datacenter as a Computer
- Barroso and Hölzle, 2009

World-Leading Research with Real-World Impact!

5 Essential Characteristics

2009-2011
16
versions

3 Service Models   4 Deployment Models

5 Essential Characteristics

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

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5 Essential Characteristics

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

2009-2011
16
versions

3 Service Models

4 Deployment Models

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

NIST Cloud Computing 3-4-5 Definition

5 Essential Characteristics

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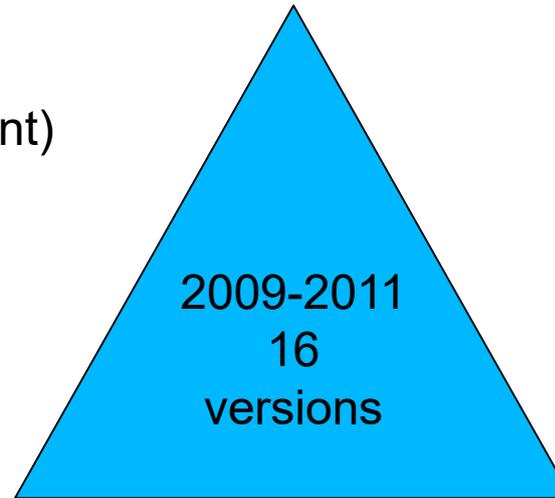Rapid elasticity
Measured service

2009-2011
16
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3 Service Models

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Infrastructure as a Service (IaaS)

4 Deployment Models

Public
Private
Community
Hybrid

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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

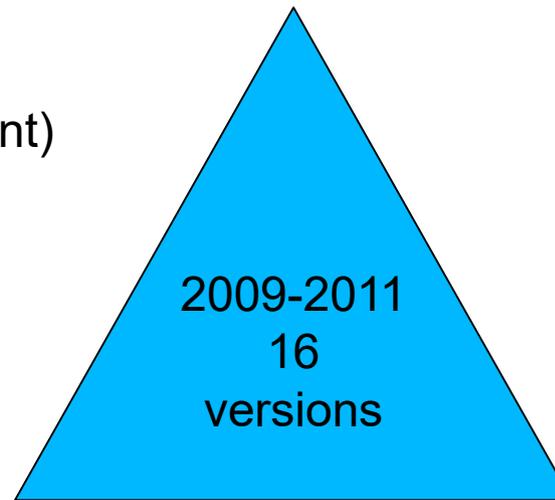## Other Common Characteristics

Geographic distribution
Homogeneity
Resilience
Massive scale
Virtualization
Security

2009-2011
16
versions

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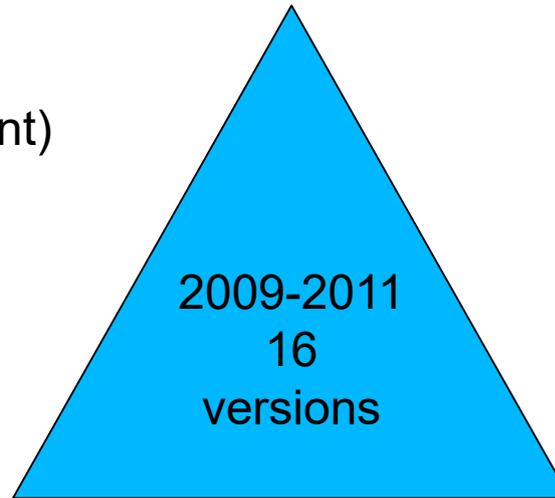
Software as a Service (SaaS)
Platform as a Service (PaaS)
Infrastructure as a Service (IaaS)

4 Deployment Models

Public
Private
Community
Hybrid

➢ "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
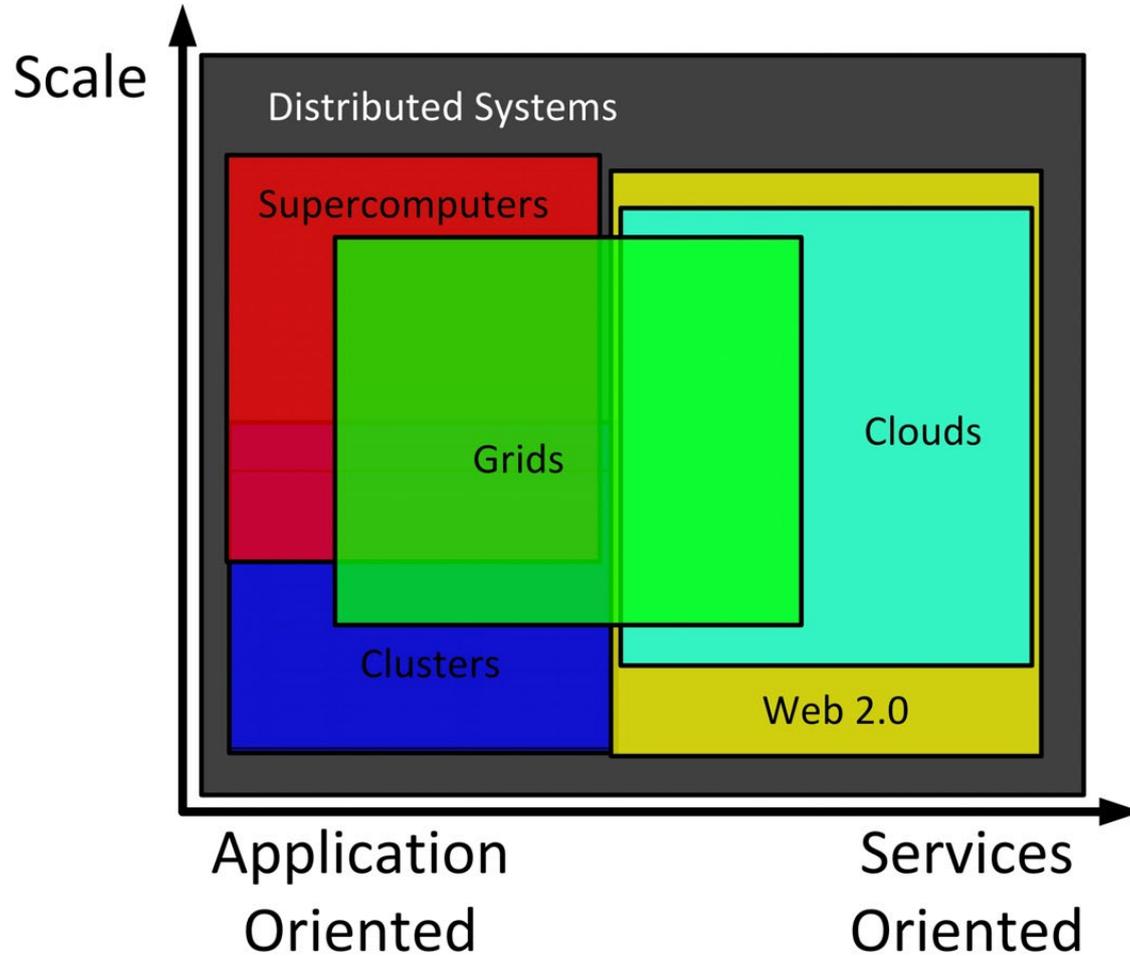
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Cloud and Grid: Foster et al 2008

World-Leading Research with Real-World Impact!

Grid 3 Point Checklist: Foster 2002

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

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Grid versus Cloud

Grid

1. Coordinates resources that are not subject to centralized control
   - ❖ Virtual Organization (VO)

   No but VOs may be enabled on demand

2. Uses standard, open, general-purpose protocols and interfaces
   - ❖ Globus toolkit

   No but standard opensource software and APIs may emerge (OpenStack is the current contender)

3. Delivers non-trivial qualities of service

   Yes

Cloud

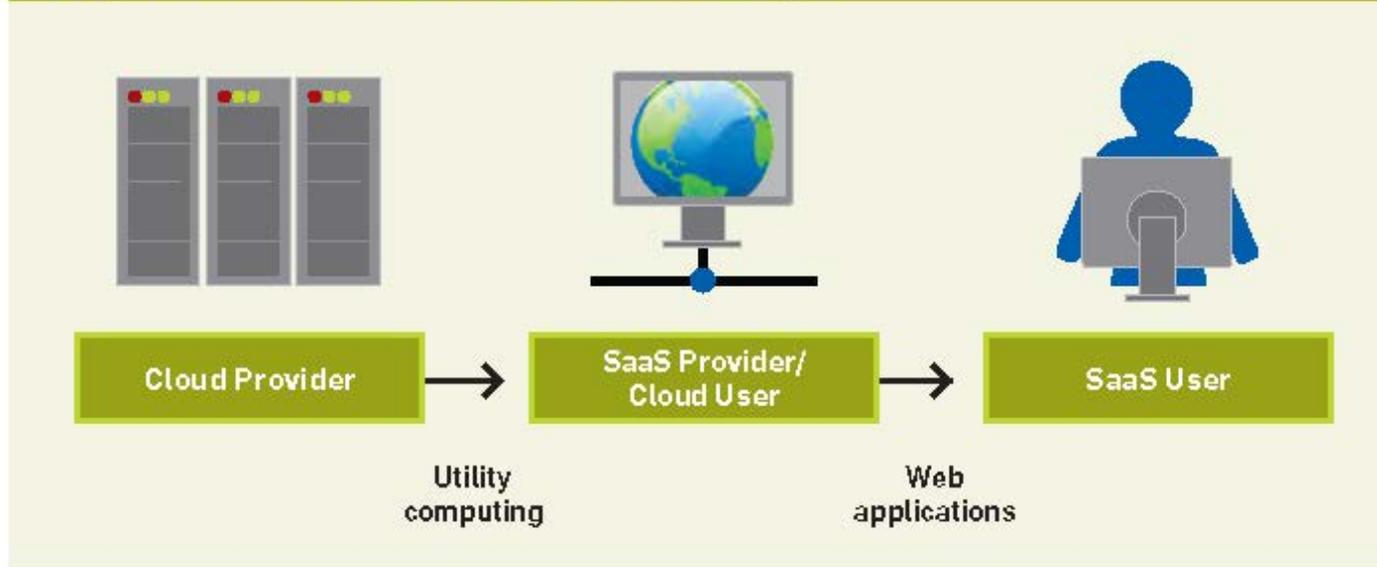|	
On-demand self service	Geographic distribution
Broad network access	Homogeneity
Resource pooling (multi-tenant)	Resilience
Rapid elasticity	Massive scale
Measured service	Virtualization
	Security

Grid versus Cloud Drivers

Cloud

- Commercially developed
- Little or no academic input
- Pay-per-use
- Payment driven
- Centrally owned hardware
- Centrally scheduled
- Single point of trust
- Simple security
- Interactive
- Commodity computing
- Small and medium businesses
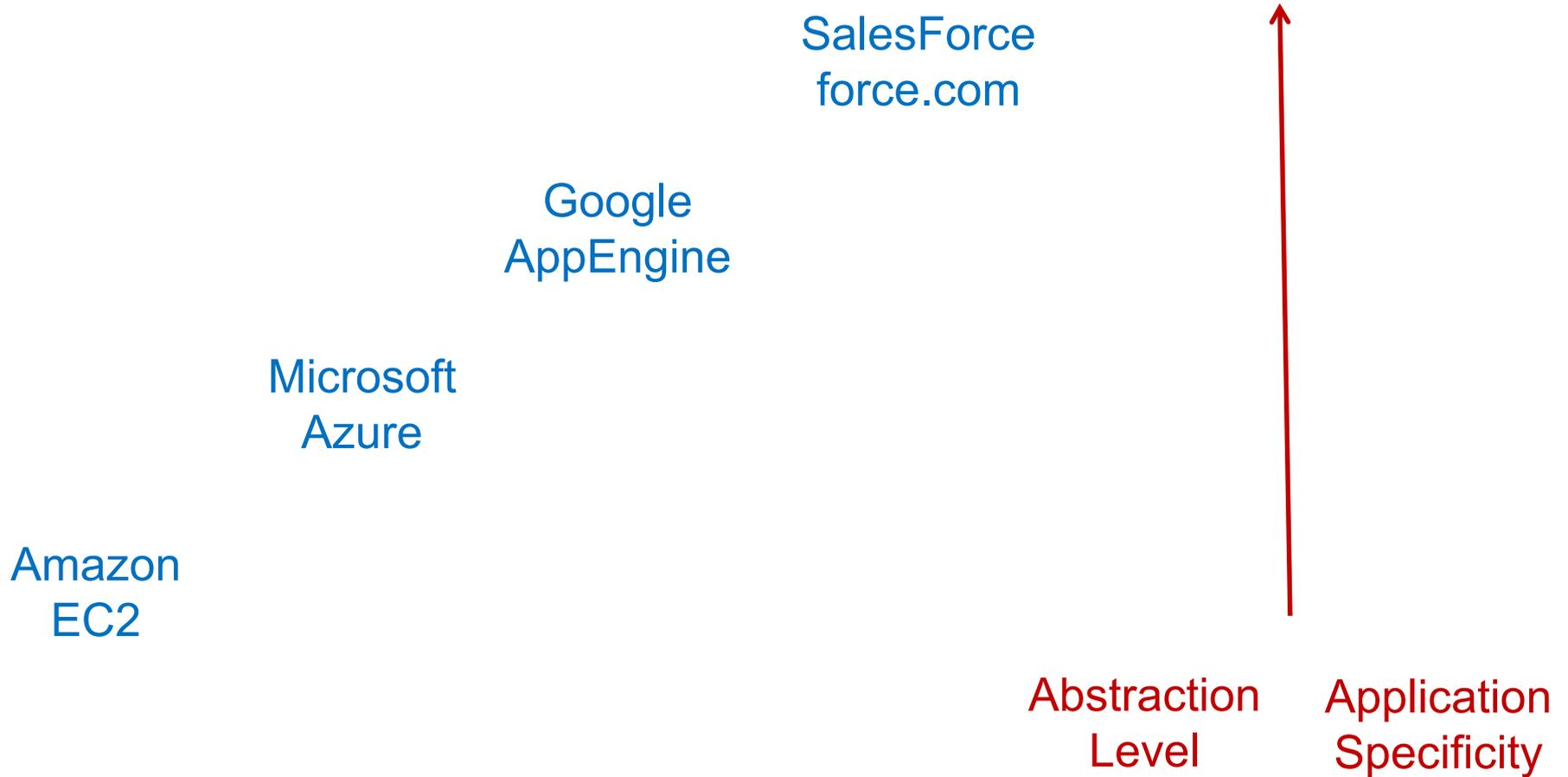- Virtualization essential
- Not so predictable performance

Grid

- DoD funded, no commercial traction
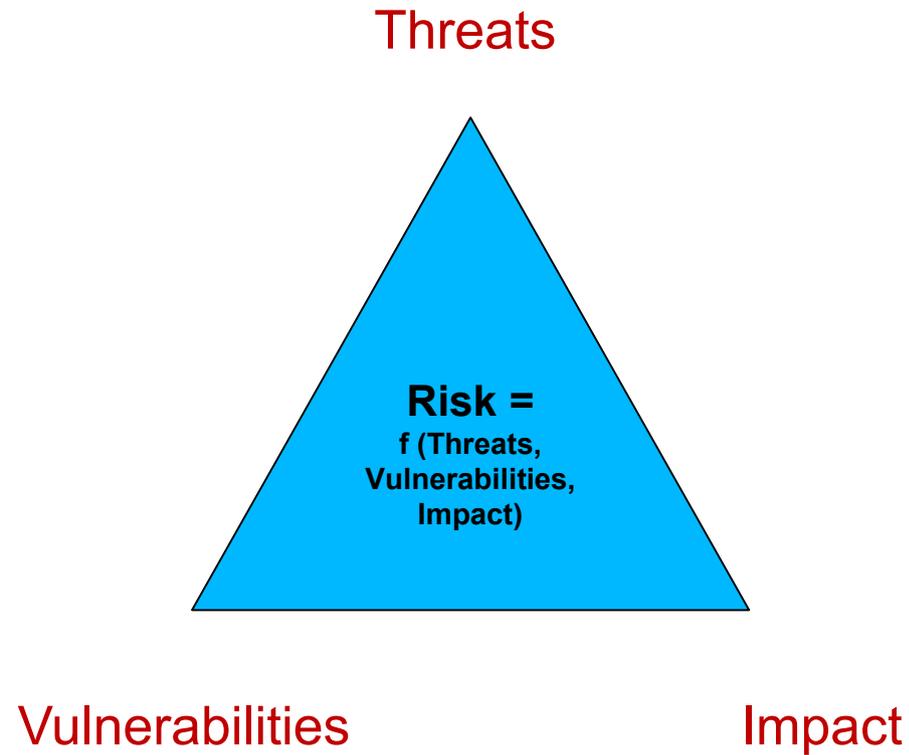- Mainly academic driven
- Pay-per-seat (one-time payment)
- Project oriented, proposal driven
- Multiply owned hardware
- Distributed scheduling
- Multiple trust points
- Complex PKI based security
- Batch
- High performance computing
- High end organizations
- Virtualization often not used
- Predictable performance

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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 a SaaS users via mashups.

Cloud Provider → SaaS Provider/Cloud User → SaaS User

Utility computing

Web applications

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➢ Not IaaS or PaaS but classes of utility computing

SalesForce
force.com

Google
AppEngine

Microsoft
Azure

Amazon
EC2

Abstraction
Level

Application
Specificity

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Threats

Risk =
f (Threats,
Vulnerabilities,
Impact)

Vulnerabilities   Impact

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Cyber Security:
What is Different in the Cloud?

Multi-Tenancy

Security and Privacy
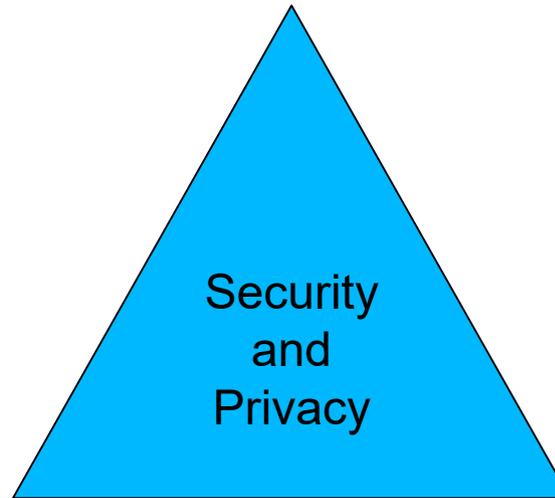
Compliance and Forensics

Cloud Service Provider

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