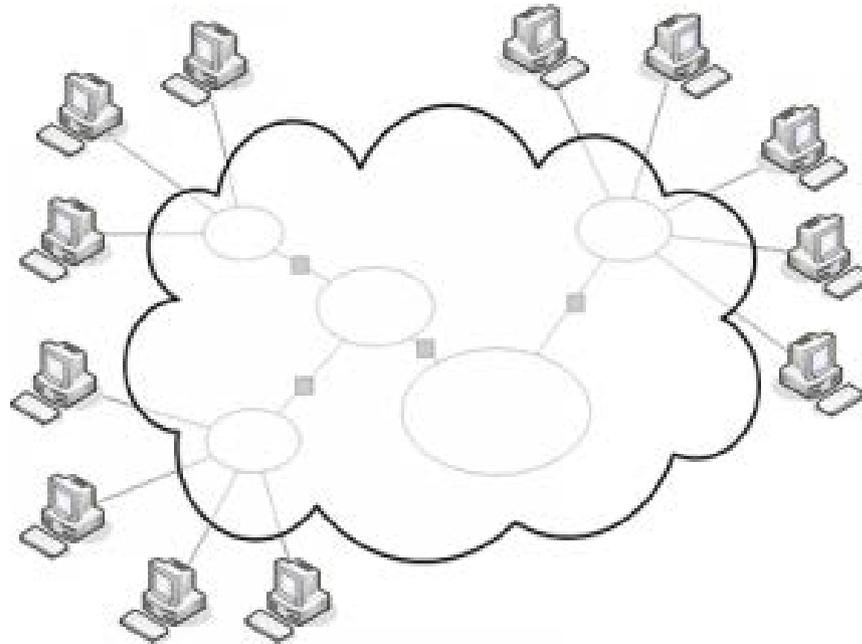I·C·S
The Institute for Cyber Security

UTSA

Views of Cloud Computing

Prof. Ravi Sandhu
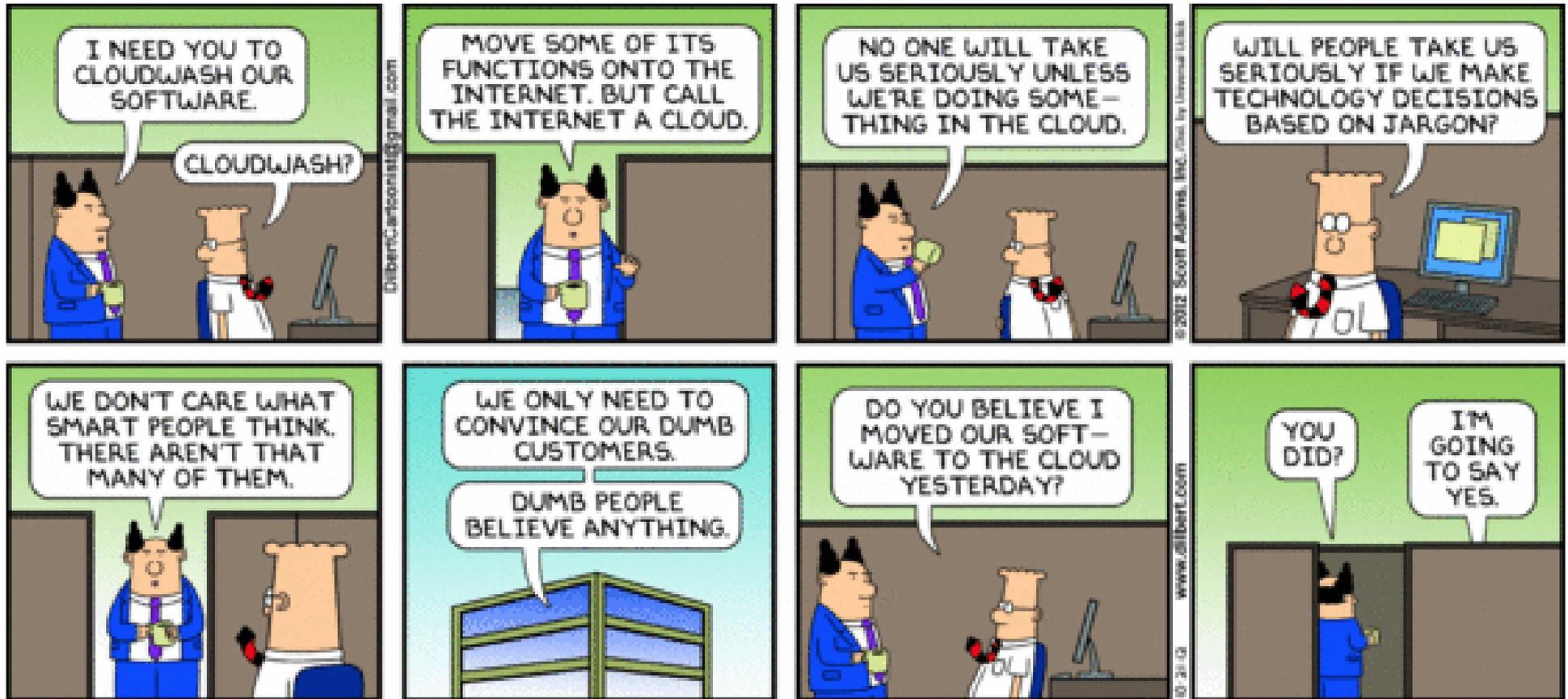Executive Director and Endowed Chair

March 25, 2016

ravi.sandhu@utsa.edu
www.profsandhu.com
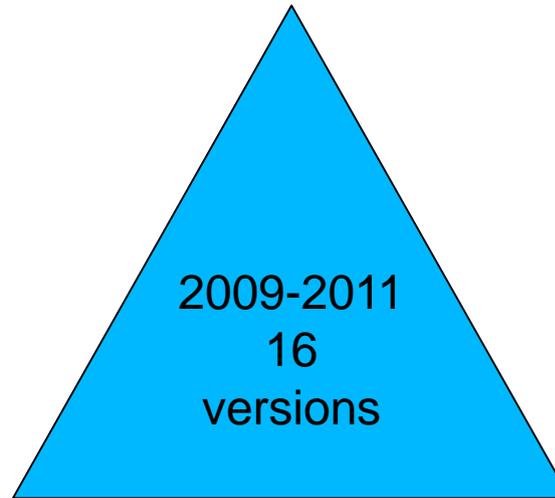
World-Leading Research with Real-World Impact!

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

The Cloud is the Computer
- IEEE Spectrum, 2008

Datacenter as a Computer
- Barroso and Hölzle, 2009
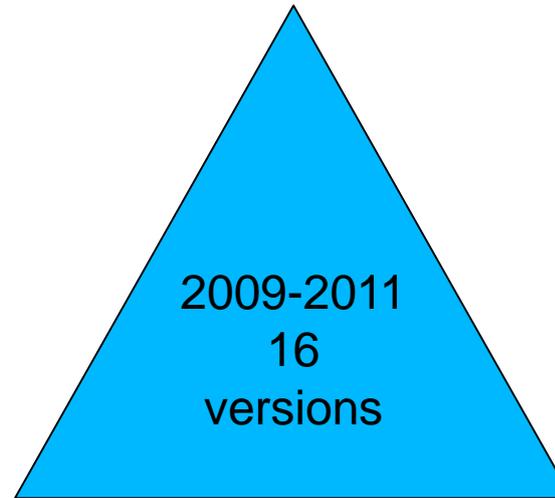
The Cloud: Perspectives and Forces

Science

Business

Engineering

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

Public
Private
Community
Hybrid

5 Essential Characteristics

On-demand self service
Broad network access
Resource pooling (multi-tenant)
Rapid elasticity
Measured service
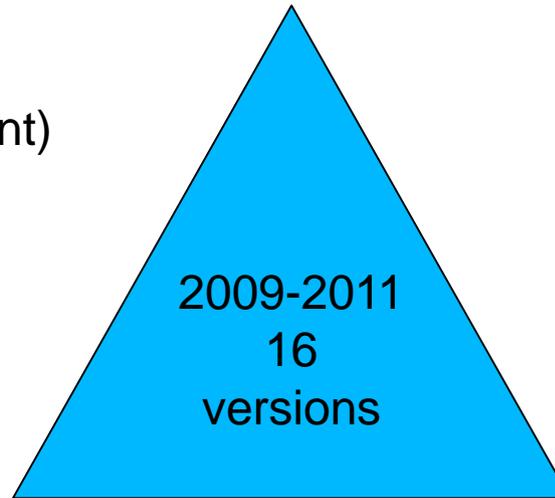
2009-2011
16
versions

3 Service Models

Software as a Service (SaaS)
Platform as a Service (PaaS)
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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
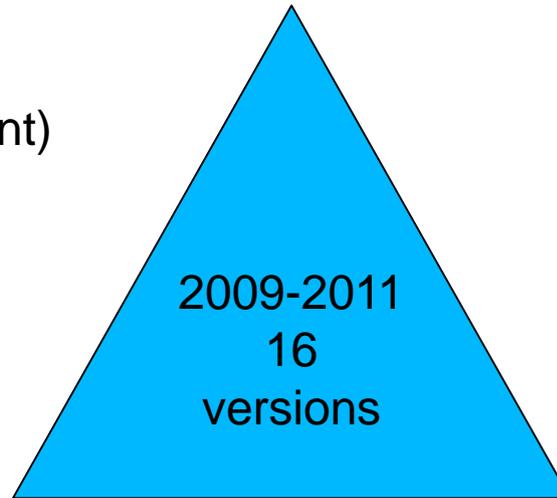Security

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

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World-Leading Research with Real-World Impact!

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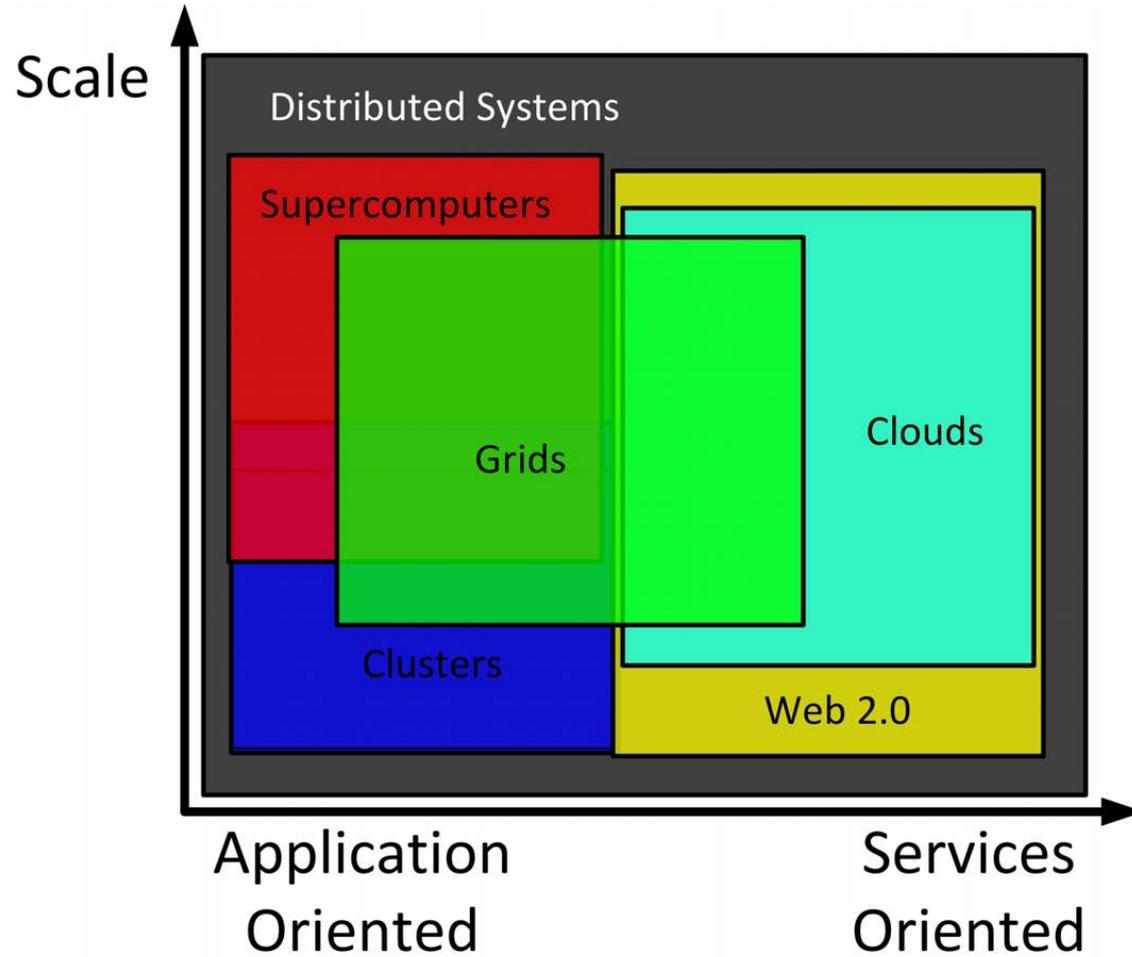
1. Coordinates resources that are not subject to centralized control
   ❖ Virtual Organization (VO)
2. Uses standard, open, general-purpose protocols and interfaces
   ❖ Globus toolkit
3. Delivers non-trivial qualities of service

Grid versus Cloud

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

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

World-Leading Research with Real-World Impact!
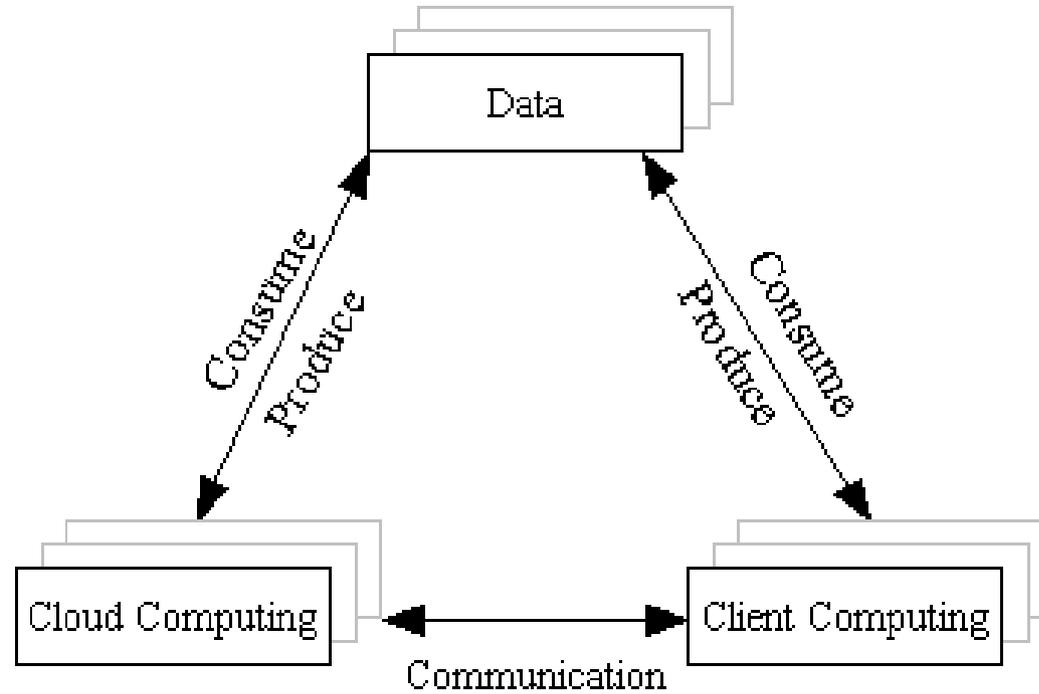
The triangle model of next-generation Internet Computing

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

➢ Not IaaS or PaaS but classes of utility computing

SalesForce
force.com

Google
AppEngine

Microsoft
Azure

Amazon
EC2

Abstraction
Level

Application
Specificity
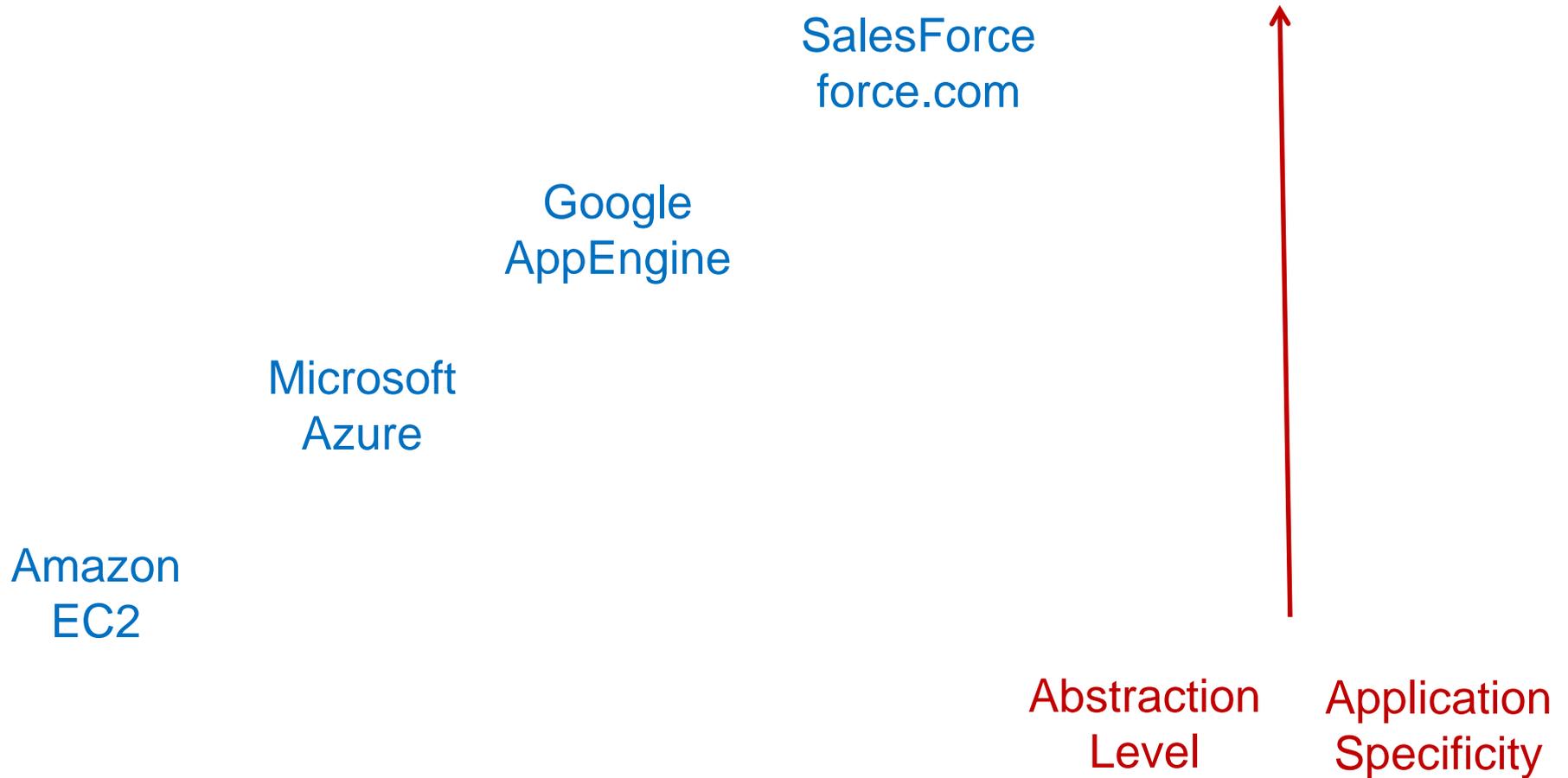
Table 1. Comparing public clouds and private data centers.

Advantage	Public Cloud	Conventional Data Center
Appearance of infinite computing resources on demand	Yes	No
Elimination of an up-front commitment by Cloud users	Yes	No
Ability to pay for use of computing resources on a short-term basis as needed	Yes	No
Economies of scale due to very large data centers	Yes	Usually not
Higher utilization by multiplexing of workloads from different organizations	Yes	Depends on company size
Simplify operation and increase utilization via resource virtualization	Yes	No

World-Leading Research with Real-World Impact!

Table 2. Top 10 obstacles to and opportunities for growth of cloud computing.

	Obstacle	Opportunity
1	Availability/Business Continuity	Use Multiple Cloud Providers
2	Data Lock-In	Standardize APIs; Compatible SW to enable Surge or Hybird Cloud Computing
3	Data Confidentiality and Auditability	Deploy Encryption, VLANs, Firewalls
4	Data Transfer Bottlenecks	FedExing Disks; Higher BW Switches
5	Performance Unpredictability	Improved VM Support; Flash Memory; Gang Schedule VMs
6	Scalable Storage	Invent Scalable Store
7	Bugs in Large Distributed Systems	Invent Debugger that relies on Distributed VMs
8	Scaling Quickly	Invent Auto-Scaler that relies on ML; Snapshots for Conservation
9	Reputation Fate Sharing	Offer reputation-guarding services like those for email
10	Software Licensing	Pay-for-use licenses

Threats

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

Vulnerabilities   Impact

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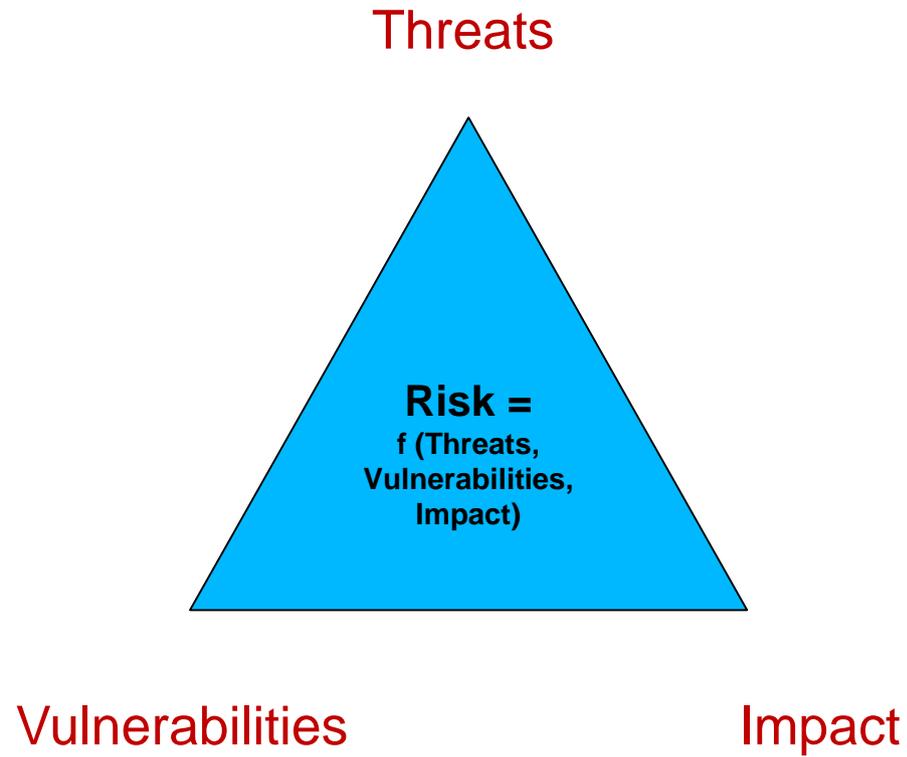
Security
and
Privacy
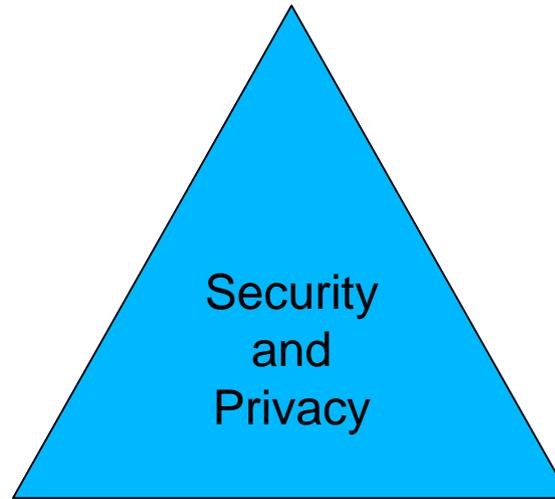
Compliance and Forensics   Cloud Service Provider