Cloud Computing

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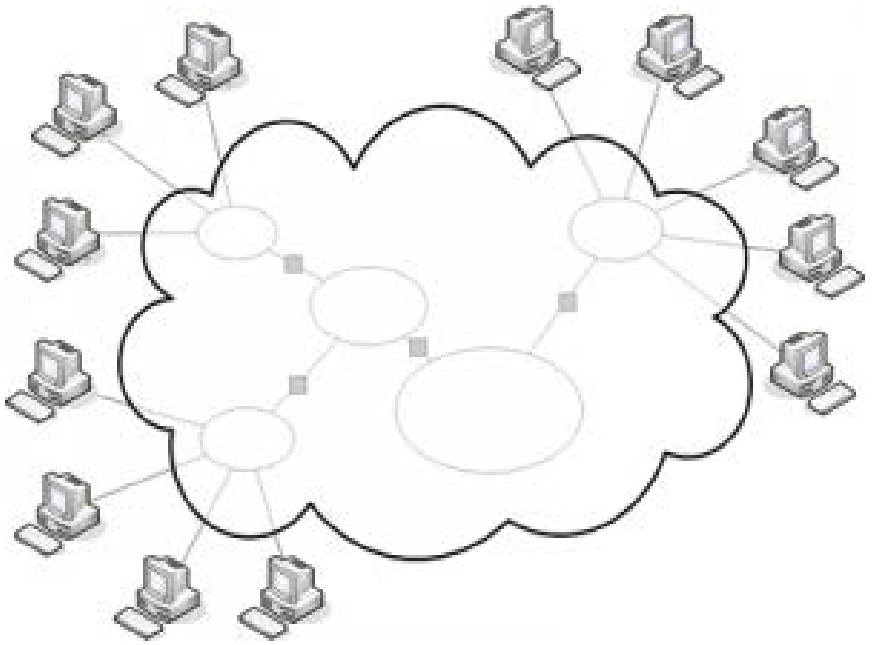
The Cloud

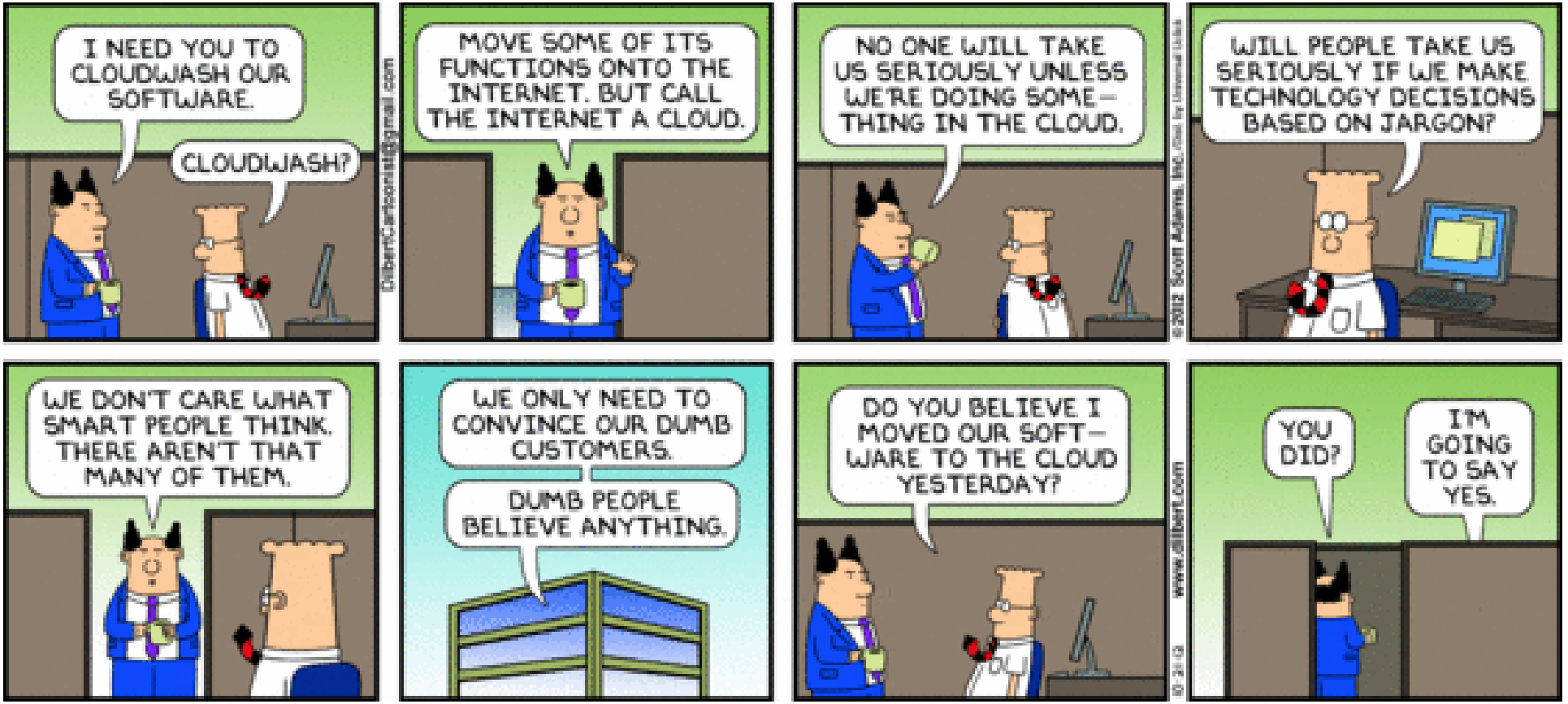


The Network is the Computer
- Sun Microsystems, early 1990s

The Cloud is the Computer
- IEEE Spectrum, 2008

Datacenter as a Computer
- Barroso and Hölzle, 2009

Cloudwashing



The Cloud: Perspectives and Forces

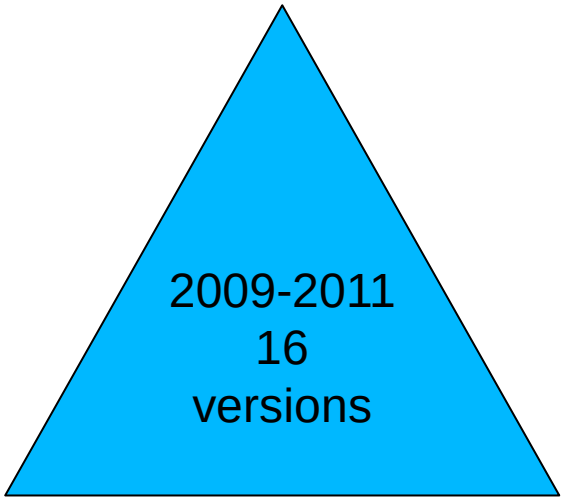
Science

Business

Engineering

NIST Cloud Computing 3-4-5 Definition

5 Essential Characteristics



3 Service Models

4 Deployment Models

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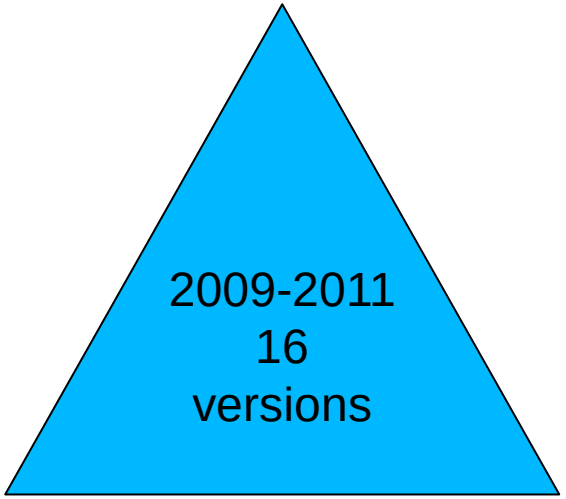


3 Service Models

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

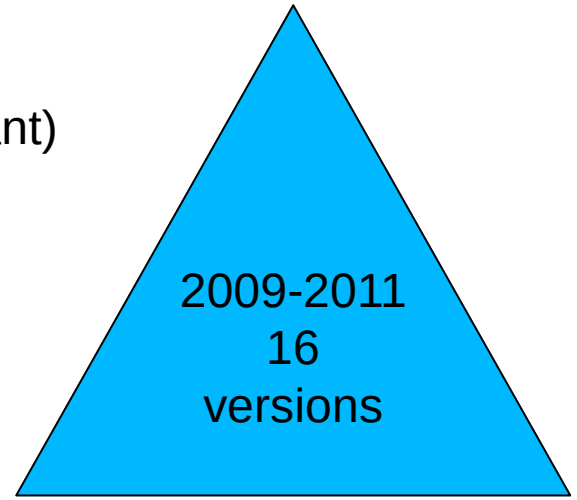
4 Deployment Models

Public
Private
Community
Hybrid

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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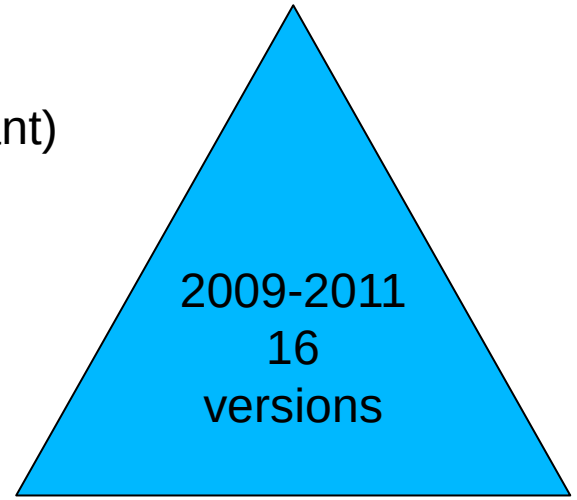

Other Common Characteristics

Geographic distribution
Homogeneity
Resilience
Massive scale
Virtualization
Security

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Cloud Pioneers

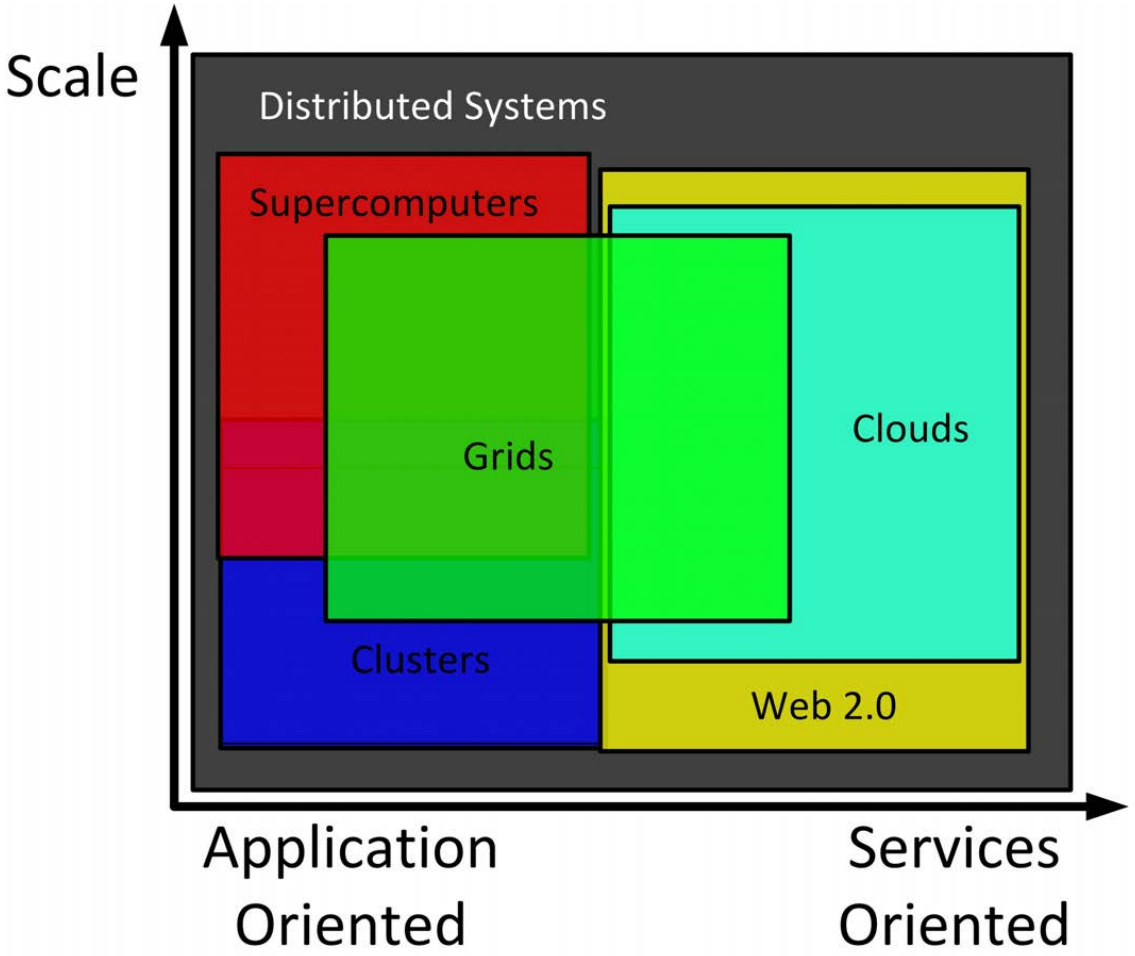
- IaaS: Amazon Web Services (AWS)
  - Compute (EC2)
  - Storage (S3)
  - Database (multiple)
  - Plus more
- IaaS: other players
  - Eucalyptus: opensource with EC2 APIs
  - OpenStack: industry backed opensource consortium (Rackspace genesis)
  - Joyent: SmartOS based
- SaaS: SalesForce, CRM (Customer Relationship Management)
  - Any web application can be pitched as SaaS
  - But don't forget "On-demand self service" and "Rapid elasticity"
- PaaS: least well defined service
  - Salesforce: force.com plus more
  - Microsoft Azure
  - Google AppEngine

Cloud and Grid: Foster et al 2008

- "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



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

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
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Rapid elasticity
Measured service

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Security

Grid versus Cloud Drivers

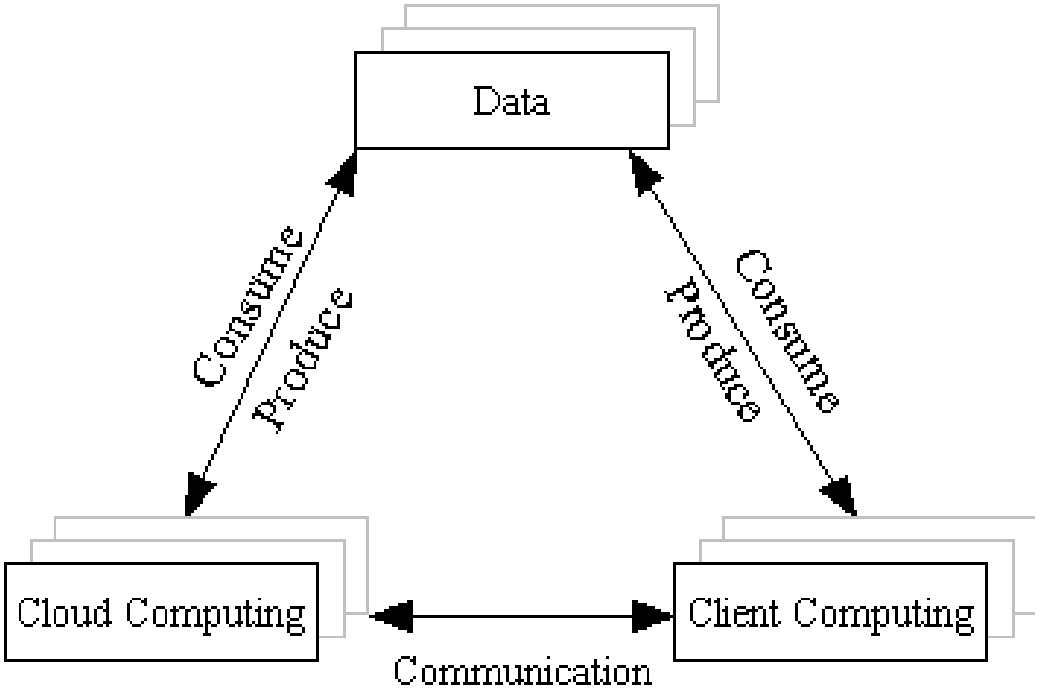
Cloud

- 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
- Cost associativity

Grid

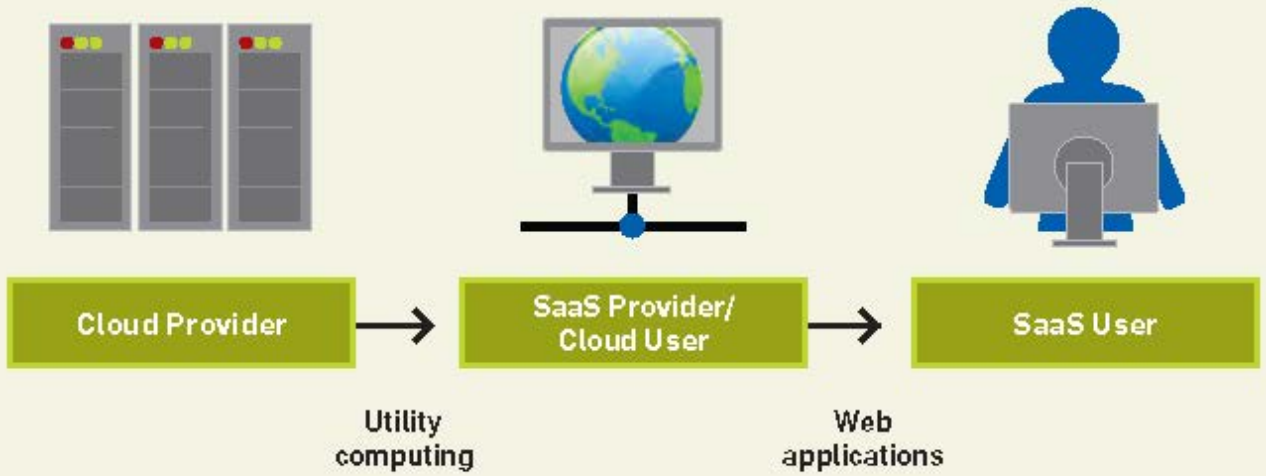
- DoD funded, no commercial traction
- Mainly academic driven
- Pay-per-seat (one-time payment
- Project oriented, proposal driven
- Multiply owned hardware
- Distributed scheduling
- Multiple trust points
- Complex PKI based security
- Batch
- High performance computing
- High end organizations
- Virtualization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

Cloud and Grid: Foster et al 2008



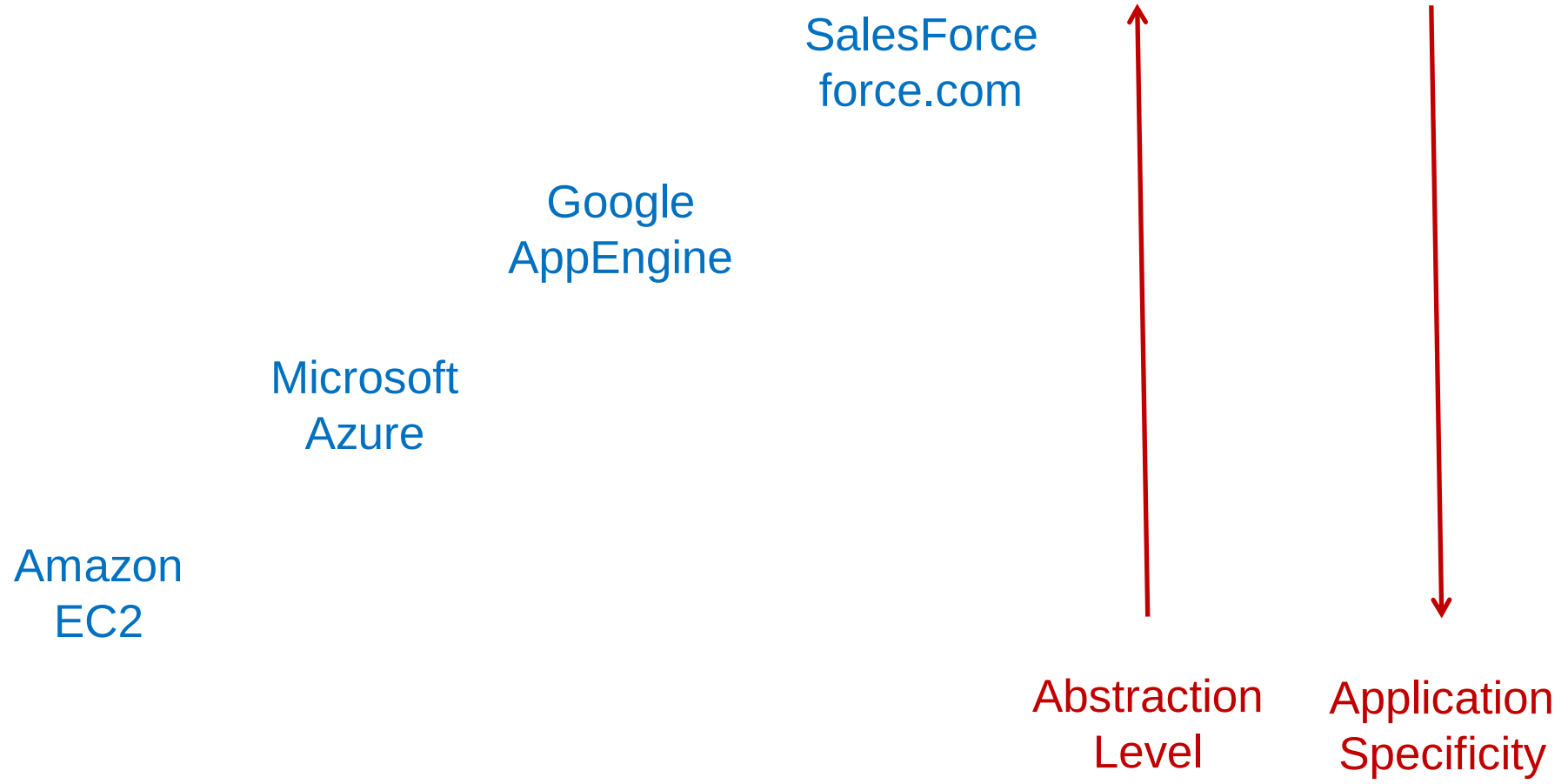
Berkeley View of Cloud: 2010

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.



Berkeley View of Cloud: 2010

- Not IaaS or PaaS but classes of utility computing



Berkeley View of Cloud: 2010

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

Berkeley View of Cloud: 2010

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