Cloud Computing

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Based on material by K. Birman, P. Francis, A.M. Nguyen, A. Tanenbaum

What is Cloud Computing?

- *I don't understand what we would do differently in the light of Cloud Computing other than change the wordings of some of our ads*

  Larry Ellision, Oracle's CEO

- *I have not heard two people say the same thing about it [cloud]. There are multiple definitions out there of "the cloud"*

  Andy Isherwood, HP's Vice President of European Software Sales

- *It's stupidity. It's worse than stupidity: it's a marketing hype campaign.*

  Richard Stallman, Free Software Foundation founder

SOFTWARE AS A SERVICE AND UTILITY COMPUTING

Software as a Service (SaaS)

Ex: SalesForce.com

Traditional Software

Build Your Own

On-Demand Utility

Plug In, Subscribe

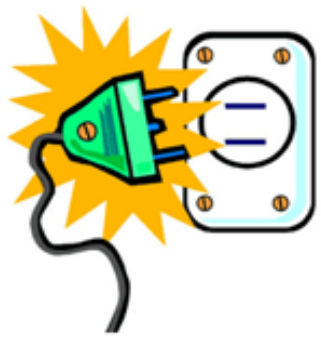
Pay-per-Use

Software as a Service (SaaS)

- Application used as on demand service
  - Often provided via the Internet
- Example: Google Apps

- Benefits to users
  - Reduce expenses: multiple computers, multiple users
  - Ease of usage: easy installation, access everywhere
- Benefits to providers
  - Easier to maintain
  - Control usage (no illegal copies)

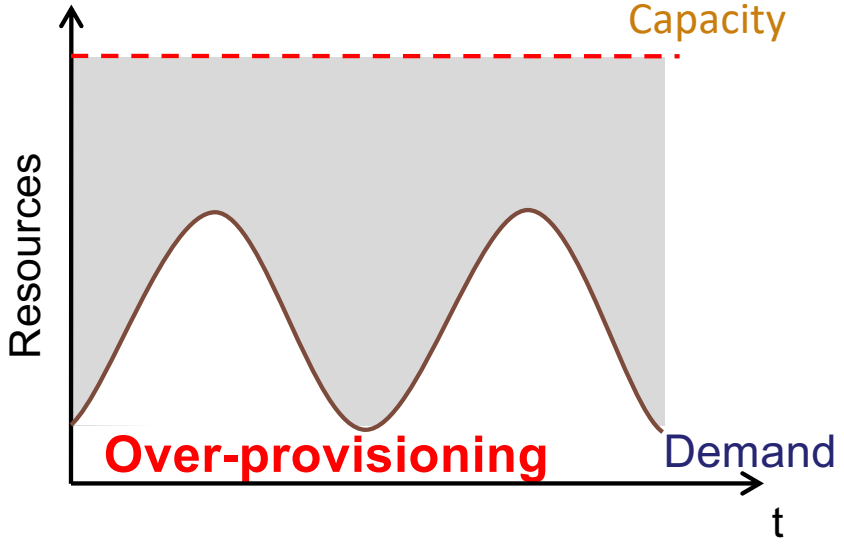
Utility Computing (UC)

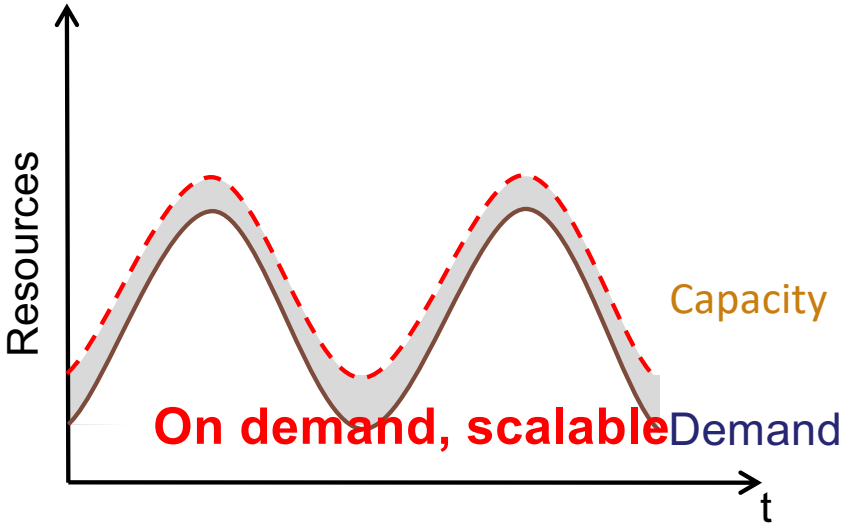


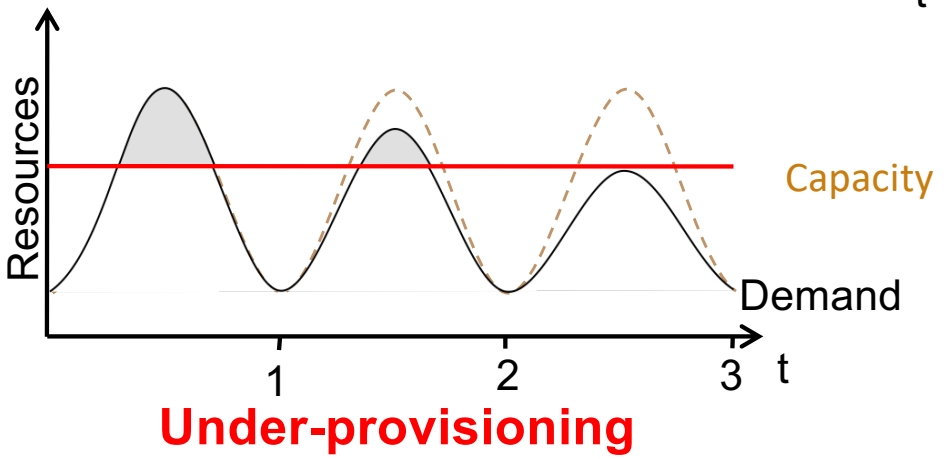
- Computing resources (cpu hours, memory, network) and platform to run software are provided as on demand service
  - *Hardware as a service (HaaS)*
  - *Infrastructure as a service (IaaS)*
  - *Platform as a Service (PaaS)*
- Examples of UC providers:
  - PaaS: MS Azure …
  - IaaS: Amazon EC2 …
- Who will use UC?

Utility Computing: Mitigate Risks

- Real world utilization 5%-20%
- Animoto demand surge: from 50 servers to 3500 servers in 3 days
- Black Friday sales







Utility Computing – Amazon EC2

- **Elastic Compute Cloud**
- Rent VM instances to run your software
- Full root-level access to VM

Amazon EC2

- Create an Amazon Machine Image (AMI)
- Upload AMI to Amazon S3 (simple storage service)
- Use Amazon EC2 web service to configure
- Choose OS, start AMI instances

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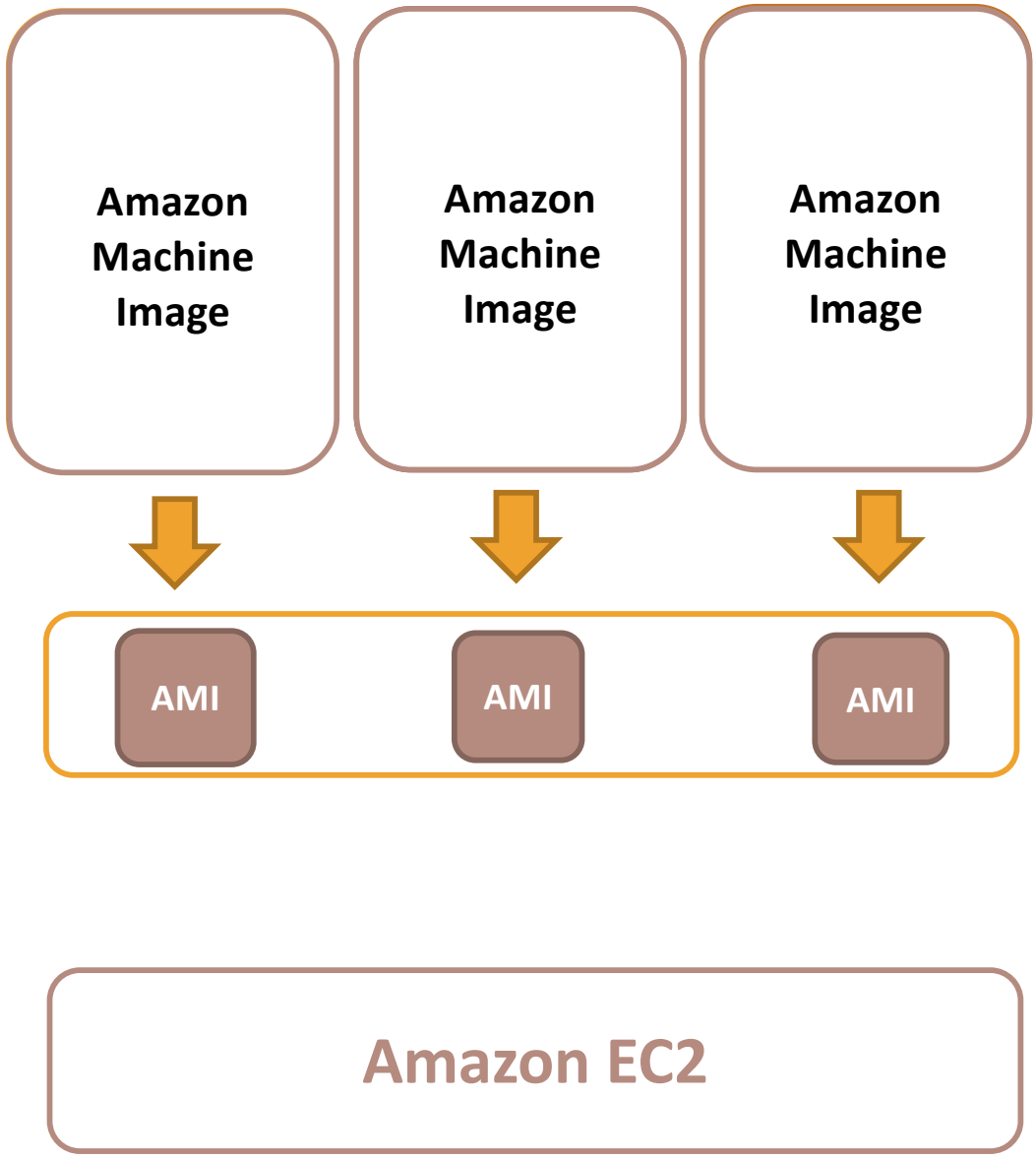

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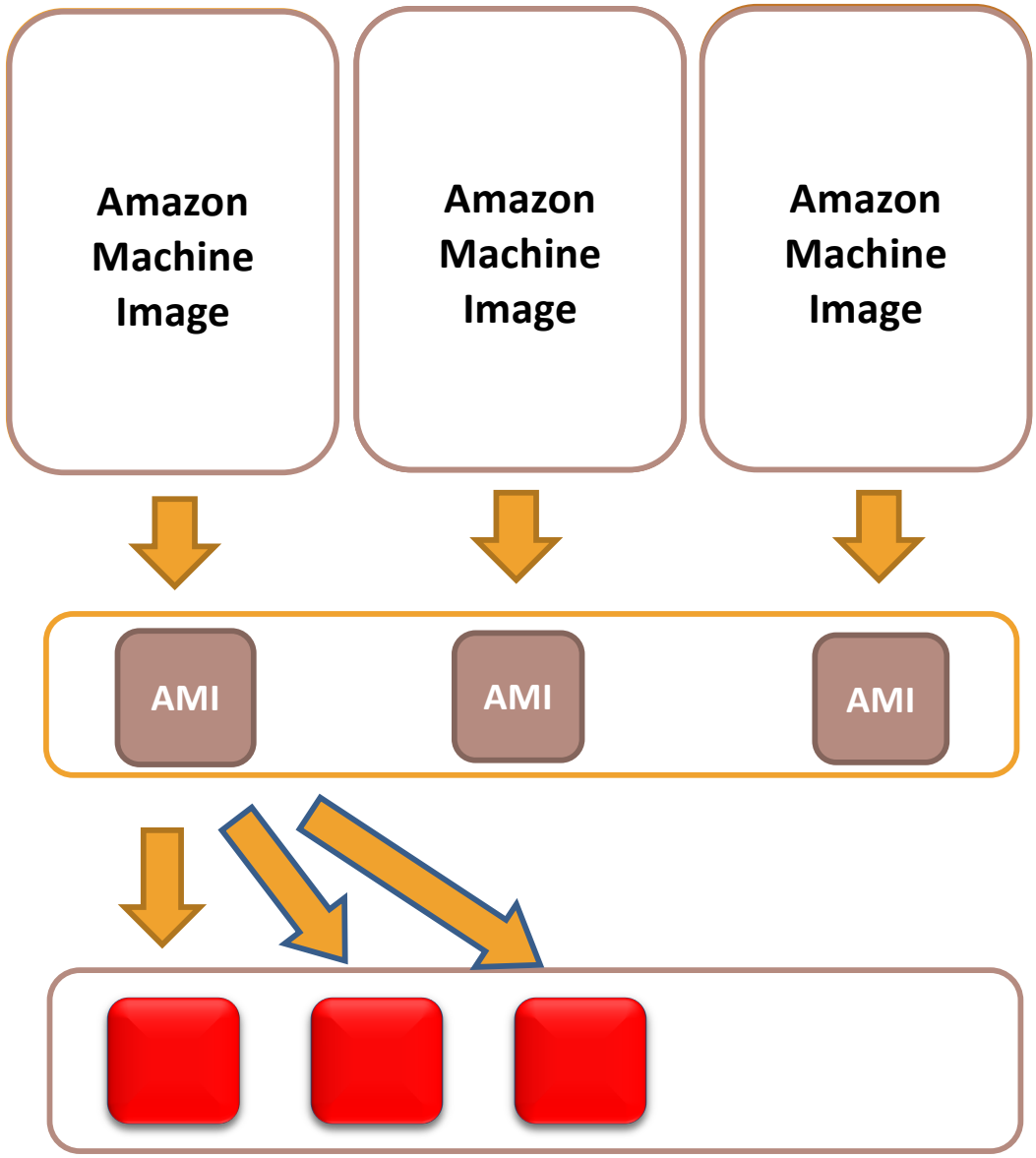
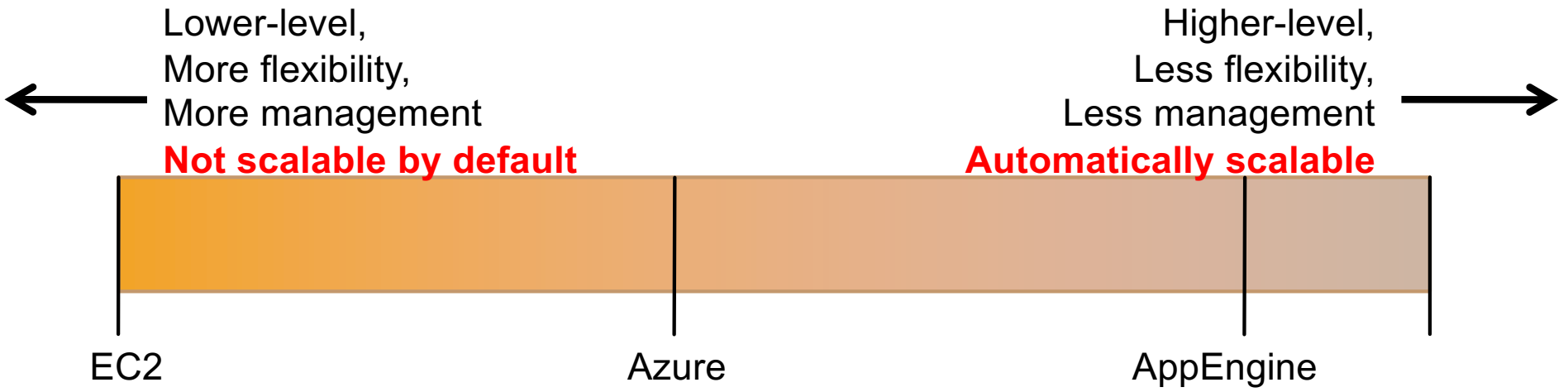


Utility Computing – MS Azure

- Write your web program and submit to Azure
- How to use
  - Download MS SDK, Azure tools
  - Develop your program locally
  - Register for an Azure id
  - Launch your application in Azure

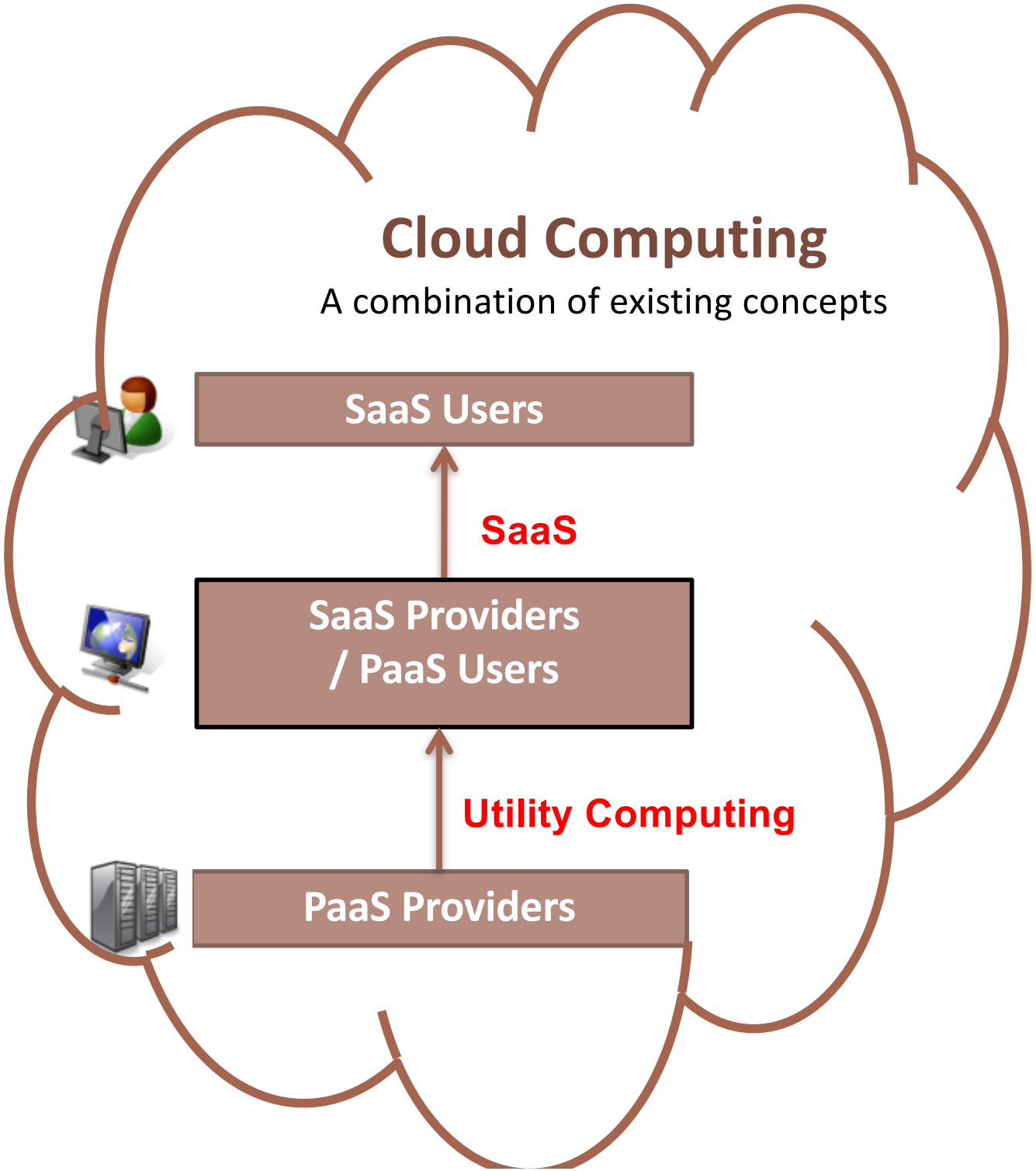
Spectrum Of Abstractions

- Different levels of abstraction
  - Instruction Set VM: Amazon EC2
  - Framework VM: MS Azure
- Similar to languages
  - Higher level abstractions can be built on top of lower ones



CLOUD COMPUTING


SaaS Users
SaaS
SaaS Providers
PaaS Users
Utility Computing
PaaS Providers


Cloud Computing
A combination of existing concepts
SaaS Users
SaaS
SaaS Providers
/ PaaS Users
Utility Computing
PaaS Providers

Cloud Computing

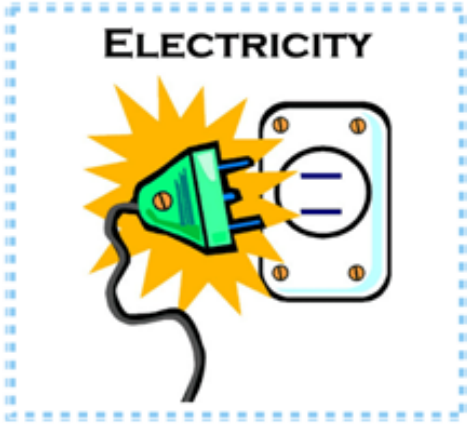
Cloud Computing = SaaS + PaaS (utility computing)

Cloud TV
(Cloud Computing)

=

Video On Demand
(SaaS)

+



Electricity On Demand
(PaaS)

Significance of Cloud Computing

- The illusion of infinite computing resources
- The elimination of an up-front commitment by users
- The ability to use and pay on demand

- Cloud Computing vs P2P?
  - Both take advantage of remote resources
  - P2P: does not use clouds (datacenters), peers do not get paid, lower reliability
- Cloud Computing vs Grid Computing?
  - Both use clouds
  - Grid Computing requires commitment, share based on common interests. Not public cloud

Cloud Killer Apps

- Mobile and web applications
  - Mobile devices: low memory & computation power
- Extensions of desktop software
  - Matlab, Mathematica
- Batch processing / MapReduce
  - Peter Harkins at The Washington Post: 200 EC2 instances (1,407 server hours), convert 17,481 pages of Hillary Clinton's travel documents within 9 hours
  - The New York Times used 100 Amazon EC2 instances + Hadoop application to recognize 4TB of raw TIFF image into 1.1 million PDFs in 24 hours ($240)

ECONOMICS OF THE CLOUD

Should I Move Into A Cloud?

- Does it really save money?

$$\text{UserHours}_{\text{cloud}} \times (\text{revenue} - \text{Cost}_{\text{cloud}}) \geq \text{UserHours}_{\text{datacenter}} \times (\text{revenue} - \frac{\text{Cost}_{\text{datacenter}}}{\text{Utilization}})$$

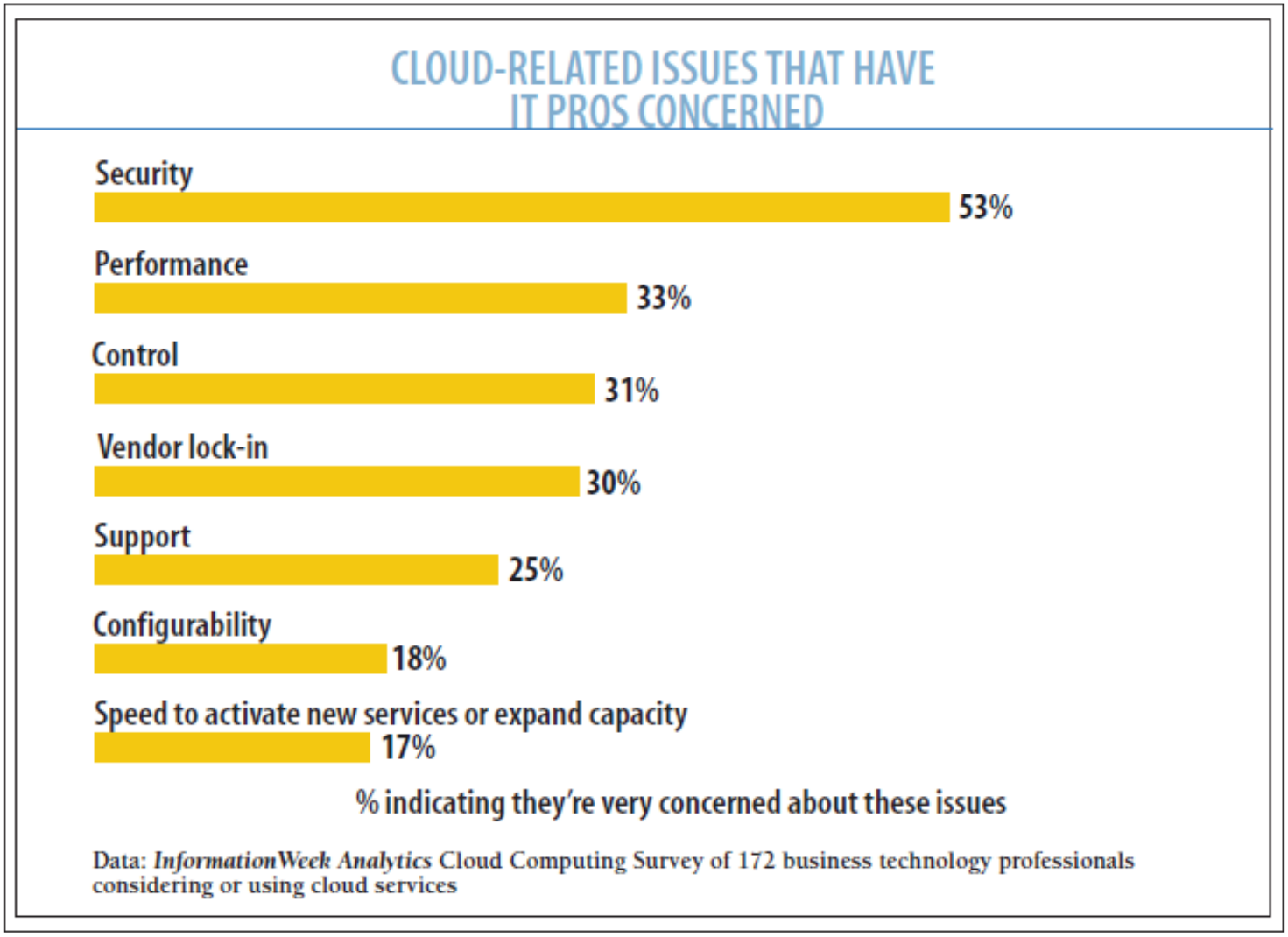
  - $Cost_{cloud} > Cost_{datacenter}$, balance by *Utilization*
  - $UserHours_{cloud} > UserHours_{datacenter}$ (under-provisioning)
- Other factors
  - Re-implement programs
  - Move data into cloud
  - What else?
- Example:
  - Upload rate 20Mbits / s. 500GB takes 55 hours
  - If can process locally in less than 55 hours → moving into a cloud would not save time

Adoption Challenges

Challenge	Opportunity
Availability	Multiple providers
Data lock-in	Standardization
Data Confidentiality and Auditability	Encryption, VLANs, Firewalls

- Coghead, a cloud vendor closed its business in February 2009
  - Customers need to rewrite their applications
  - Another company will automatically convert customer data to their proprietary formats…
- Online storage service The Linkup closed July 10, 2008
  - 20,000 paying subscribers lost their data

Adoption Challenges



Cloud Control, InformationWeek Reports, 2009

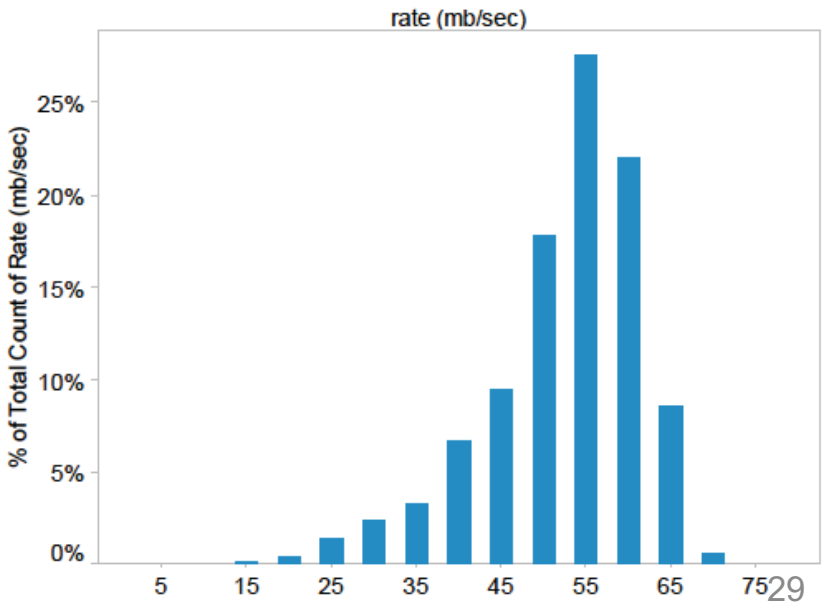
Growth Challenges

Challenge	Opportunity
Data transfer bottlenecks	FedEx-ing disks, reuse data multiple times
Performance unpredictability	Improved VM support, flash memory
Scalable storage	Invent scalable storage
Bugs in large distributed systems	Invent Debugger using Distributed VMs
Scaling quickly	Invent Auto-Scaler

Growth Challenges

- Data transfer bottle neck
  - WAN cost reduces slowest:
    2003 → 2008: WAN 2.7x, CPU 16x, storage 10x
  - Fastest way to transfer large data: send the disks

- Performance unpredictability
  - Large variation in I/O operations
  - Inefficiency in I/O virtualization



Policy And Business Challenge

Challenge	Opportunity
Reputation Fate Sharing	Offer reputation-guarding services like those for email
Software Licensing	Pay-for-use licenses; Bulk use sales

- Reputation: Many blacklists use IP addresses and IP ranges
- Software licensing:
  - Open source software readily applicable
  - Windows, IBM software offered per hour for EC2