Architectural Implications of Cloud Computing

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SATURN 2011
May 18, 2011

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Agenda

Basic Cloud Computing Concepts

Architectural Implications of Cloud Computing

Final Thoughts

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Cloud Computing

"A large-scale distributed computing paradigm that is driven by economies of scale, in which a pool of abstracted, virtualized, dynamically-scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet." *

jaworski.net

* I. Foster, Y. Zhau, R. Ioan, and S. Lu. "Cloud Computing and Grid Computing : 360-Degree Compared." Grid Computing Environments Workshop, 2008.

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Cloud Computing Types

Software-as-a-Service (SaaS)

Platform-as-a-Service (PaaS)

Infrastructure-as-a-Service (IaaS)

Based on Type of Capability

Public Cloud

Private Cloud

Based on Who Can Access Resources

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Infrastructure-as-a-Service (IaaS)

Mainly computational infrastructure available over the internet, such as compute cycles and storage

Allows organizations and developers to extend their IT infrastructure on an on-demand basis

Examples of IaaS Providers

- Amazon Elastic Compute Cloud (EC2)
  - Provides users a special virtual machine (AMI) that can be deployed and run on the EC2 infrastructure
- Amazon Simple Storage Solution (S3)
  - Provides users access to dynamically scalable storage resources
- IBM Computing on Demand (CoD)
  - Provides users access to highly configurable servers plus value-added services such as data storage
- Microsoft Live Mesh
  - Provides users access to a distributed file system; targeted at individual use

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Platform-as-a-Service (PaaS)

Application development platforms the allow the usage of external resources to create and host applications of a larger scale than an individual or small organization would be able to handle

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Examples of PaaS providers

- Akamai EdgePlatform
  - Large distributed computing platform for web application deployment (focus on analysis and monitoring of resources)
- Force.com
  - Platform to build and run applications and components bought from AppExchange or custom applications
- Google App Engine
  - Platform to develop and run applications on Google's infrastructure
- Microsoft Azure Services Platform
  - On-demand compute and storage services as well as a development platform based on Windows Azure
- Yahoo! Open Strategy (Y!OS)
  - Platform to develop and web applications on top of the existing Yahoo! Platform (focus on social applications)

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Software-as-a-Service (SaaS)

Model of software deployment in which a third-party provider licenses an application to customers for use as a service on demand

Examples

- Google Apps
  - Web-based office tools such as e-mail, calendar and document management tools
- Salesforce.com
  - Full customer relationship management (CRM) application
- Zoho
  - Large suite of web-based applications, mostly for enterprise use

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Cloud Computing Types — Based on Access

Public

- Offered as a service, usually over an Internet connection
- Typically charge a pay-per-use fee
- Users can scale on-demand and do not need to purchase hardware
- Cloud providers manage the infrastructure and pool resources into capacity required by consumers

Private

- Deployed inside the firewall and managed by the user organization
- User organization owns the software and hardware running in the cloud
- User organization manages the cloud and provides cloud resources
- Resources typically not shared outside the organization and full control is retained by the organization

PERSPECTIVE

Cloud Consumer

Cloud Provider

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Drivers for Cloud Computing Adoption

Scalability	Organizations have access to a large amount of resources that scale based on user demand
Elasticity	Organization’s can manually or dynamically decide on resource utilization based on changing needs
Virtualization	Each user has a single view of the available resources, independently of how they are arranged in terms of physical devices
Lower Infrastructure Costs	The pay-per-use model allows an organization to only pay for the resources they need with basically no investment in the physical resources available in the cloud. There are no infrastructure maintenance or upgrade costs
Availability	Organizations have the ability for the user to access data and applications from around the globe
Collaboration	Organizations are starting to see the cloud as a way to work simultaneously on common data and information
Risk Reduction	Organizations can use the cloud to test ideas and concepts before making major investments in technology
Reliability	In order to support SLAs (service-level agreements), cloud providers have reliability mechanisms that are much more robust than those that could be cost-effectively provided by a single organization

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Barriers for Cloud Computing Adoption

Security	The key concern is data privacy: organizations do not have control of or know where their data is being stored
Interoperability	A universal set of standards and/or interfaces has not yet been defined, resulting in a significant risk of vendor lock-in
Resource Control	The amount of control that the organization has over the cloud environment varies greatly
Latency	All access to the cloud is done via the internet, introducing latency into every communication between the user and the environment
Platform or Language Constraints	Some cloud environments provide support for specific platforms and languages only
Regulation	There are concerns in the cloud computing community over jurisdiction, data protection, fair information practices, and international data transfer

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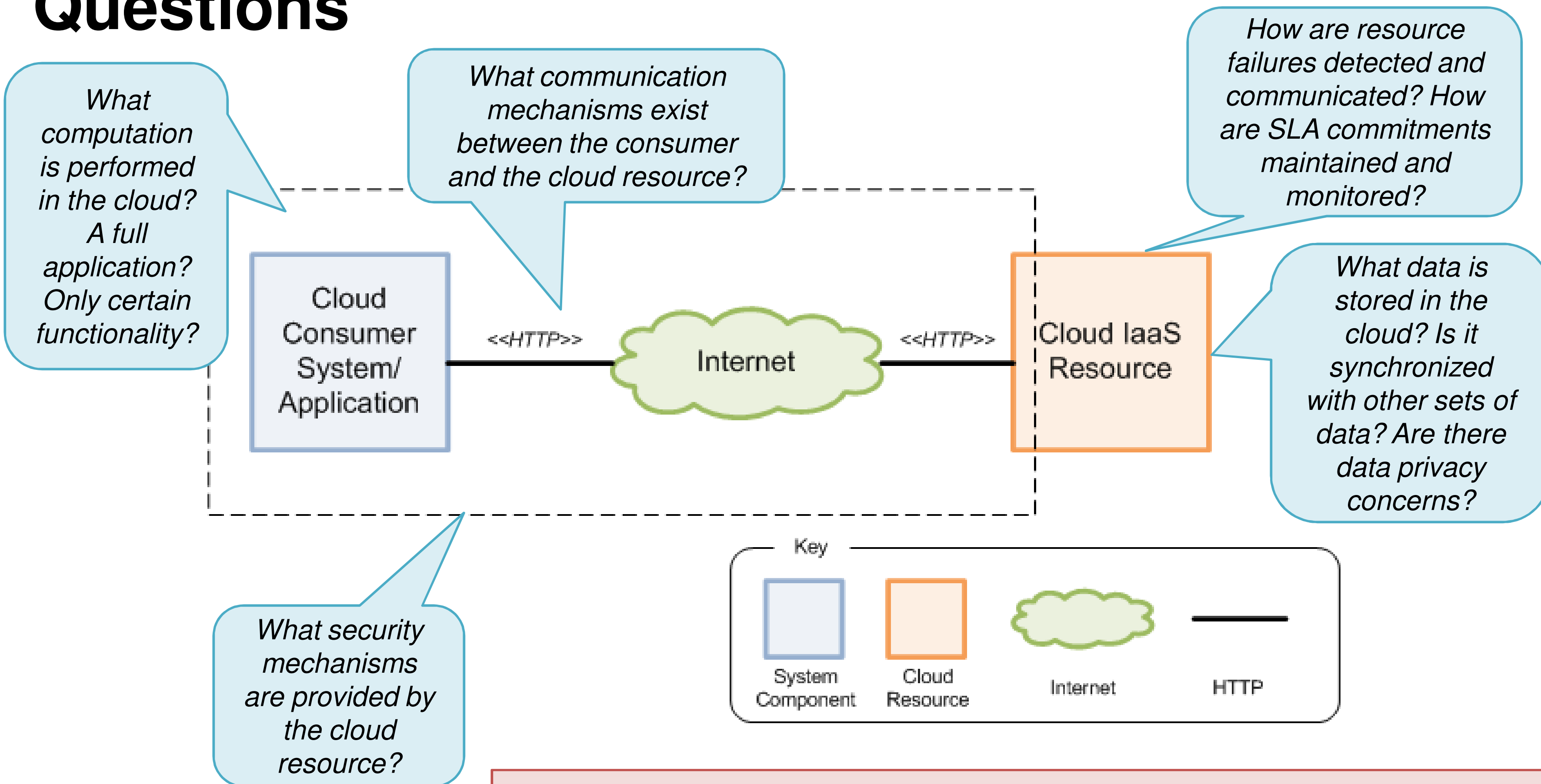
IaaS: Examples of Architecture and Design Questions



Systems residing in the cloud or using resources from the cloud will have to be designed and architected to account for lack of full control over important quality attributes

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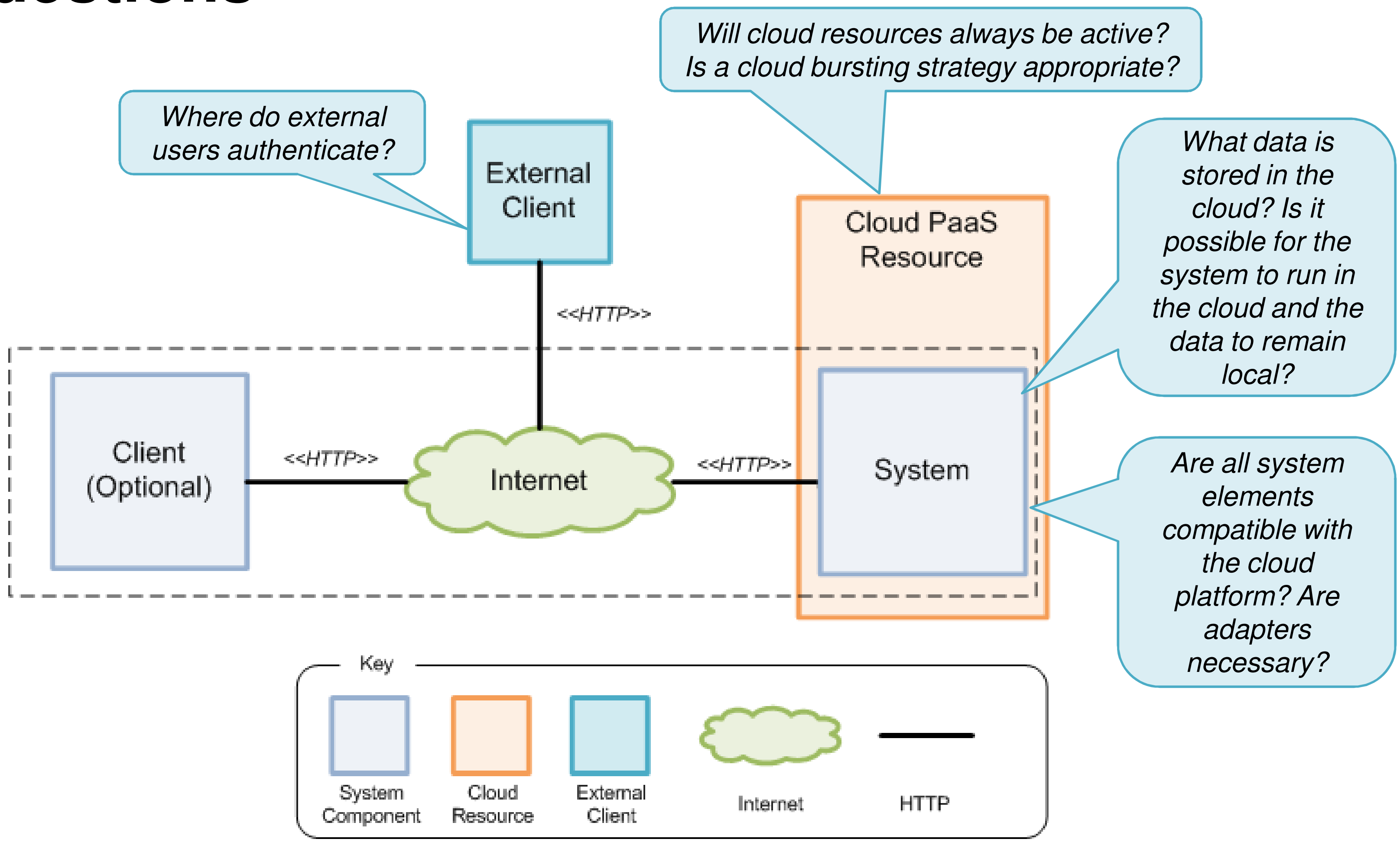
PaaS: Examples of Architecture and Design Questions



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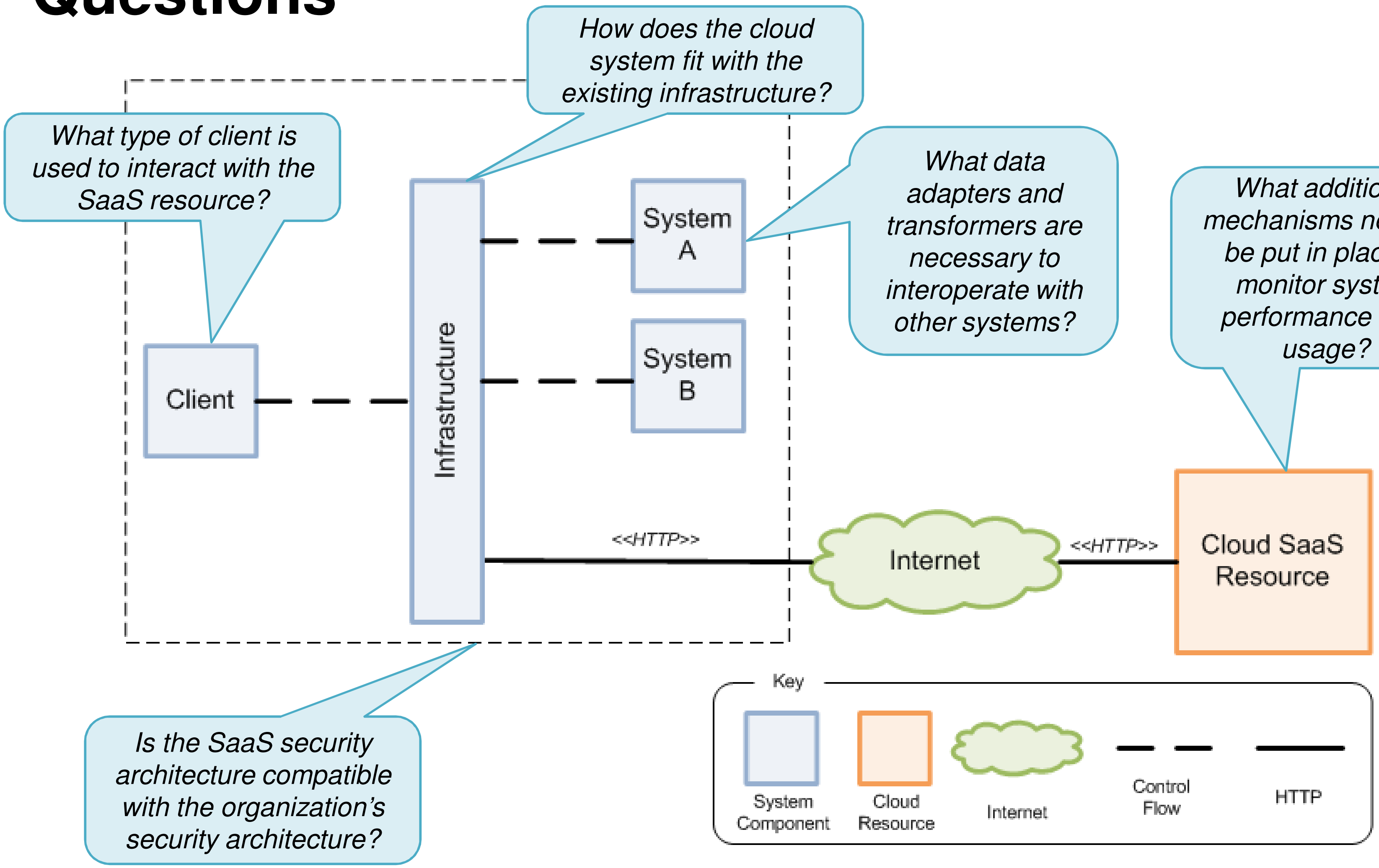
SaaS: Examples of Architecture and Design Questions



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Cloud Consumer
Example Decision # 1: Data Model

Typical decisions of a distributed environment

- Local vs. Remote
- Total vs. Partitioned
- Distributed vs. Centralized
- Active Replication vs. Passive Replication
- Data Security Model

Challenges

- Data privacy
- Data synchronization
- Performance

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Cloud Consumer
Example Decision # 2: User Authentication Model

Authentication is the mechanism by which consumers and providers prove to one another that they are acting on behalf of specific users or systems

Typical decisions of a distributed, multi-organizational environment

- Local vs. Remote Authentication
- Single Sign-On or Separate Authentication
- Local or Remote Identity Data
- Authentication Method

Challenges

- Incompatible authentication methods
- Physical security of identity data
- Synchronization of identity data
- Auditing

blogs.verisign.com

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Cloud Consumer
Example Decision # 3: Allocation of Functionality

Decisions depend on the type of cloud implementation

- What functionality to deploy in the cloud?
- What functionality has to be implemented in addition to the functionality offered by the cloud provider?
  - Security
  - Management
  - Abstraction layers, e.g. data access, transformations, adapters

leogrilo.files.wordpress.com

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Cloud Consumer
Example Decision # 4: Cloud Bursting

Refers to a system that is designed for average load, but is capable of load balancing to a cloud when it reaches its full capacity

Decisions

- Activation, initialization and de-activation of the cloud resource
- State and data synchronization
- Computational elements to determine full capacity
- Computational elements for monitoring load and usage

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Cloud Consumer
Example Decision # 5: Cloud Resource Management

Decisions

- Elements for failure detection and communication
- Elements for SLA monitoring
- Logging: where, what and when

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Cloud Provider
Example Decision #1: Multi-Tenancy 1

Mainly in SaaS implementations, a tenant is an organization that makes use of cloud resources

Multi-tenancy requires

- Awareness of tenant context: the capability of recognizing the identity of the tenant requesting the resources based on message information as well as configuration data
- Data isolation: tenants should only have access to their own data
- Performance isolation: resource performance should conform to service-level agreements, regardless of the load on the system

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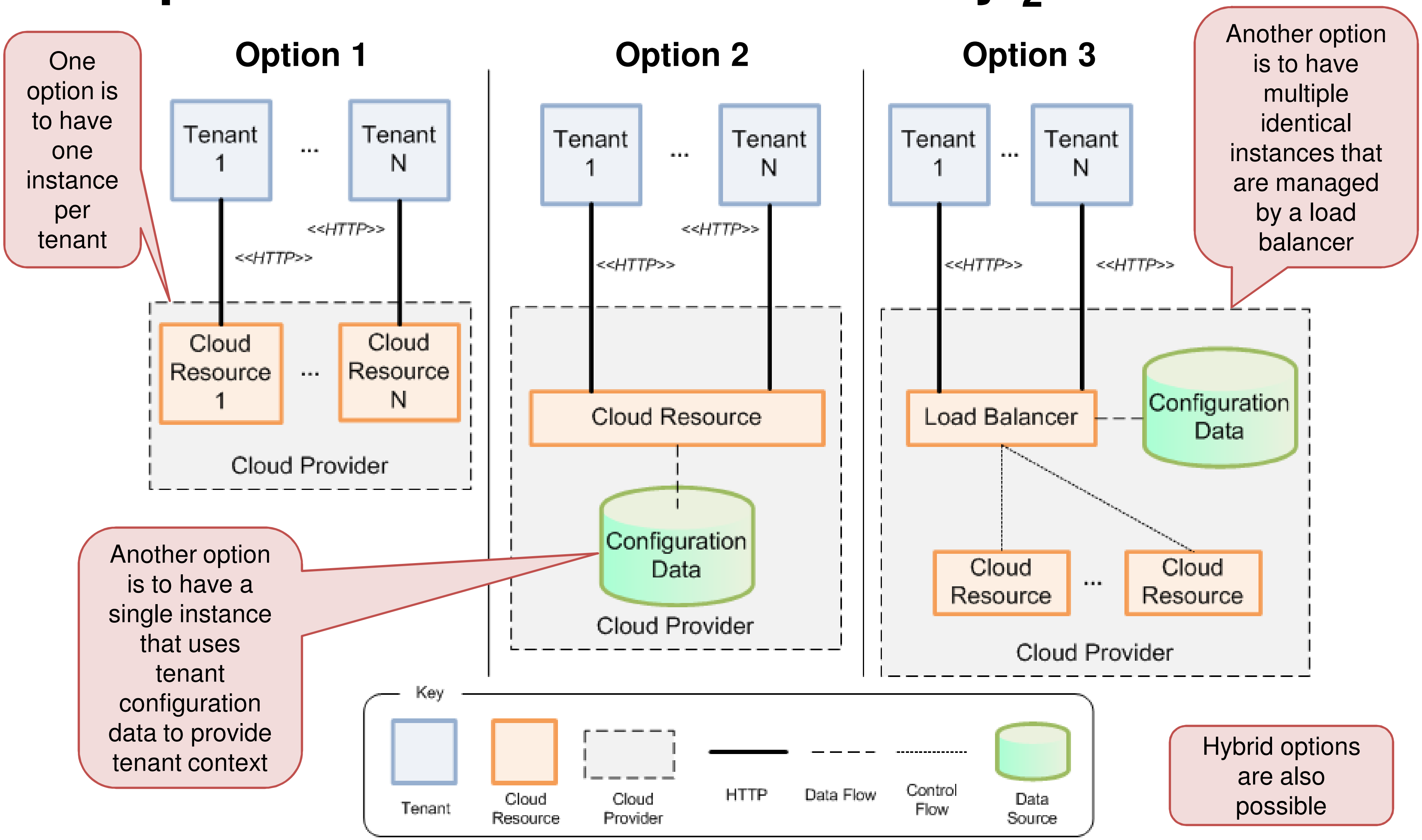
Cloud Provider
Example Decision #1: Multi-Tenancy 2



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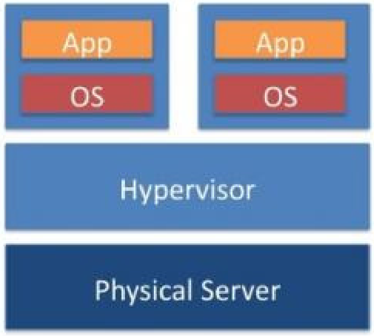
Cloud Provider
Example Decision #2: Virtualization Strategy 1

Virtualization in general is the abstraction of computing resources, e.g.

- Network virtualization: division of available bandwidth into channels that can be assigned to a particular resource in real time
- Storage virtualization: combination of physical storage devices into what appears to be a single storage device , e.g. SAN (storage area network)
- Server virtualization: hiding of server resources (number and identity of individual physical servers, processors, and operating systems) from server users, e.g. VMs (virtual machines)

Server Virtualization Example



news.cnet.com/i/bto/20090528/Virtualization_stack_270x258.jpg

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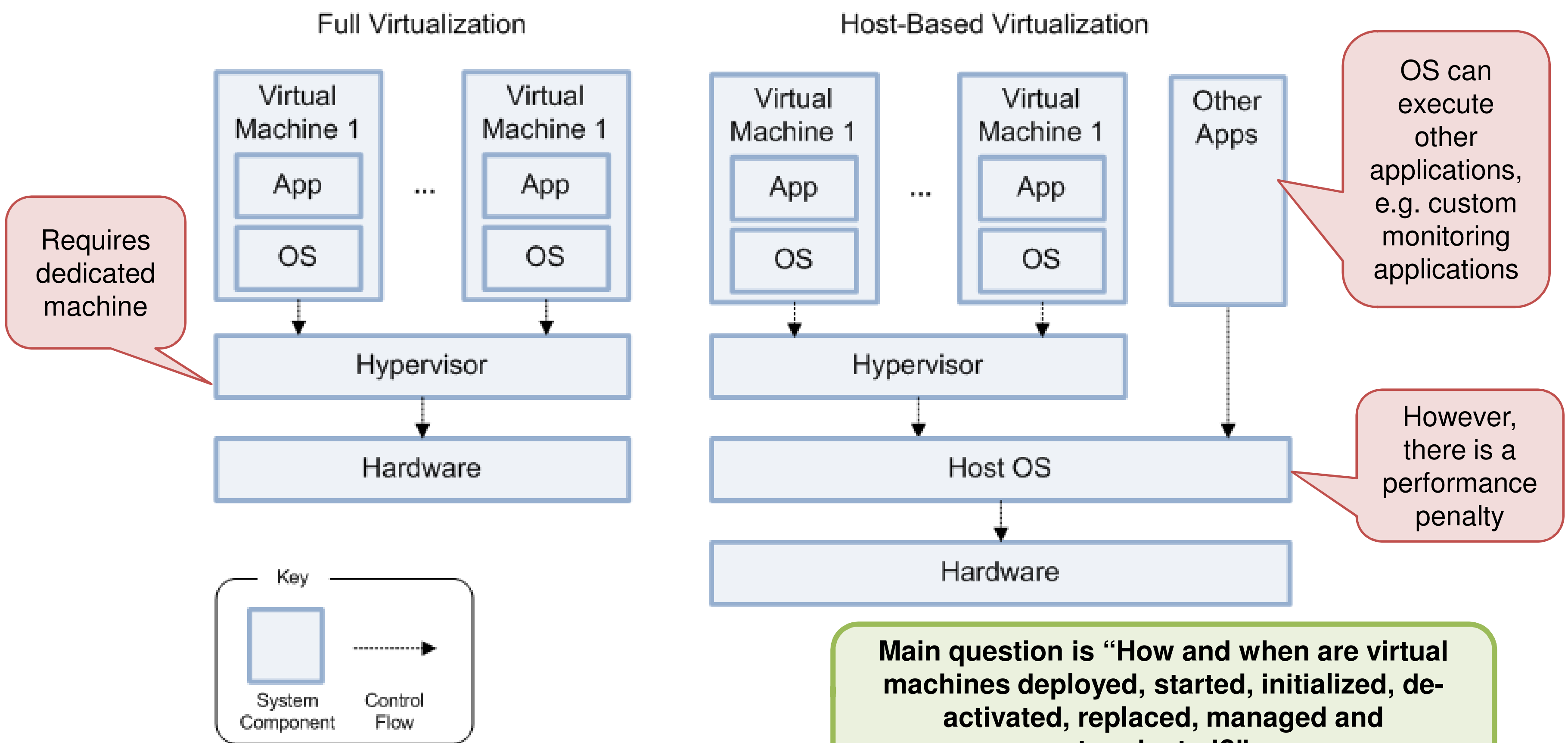
Cloud Provider
Example Decision #2: Virtualization Strategy 2

Server Virtualization Example



Main question is "How and when are virtual machines deployed, started, initialized, de-activated, replaced, managed and terminated?"

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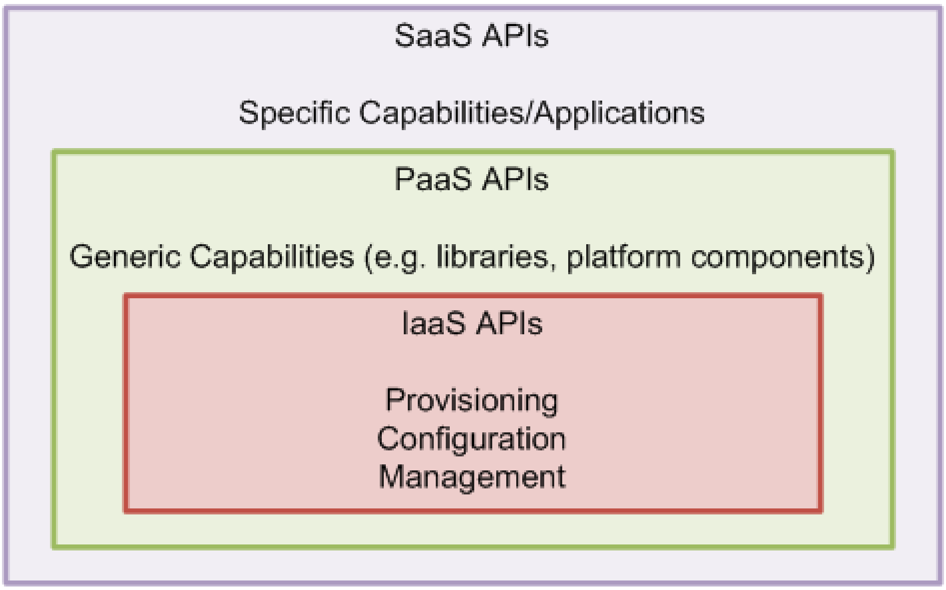
Cloud Provider
Example Decision #3: Resource Interfaces 1

Cloud APIs are not yet standardized, so each cloud provider has its own specific APIs for managing its services

Currently, most Cloud APIs are SOAP- or REST-based



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Cloud Provider
Example Decision #3: Resource Interfaces 2

Supported Protocols

Operations

- Functionality
- Configuration
- Management

QoS Support

- Security
- Usability
- Configurability

Sample Amazon EC2 Operations (IaaS)
- Create Image
- Stop Instances
- Create Security Group
- Monitor Instances

Sample Google App Engine Operations (PaaS)
- Upload Application Code
- Authenticate User
- Send E-mail

Sample Zoho.com Operations (SaaS)
- Set Up Application
- View Application Usage Data
- Embed in “X”

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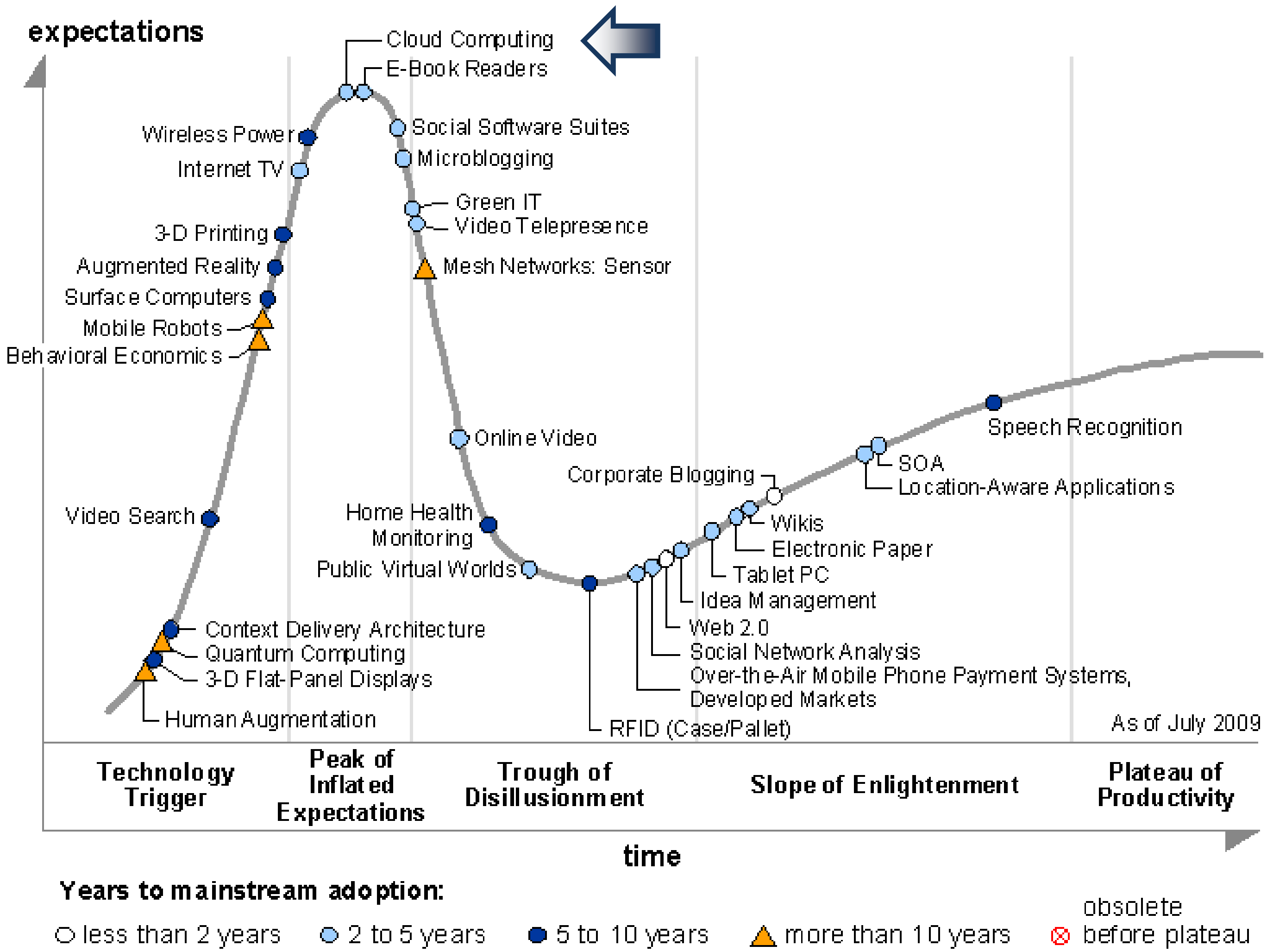
Cloud Computing is at the "Peak of Inflated Expectations"



Source: Gartner, Hype Cycle for Emerging Technologies, 2009

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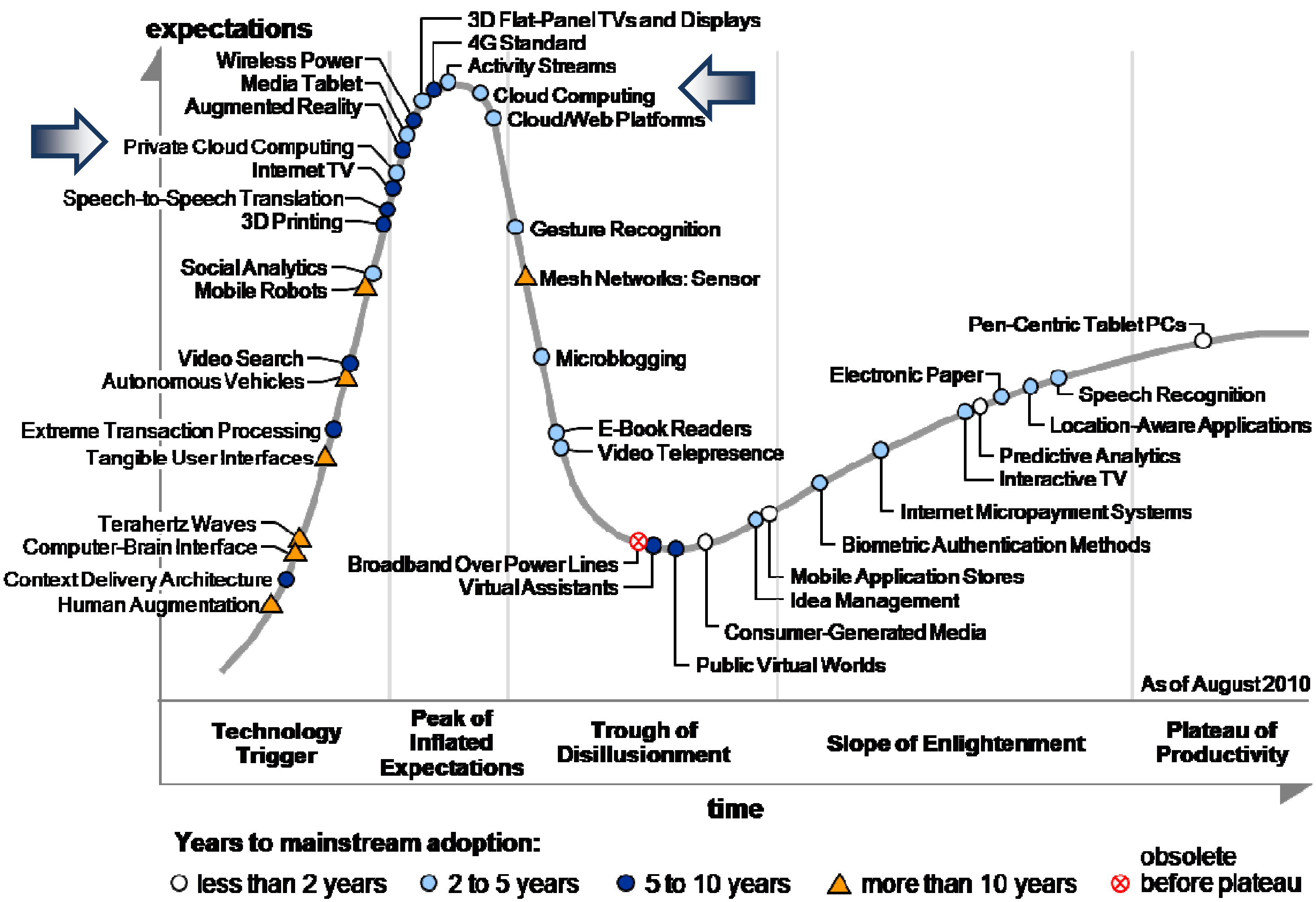
The Concept of Private Clouds is Starting to Appear



Source: Gartner, Hype Cycle for Emerging Technologies, 2010

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Final Thoughts 1

Cloud Computing is in essence an **economic model**

- It is a different way to acquire and manage IT resources

There are multiple cloud providers—**the cloud is real**

- Currently most cloud consumers are small enterprises
- Large enterprises are exploring private clouds
- The number of providers will most probably grow as people start seeing greater savings and improvements to reduce adoption barriers

Cloud Computing adoption requires **cost/benefit/risk analysis** to determine

- What resources to move to the cloud (if any)
- What situations warrant use of cloud resources, even for one-time situations
- Implementation of private clouds vs. usage of public clouds
- What risks are associated with using resources on the cloud
- What risks are associated to providing resources in the cloud

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Final Thoughts $_2$

Decisions from a cloud consumer perspective depend on

- Required control level
- Required security level
- Compatibility with local infrastructure

Decisions from a cloud provider perspective depend on

- Market/user characteristics
- Established SLAs
- Available technology

askbobrankin.com

In general, these are not fully technical decisions

- Processes — especially engineering practices
- Governance
- Cost/Benefit analysis

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Cloud Provider and Tool References

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- Akamai EdgePlatform: http://www.akamai.com/html/technology/edgeplatform.html
- Amazon Elastic Compute Cloud (EC2): http://aws.amazon.com/ec2/
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- Eucalyptus Systems: http://www.eucalyptus.com/
- Force.com: http://www.salesforce.com/platform/
- Google App Engine: http://code.google.com/appengine/
- Google Apps: http://www.google.com/apps/intl/en/business/index.html
- IBM Computing On Demand: http://www-03.ibm.com/systems/deepcomputing/cod/
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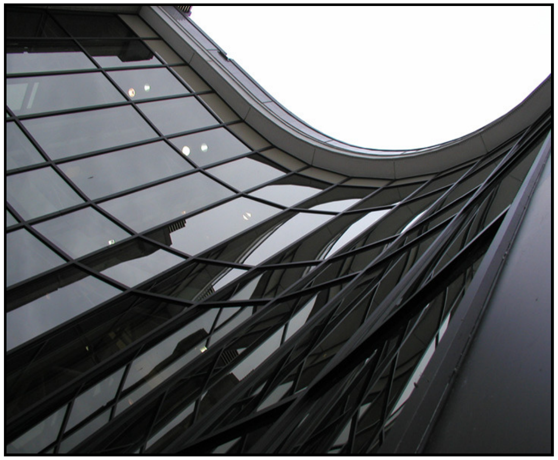

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