

Cloud Architecture

Week 2

School of Software

Faculty of Engineering and Information Technology

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SCHOOL OF SOFTWARE

Learning Objectives

- Understand the overall Cloud Reference Architecture
 - Cloud Reference Architecture by NIST
 - Cloud Reference Architecture by IBM
- Understand the role of the various components within the Cloud Reference Architecture
- Understand the various types of Cloud Deployment Models

What is cloud reference architecture?

- Collection of the actors and their activities needed in the process of cloud service delivery
 - Aids in understanding the process of cloud service delivery
- Serves as a blueprint for engineering cloud-based solutions, and for migrating applications to the cloud

Cloud Reference Architecture (CRA)

- NIST CRA developed based on real-world (aka practical) input and feedback from the developers
 - Proposed and defined by NIST (National Institute of Standards and Technology) – A US Federal Government Agency
- More than one cloud reference architecture
 - Subtle differences between them (Example: CRA by NIST and CRA by IBM)

“Architectural elements” in NIST CRA

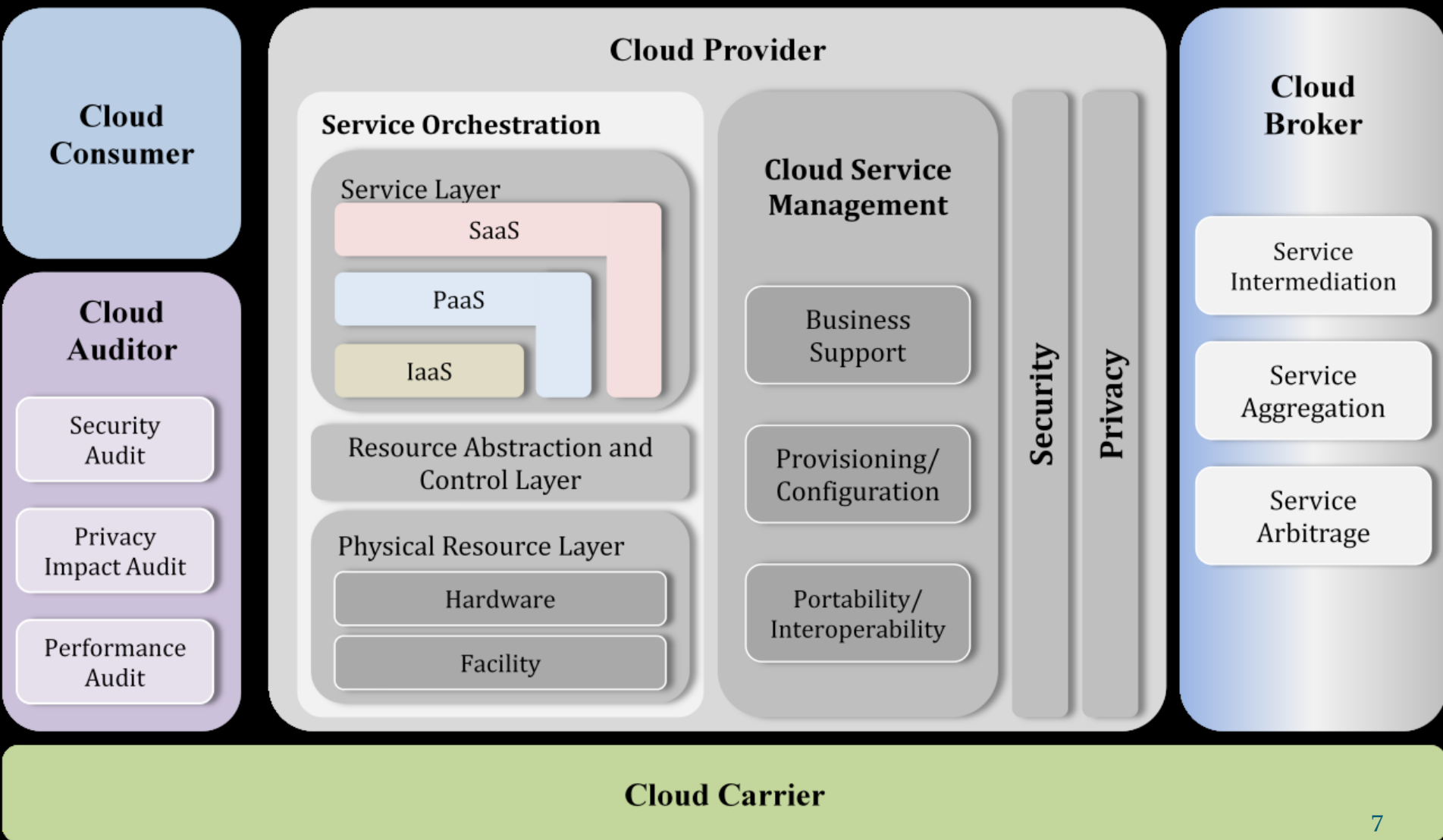
- NIST CRA is defined in terms of the following three elements:
 - Actor: An entity (software, person, or an organization) which performs a defined task (a.k.a activity) in the context of cloud computing
 - Activities (A): The collection of all the set of functions or tasks an actor performs.
 - Functions (F): A specific task that is performed by an actor

$$A = \{F_1, F_2, F_3, \dots F_n\}$$

Example

- Example of an actor: Cloud Consumer ← Actor
 - What does a cloud consumer do?
 - Requests for a cloud service and consumes it ← Activity
 - How does a cloud consumer perform its above mentioned activity?
 - Make use of search engine to look for a given provider
 - Consume the requested service
 - Pay for the consumed service
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- ```
graph LR; Actor[Actor] --> ActorText[Example of an actor: Cloud Consumer]; Activity[Activity] --> ActivityText[Requests for a cloud service and consumes it]; Functions[Functions] --> F1[Make use of search engine to look for a given provider]; Functions --> F2[Consume the requested service]; Functions --> F3[Pay for the consumed service];
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# NIST Cloud Reference Architecture (Source NIST)



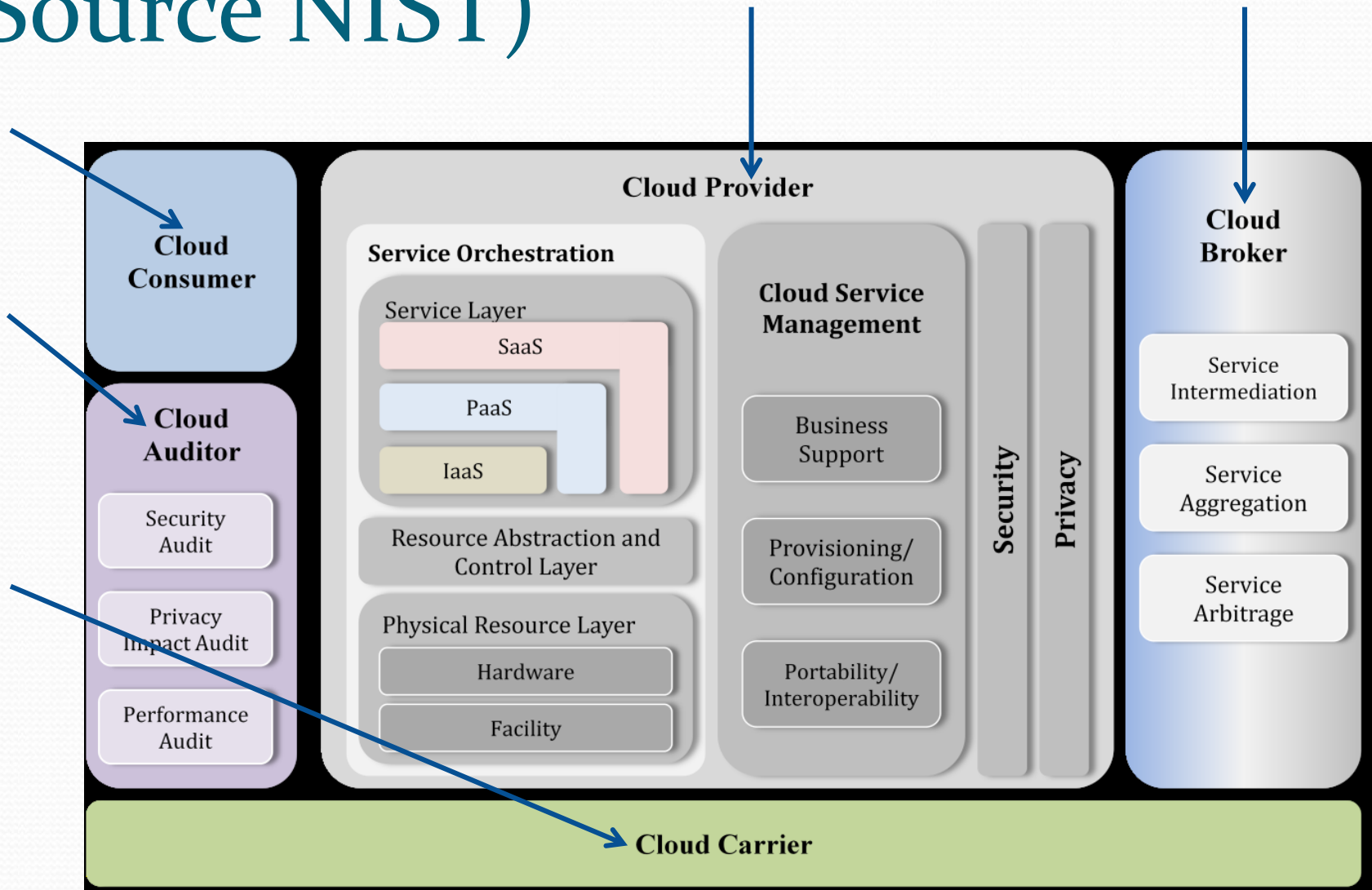
# NIST Reference Architecture ... Actors

## ► Five Major Actors

| Actor Name            | Actor Definition (Source NIST)                                                                                                                                       |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Cloud Consumer</b> | A person or an organization that maintains a business relationship with, and uses service from Cloud Providers.                                                      |
| <b>Cloud Provider</b> | A person or an organization responsible for making a service available to other parties over the cloud.                                                              |
| <b>Cloud Auditor</b>  | A party that can conduct an independent assessment of cloud services, such as, information system operations, performance, and security of the cloud implementation. |
| <b>Cloud Broker</b>   | An entity that manages the delivery of cloud service on behalf of <i>Cloud Provider</i> .                                                                            |
| <b>Cloud Carrier</b>  | An intermediary that provides connectivity and transport of cloud services from <i>Cloud Providers</i> to <i>Cloud Consumers</i> .                                   |

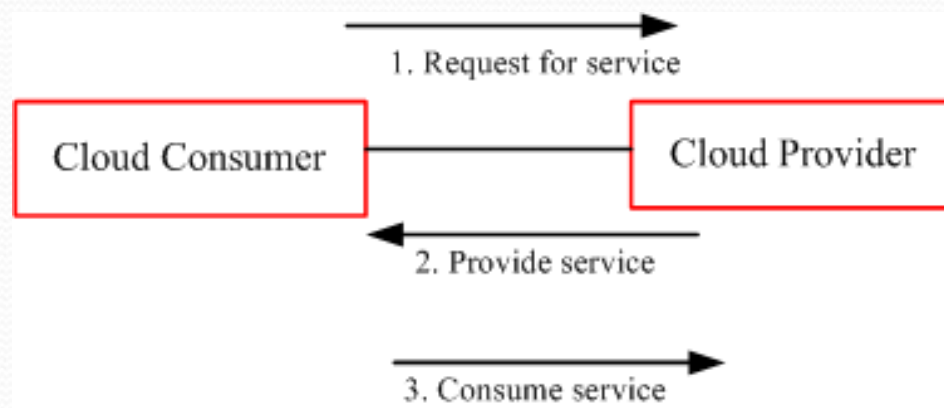


# NIST Cloud Reference Architecture (Source NIST)



# What is a cloud consumer?

- Cloud consumer is a software, person or an organization that consumes a given “cloud-based service” from a cloud provider.



**Figure:** Typical interaction between cloud consumer and cloud provider

# What does a cloud consumer do?

- Typical functions performed by cloud consumer:
  - Search for required service (and select it)
    - Use Service Catalogue; (or)
    - Use Search Engine
  - Request for cloud service from the cloud provider
  - Engage in negotiation process to set up SLAs with the cloud provider (if applicable)
  - Honour the SLAs and arrange for payment for consumed services



# What is a cloud provider?

- A person or an organization that is responsible for making a service available to other parties over the cloud.
- Workflow of “functions” performed by cloud provider:
  - Create (i.e., develop) the cloud service
  - Develop a user interface for the cloud consumer
  - Negotiate SLA agreements with the cloud consumer (if applicable)
  - Manage, update, upgrade the deployed service (Cloud Service Management)

# Types of Cloud Providers

- IaaS Providers

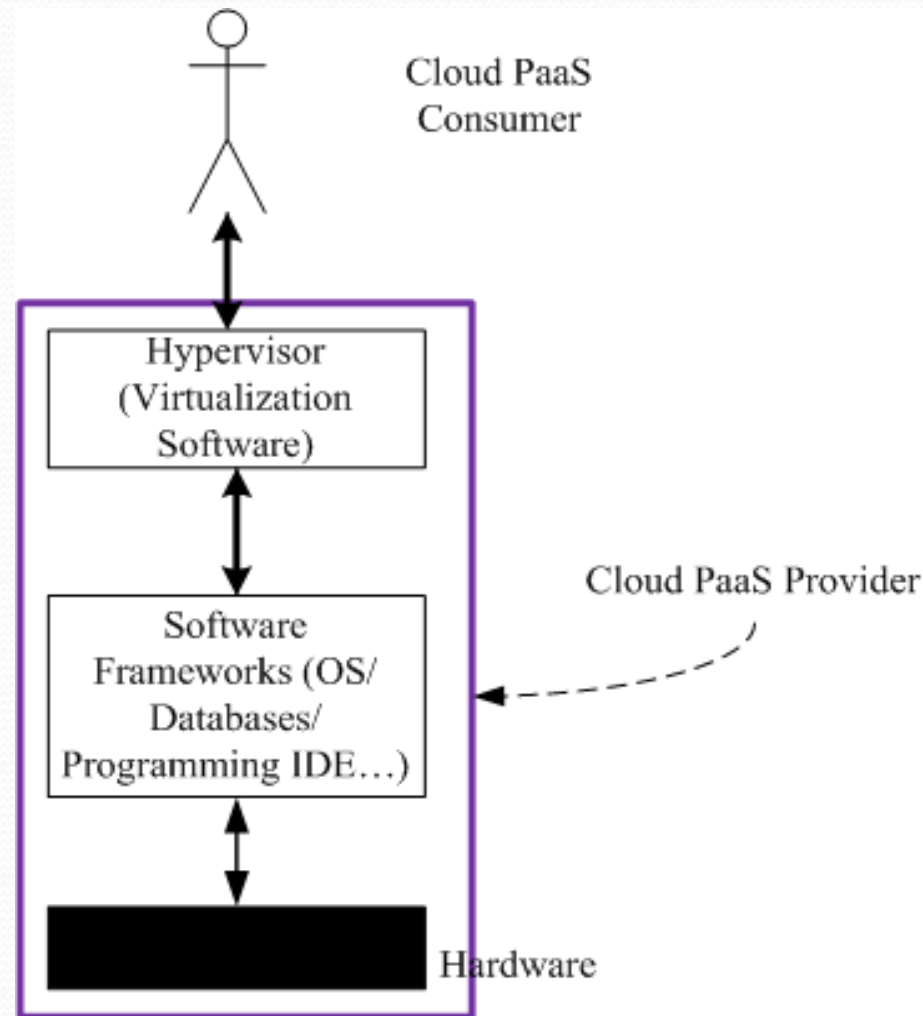
- Acquire and pool hardware resources (in a data centre) that will be provisioned
- Run virtualization software on top of provisioned resources and link with IaaS consumers (user interface)
- Example: Amazon Web Services

- PaaS Providers

- Acquire, configure and maintain resources that will be provisioned to users for software development (databases, programming IDE...etc.)
- Run software on top of these provisioned resources to link with the PaaS consumers (virtualization software and user interface)
- The provisioned resources run on top of hardware that is opaque to the PaaS consumer
- Example: Google App Engine



# PaaS Provider



**Figure:** Layers of PaaS provider and their visibility to PaaS Consumer

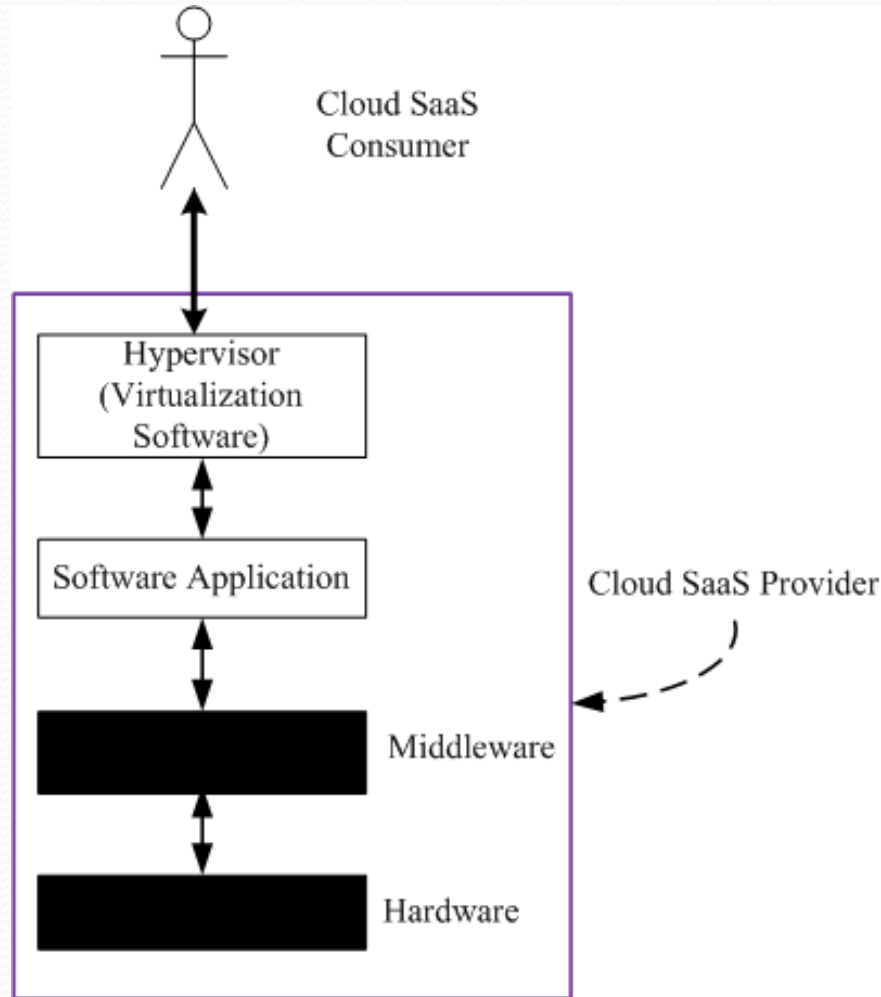


# Types of Cloud Providers

- SaaS Providers

- Acquire, configure and maintain software applications that will be provisioned to multiple users.
- Run virtualization software on top of these provisioned applications
- Link with the SaaS consumers via a user-interface

# SaaS Provider



**Figure:** Layers of SaaS provider and their visibility to SaaS Consumer

# Families of Cloud Services

(Patrick et al)



## Software-as-a Service (SaaS)

### Definitions

As-a-service delivery of applications targeted at private users (e.g. social networking, micro-blogging) and business users (e.g. ERP, CRM)

### Key actors

Salesforce.com  
Google Apps  
Oracle  
Facebook  
Netsuite

## Platform-as-a Service (PaaS)

As-a-service delivery of tools for development, testing, deployment, hosting and application maintenance

Force.com  
Caspio  
Google Apps Engine  
Microsoft Azure

## Infrastructure-as-a-Service (IaaS)

As-a-service delivery of virtual CPUs, disk space, and database services

Rightscale  
Amazon web services  
Eucalyptus  
Gogrid



# What is a cloud auditor?

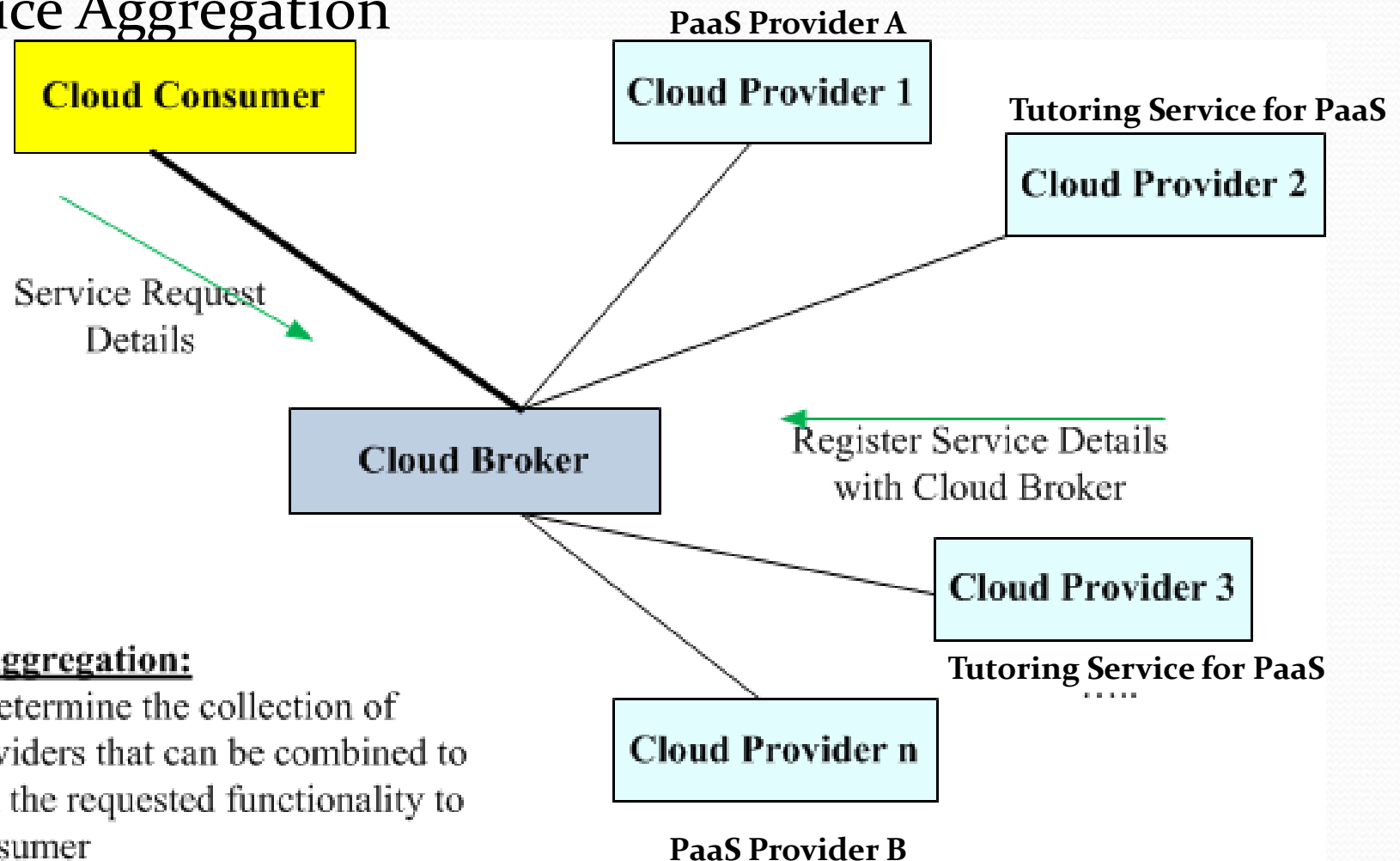
- An independent, third party entity (not related to either the cloud consumer or the cloud provider)
- Systematically and periodically probes the service provided by the cloud provider
- Typical probing activities are to determine compliance in:
  - Privacy policy adherence
  - Implementation of security controls

# What is a cloud broker?

- An intermediary entity that manages the delivery of cloud services (on behalf of cloud provider).
- Two broad scenarios where a broker may be involved:
  - Manages the delivery of service on behalf of the cloud provider (Proxy Service Delivery);
  - A cloud broker may assist the cloud consumer to search for an appropriate service (Service Matchmaking)
- May not be present in each relationship

# Example of service matchmaking

- Service Aggregation



**Service Aggregation:**

**Step 1:** Determine the collection of cloud providers that can be combined to deliver on the requested functionality to cloud consumer

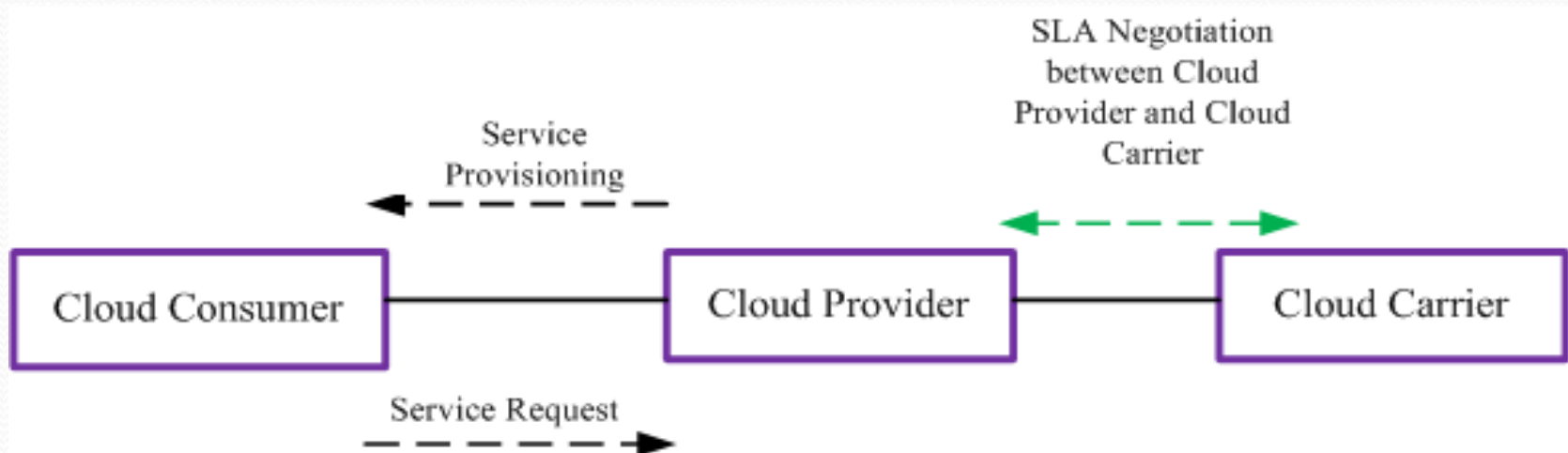
**Step 2:** Aggregate the different selected cloud services and present a single interface to the cloud consumer



# What is a cloud carrier?

- An intermediate entity (usually an organization) that provides the necessary logistics for the cloud service
  - Provides the platform for delivering the service
- Does not enhance, modify or augment the service.
- Key player in ensuring the QoS of delivered cloud service.
- Example: ISPs

# Example of an interaction between actors .. 1

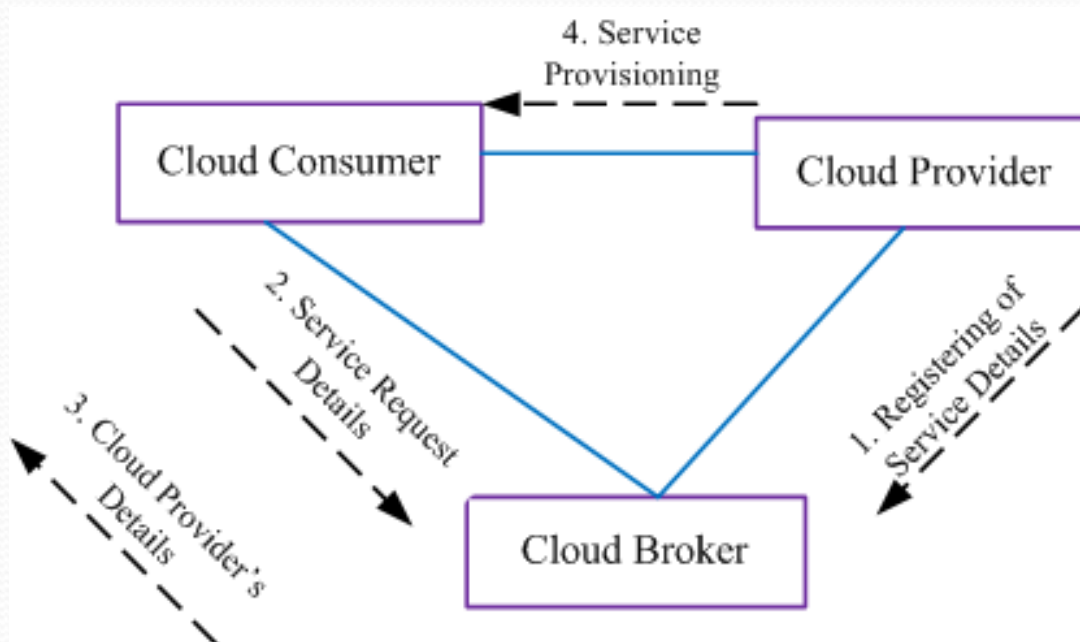
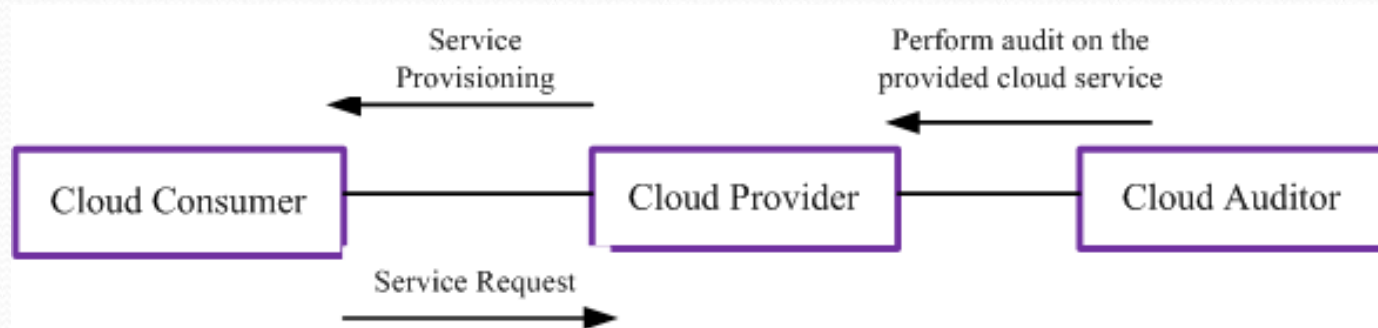


**Example 1:** Interaction between Cloud Consumer, Cloud Provider and Cloud Carrier

- Relationship between Cloud Consumer, Cloud Provider and Cloud Carrier

# Examples of an interaction between actors .. 2

**Example 2:** Interaction between Cloud Consumer, Cloud Provider and Cloud Auditor



**Example 3:** Interaction between Cloud Consumer, Cloud Provider and Cloud Broker



# Physical Resource Layer

- “Physical” hardware resources
- Actual resources that will be provisioned to the cloud consumers
- Includes basic facilities which are necessary to provide cloud services such as electrical power, bandwidth...etc.

# Resource Abstraction and Control Layer

- Resource Abstraction and Control Layer
  - Two broad functionalities – “*resource abstraction*” and “*control*”
- Resource Abstraction layer
  - *Provides functionality of exposing the physical (actual) resources to the cloud consumer (as virtual resources)*
    - Carries out mapping between virtual resources and physical resources
- Control Layer
  - *Provides functionality to control the provided resources*
    - Comprises of software components that enable the cloud provider to manage the underlying cloud resources
    - Functionality such as usage monitoring of the cloud resources



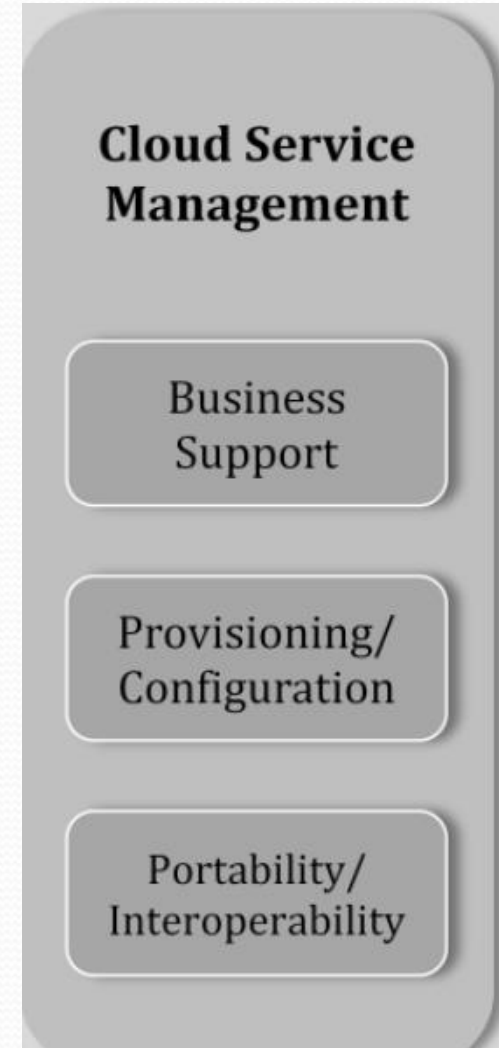
# Service Layer

- Define the interface to the cloud consumer (HTTP or HTTPS or FTP) (a.k.a. access point or access layer)
- *Provides a mechanism (interface) for the end user to use the provided resources*



# Cloud Service Management

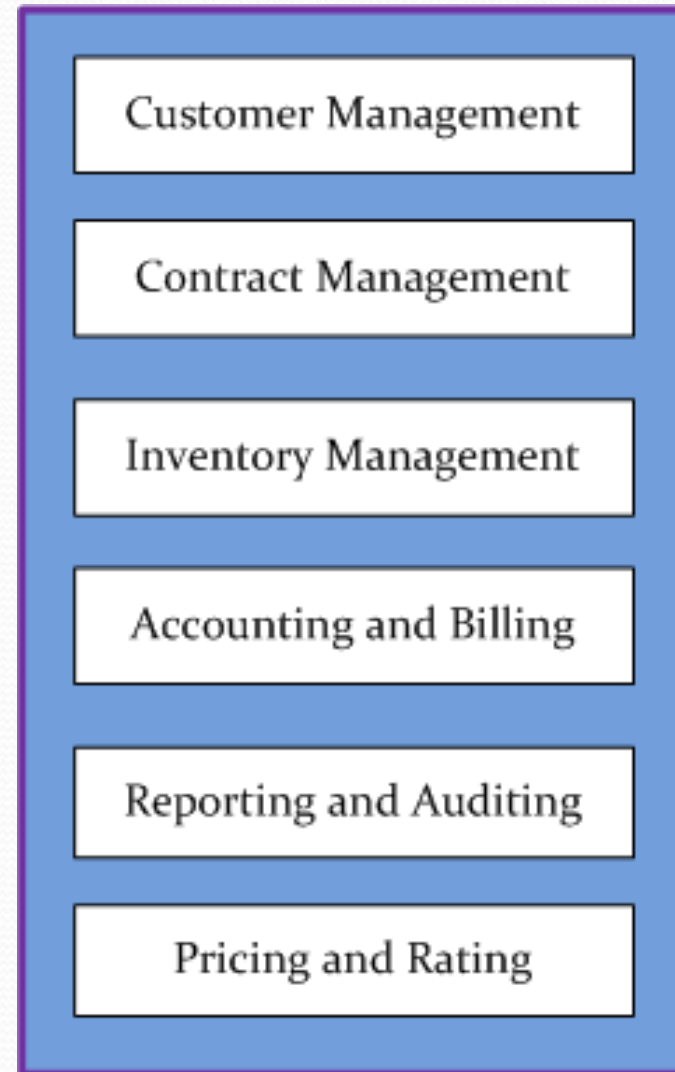
- Encompasses all the service-related functions provided by the cloud provider
- Three sub-layers:
  - Business Support Functions;
  - Provisioning Functions;
  - Portability/Interoperability Functions.



**Figure:** Cloud service management

# Business Support Layer

- Contains “basic” business-related service support functions required by the consumer
- Example of services in this layer include:
  - Customer Account Management
  - Customer Contract Management
  - Accounting and Billing
  - .....



**Figure:** Business Support Layer

# Provisioning/Configuration Support Layer

- Contains “advanced” business-related service support functions
- Example of services in this layer include:
  - Resource changing
  - SLA management

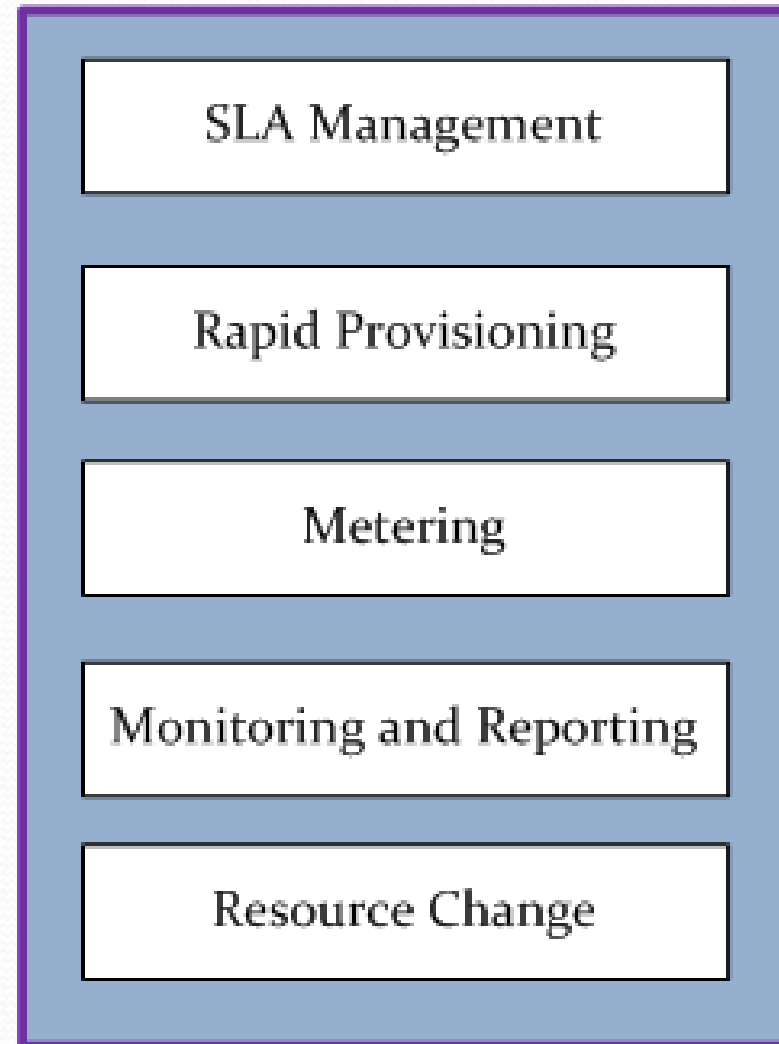


Figure: Provisioning Layer



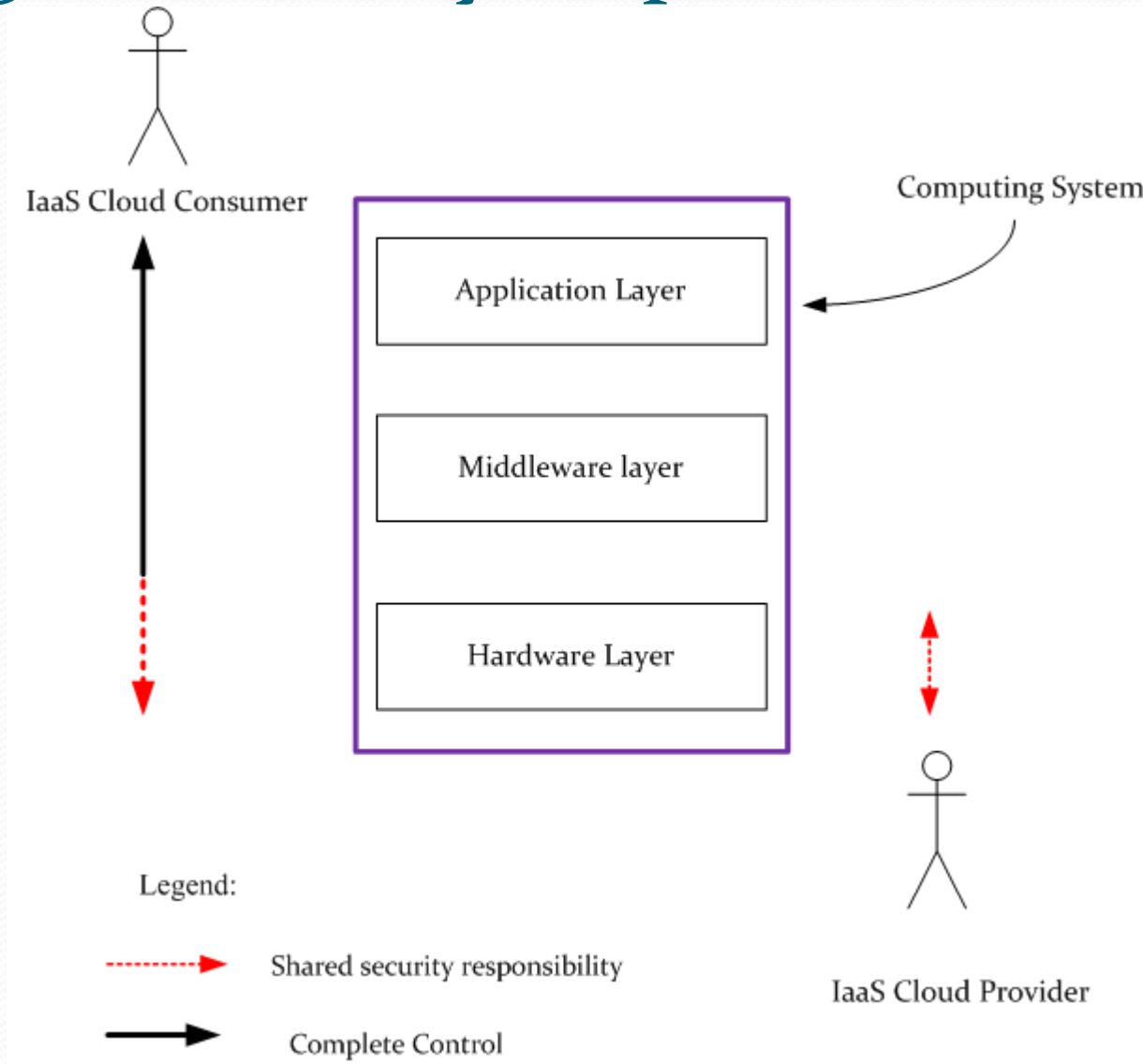
# Portability Layer

- Portability in cloud computing refers to moving (data, software service or virtual machine), from one cloud provider to another, with minimal or no disruption and/or cost
- Portability needs to be primarily considered for PaaS and SaaS
  - Software Service (written in Java vs., written in Python vs., written in Apex vs., written in Go!)

# Security Layer

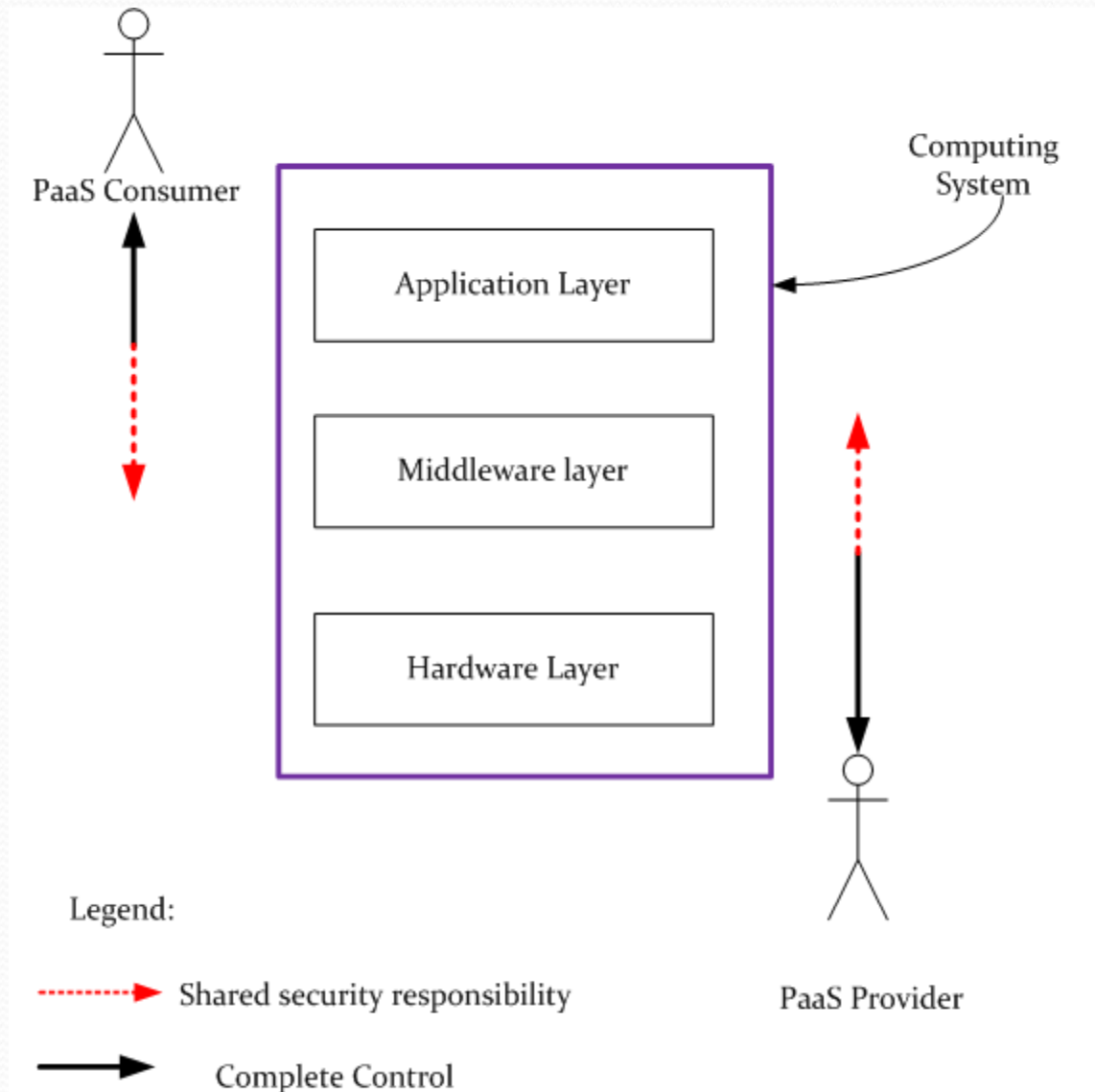
- Responsible for managing the security issue in the cloud instance
- Present across all the different types of cloud services
  - Security in SaaS; vs. Security in PaaS; vs. Security in IaaS.
- Security in cloud computing takes a different dimension - shared between cloud consumer and cloud provider
- Major current concern of enterprises in migrating to the cloud

# Sharing of Security responsibilities in IaaS

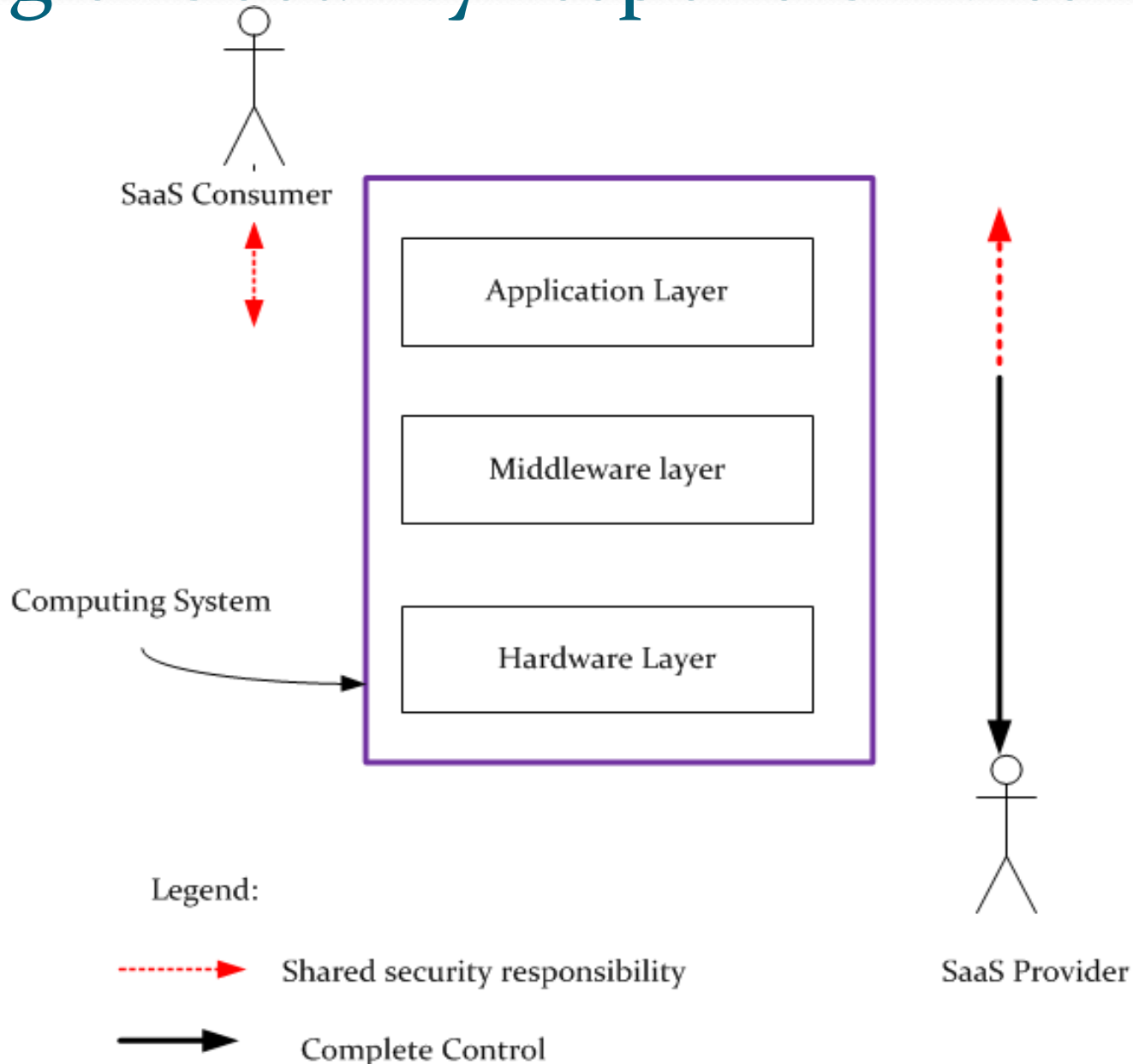




# Sharing of Security responsibilities in PaaS



# Sharing of Security responsibilities in SaaS

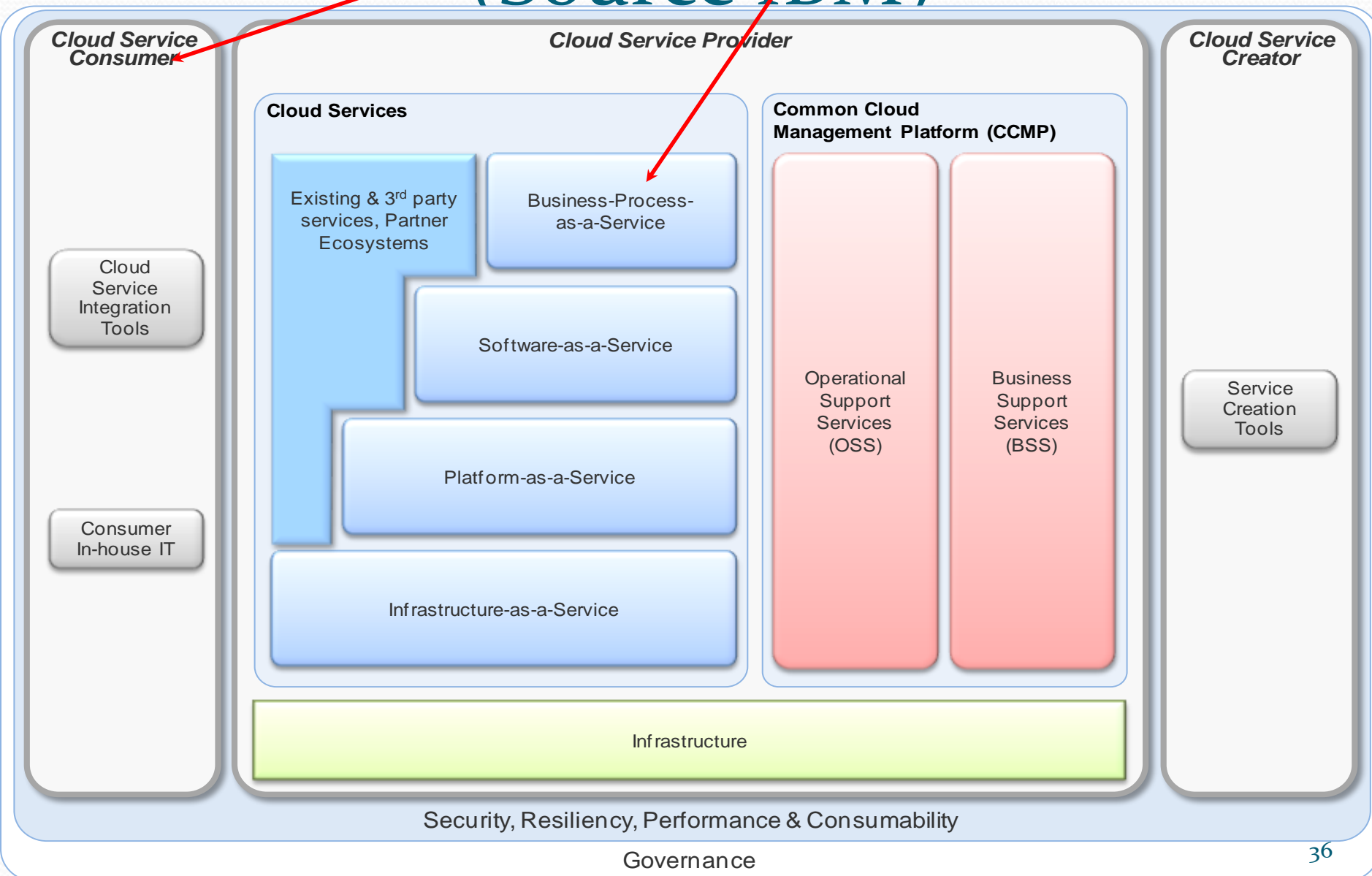


# Privacy Layer

- Responsible for protecting and assuring the proper use (or disposition) of confidential information collected from cloud consumers
- Privacy is a big issue across all the types of cloud services
  - Privacy of raw stored data; (and)
  - Privacy of information in software services; (and)
  - Privacy of information in Virtual machines.
- Various cloud providers have different privacy policies.



# IBM Cloud Reference Architecture (Source IBM)



# IBM Cloud Reference Architecture

- Types of cloud service offerings (as per IBM)
  - IaaS, PaaS, SaaS; and
  - BPaaS.
- Major differences with NIST CRA
  - 4 types of cloud service offerings
  - Emphasis on cloud integration with in-house IT infrastructure

# Integration with in-house IT

- Cloud-based service consumption would only be part of the overall enterprise IT infrastructure
- This layer focuses on an integration between in-house IT infrastructure and cloud infrastructure





# IBM Cloud Reference Architecture

- Business Process: A business process or business method is a collection of related, structured activities or tasks that serve a particular goal for customers (Wikipedia, 2012)
- Examples of Business Process (Customer Feedback, Customer Registration, Product Ordering, etc...)
- Business Processes are structured and may be customized by a particular organization to suit its needs (Customer Feedback process by various companies)
- BPaaS is used to refer to business processes that are delivered using the cloud to the consumers

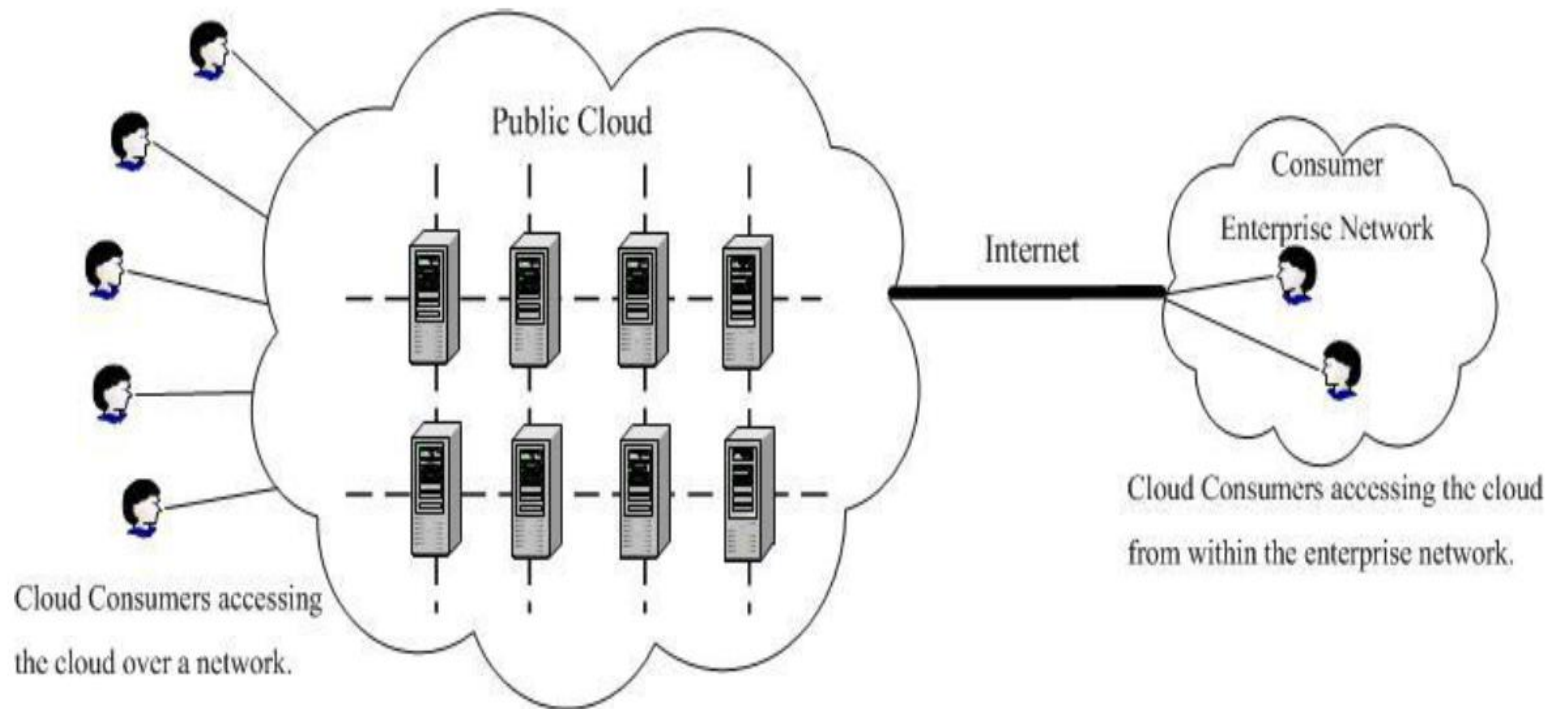
# Cloud Service Deployment Models

- Manifests how a given cloud provider provides cloud services
- Four service deployment models
  - Public Cloud (a.k.a., Cloud)
  - Private Cloud
  - Community Cloud
  - Hybrid Cloud



# Public Cloud

- A public cloud is one in which the computing resources are made available to the general public over a public network.
- Examples: Amazon Elastic Compute Cloud (Amazon EC2); Google AppEngine; Microsoft Azure



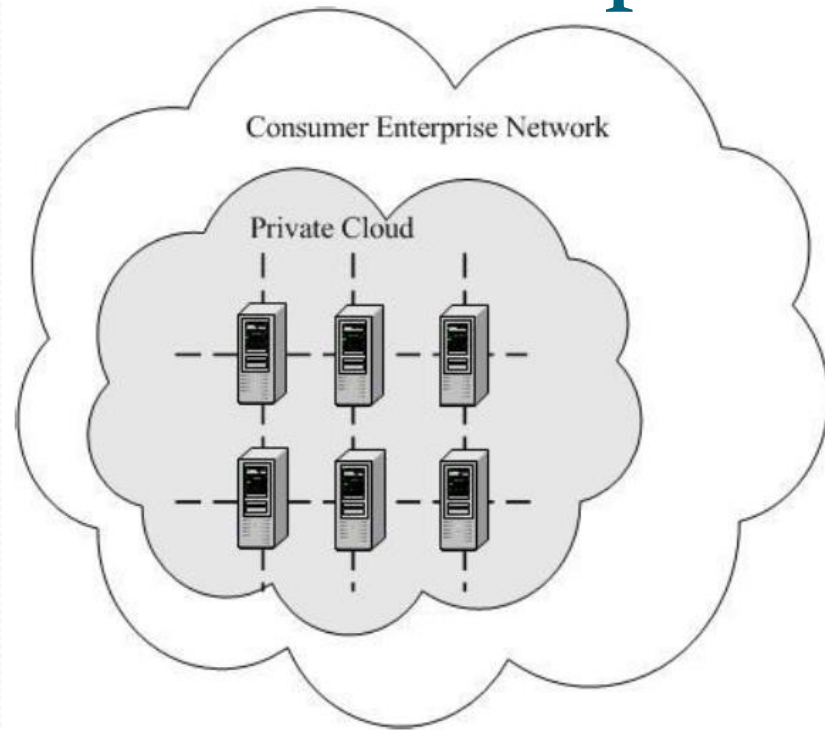
**Figure:** Public Cloud



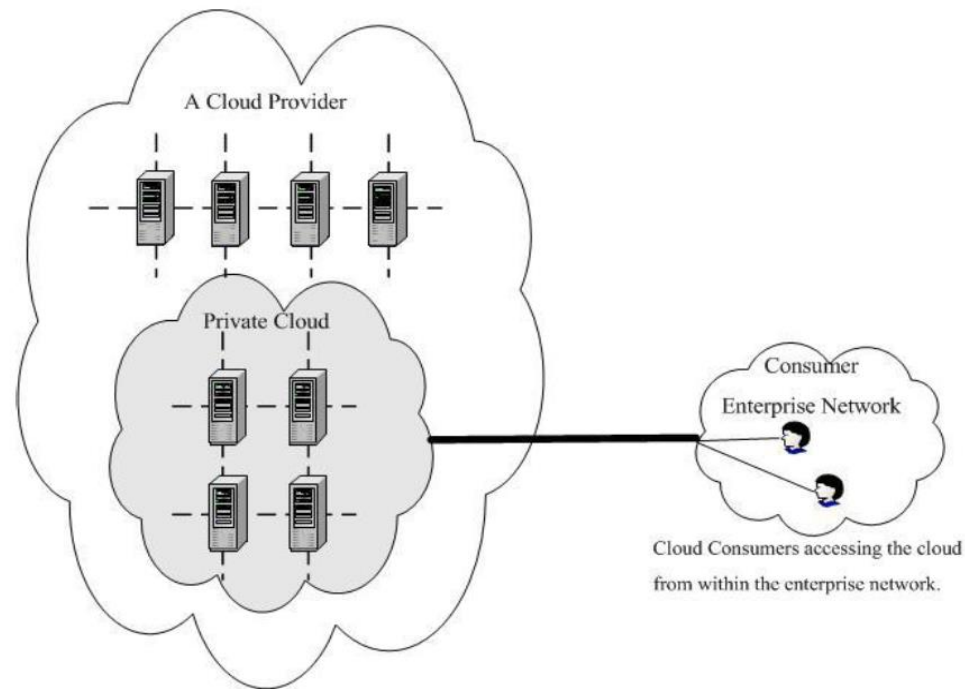
# Private Cloud

- An organization-centric cloud that has been engineered to cater for its needs only.
  - Available only to the members of the owning organization.
- May be hosted within the organization (on-site hosting), or by a third party (out-sourced hosting)
- On-site vs. Out-sourced decision (trade-off in terms of security, and privacy of information)

# Onsite private cloud vs. Outsourced private cloud



**Figure:** On-site private cloud



**Figure:** Out-sourced private cloud

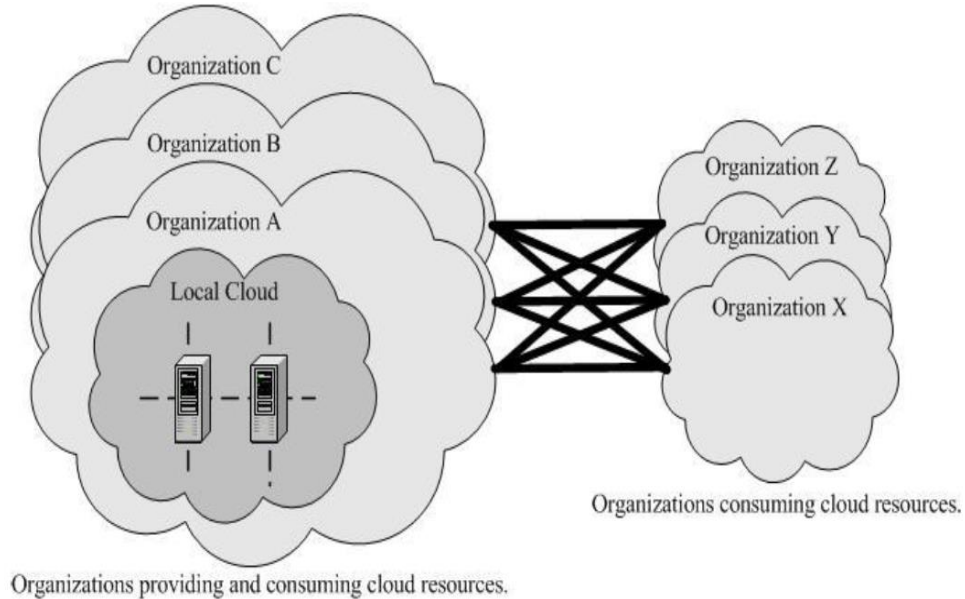


# Community Clouds (Vertical Clouds)

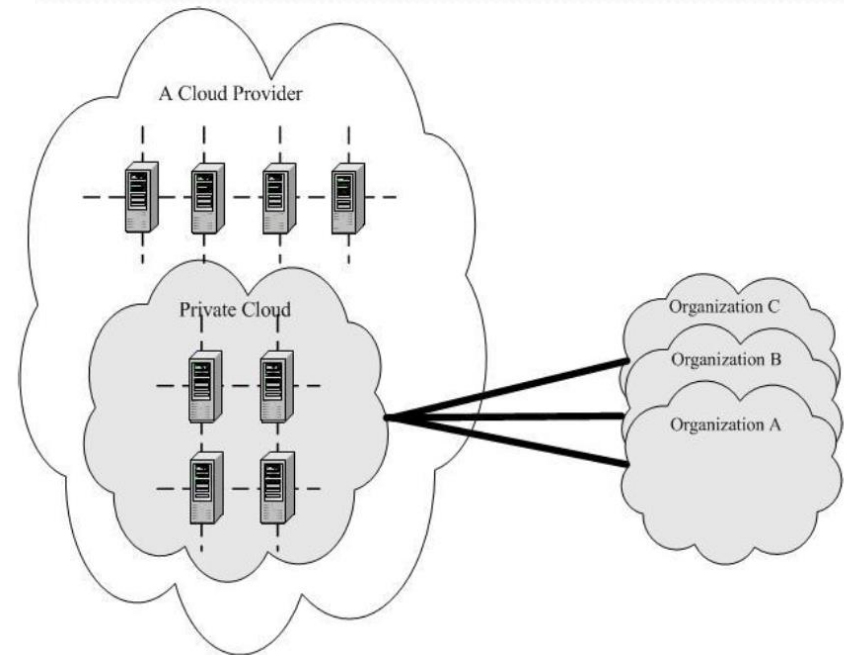
- A cloud that has been engineered to cater for the needs of a given community or sector only
- Community is a broader term than an organization and encompasses consumers from multiple organizations.
- Community is a group of users that have similar set of requirements (Cloud for Healthcare services; Cloud for government agencies; Cloud for Banks)
- Visible only to the members of that community.
- May be hosted within the community (on-site hosting), or by a third party (out-sourced hosting)
- Examples: Terremark



# Types of Community Clouds



**Figure:** On-site community cloud



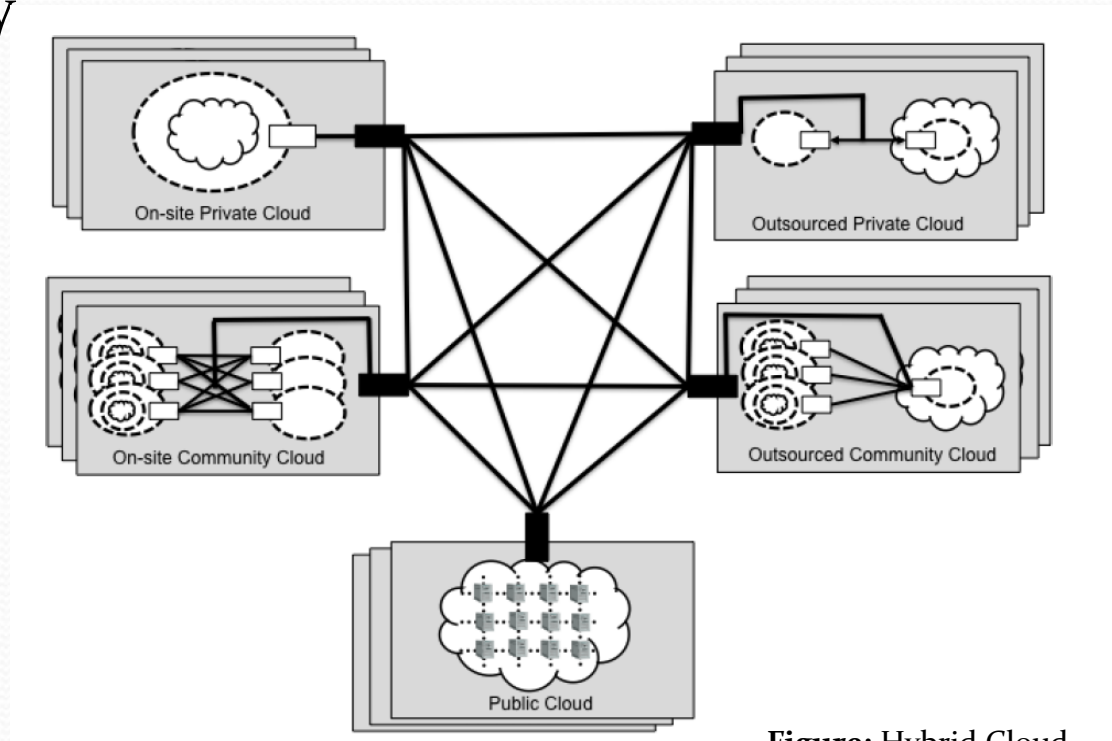
**Figure:** Out-sourced community cloud

# Public cloud (vs.) private cloud (vs.) community cloud

|                                           | Private cloud                                              | Community cloud                         | Public cloud                        |
|-------------------------------------------|------------------------------------------------------------|-----------------------------------------|-------------------------------------|
| <b>Purpose</b><br>(What is it meant for?) | To serve members of a given organization                   | To serve members of a given community   | To serve the general public         |
| <b>Location</b><br>(Where is it located?) | On-site or out-sourced                                     | On-site or out-sourced                  | At the cloud provider's location    |
| <b>User-base</b><br>(Who can use it?)     | Hundreds... or thousands.. of “organization” specific user | Thousands of “community” specific users | Tens of thousands or “public users” |

# Hybrid Cloud

- Composition of two or more clouds (private, public, community)
- The different clouds are connected by standardized or proprietary technology that enables data and application portability



**Figure:** Hybrid Cloud



# Conclusion

- Reference Architecture
  - NIST Reference Architecture
  - IBM Reference Architecture
- Cloud Deployment Models

# Reading

## Books

1. Rhoton, J. (2010), Cloud computing explained, Recursive Press, UK – Chapter 2
2. Rhoton, J., Haukioja, R. (2011), Cloud computing architected, Recursive Press, UK – Chapter 2
3. Shroff, G. (2010), Enterprise cloud computing: technology, architecture, application, Cambridge University Press, UK – Chapter 4



# Reading Papers

These slides have been made using the content from the following papers

1. F. Lie, J. Tong, J. Mao, R. Bohn, J. Messina, L. Badger and D. Leaf. (2011). NIST Cloud Computing Reference Architecture.
2. M. Behrendt, B. Glasner, P. Kopp, R. Dieckmann, G., Breiter, S. Pappe, H. Kreger and A. Arsanjani. (2011). IBM Cloud Computing Reference Architecture 2.0.
3. Patrick Callewaert, Paul A. Robinson, Peter Blatman, “Cloud Computing- Forecasting Change”, Deloitte Consulting.