A Strawman Model

NIST Cloud Computing Reference Architecture and Taxonomy Working Group

January 3, 2011
Objective

Our objective is to define a neutral architecture consistent with NIST definition of cloud computing that:

- Represents the three service models, four deployment models, and five essential characteristics
- Relates different cloud services and map them to the overall model
- Serves as a roadmap for IT to design and deploy cloud infrastructures

In this report, we present our initial design of cloud computing reference architecture.
Cloud Computing Conceptual Model
- Top-Level View

• The cloud computing conceptual model consists of four domains – and its sub-domains - each of which contains its own actors and applications.
  – *Actors* may be devices, computer systems and/or the organizations that own them.
  – *Applications* are the tasks performed by the actors within the domains.

• The cloud computing conceptual model is presented as successive diagrams of increasing level of details.

• The top-level domains and their actors:
  – *Cloud Service Consumers*: The users of cloud services. May select/use/pay services. Can be another cloud service provider to other consumers. Three consumer types are discussed, each using applications in the category of SaaS/PaaS/IaaS.
  – *Cloud Service Providers*: The organizations provide/manage/bill cloud services to consumers.
  – *Cloud Service Developers*: The organizations create/publish/monitor cloud services for providers.
  – *Cloud Service Distributors*: The distributors of cloud services to customers.
Cloud Computing Conceptual Model
- Top-Level View

Cloud Service Consumers

Cloud Service Distributors

Cloud Service Providers

Cloud Service Developers, Vendors

Interactive communication flow
Cloud Service Consumers

- Cloud consumers are categorized into three groups, based on the different application/usage scenarios they use.
  - **Biz users:** The end users of SaaS. Use application/service for biz process operations.
  - **CIOs and IT managers:** Users of PaaS. Develop, test, deploy and manage services for application development.
  - **System developers:** Users of IaaS. Create/install, manage and monitor services for IT infrastructure operations.

- Some example usage scenarios are listed in the following diagram.

- **Ref:**
Cloud Service Consumers

Cloud Service Distributors

Biz Users
- SaaS
  - Legal
  - Human Resources
  - Social Networks
  - Backup & Recovery
  - Financials
  - Content Management
  - Email & Office Productivity

ClOs and IT managers
- PaaS
  - Business Intelligence
  - Database
  - Development & Testing
  - Integration

System Developers
- IaaS
  - Storage
  - CDN
  - Backup & Recovery
  - Application Hosting
  - Compute

Note: The listed usage scenarios is not complete, and will be appended in the future.

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National Institute of Standards and Technology
U.S. Department of Commerce
Cloud Service Providers

• Cloud service providers perform services to support the business processes of cloud service consumers at agreed service levels and costs.

• The providers perform different tasks for different service types.
  – SaaS providers: Install, manage and maintain the software
  – PaaS providers: Manage the cloud infrastructure for the platform
  – IaaS providers: Maintain the storage, database, message queue or other middleware, or the hosting environment for virtual machines

• The operations of service providers are discussed in further details from the following perspectives: service deployment, service orchestration, business support and operational support.

• Ref:
Cloud Service Providers - Top-level View

Cloud Service Consumers

Cloud Service Providers

Service Deployment

Service Orchestration

Business Support

Operational Support

Cloud Service Distributors

Cloud Service Developers, Vendors

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Cloud Service Providers – Service Deployment

- Cloud infrastructure is operated in the following four deployment models:
  - *Private cloud*:
    - Operated solely for an organization. May be managed by the organization or a third party and may exist on premise or off premise.
  - *Community cloud*:
    - Shared by several organizations in support of a specific community that has shared concerns. May be managed by the organizations or a third party and may exist on premise or off premise.
  - *Public cloud*:
    - Made available to the general public or a large industry group. Owned by an organization selling cloud services.
  - *Hybrid cloud*:
    - A composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability.

- Ref:
Cloud Service Providers – Service Deployment

From Lee Badger & Tim Grance’s slides “Standards Acceleration to Jumpstart Adoption of Cloud Computing (SAJACC)”.

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Cloud Service Providers – Service Orchestration

• Service orchestration refers to the arrangement, coordination and management of cloud infrastructure to provide different cloud services to meet IT and business requirements.

• Cloud service providers build upon different layers of the infrastructure stack in support of different services.
  – The top-down layers of cloud infrastructure stack include: application, middleware, OS, hypervisor, and hardware.
  – IaaS providers: Use hardware, hypervisor and OS.
  – PaaS providers: Use hardware, hypervisor, OS, and middleware.
  – SaaS providers: Use the whole stack.

• The providers have different control over the infrastructure stack for different services.
  – IaaS providers: Have admin control on hypervisor, hardware.
  – PaaS providers: Have admin control on application, middleware. Have total control on OS, hypervisor, hardware.
  – SaaS providers: Have admin control on application. Have total control on middleware, OS, hypervisor, hardware.

• Ref:
Cloud Service Providers – Service Orchestration

Cloud Service Providers

- Service Orchestration

System Developers

CIOs and IT Managers

Biz Users

SaaS
- Application

PaaS
- Middleware

IaaS
- OS
- Hypervisor
- Hardware

Software as a Service

Platform as a Service

Infrastructure as a Service

Cloud Service Developers, Vendors

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Cloud Service Providers – Business Support

• Cloud service providers should support a set of business-relevant services that are directly dealing with cloud consumers.
  
  – *Customer management*: Manage customer accounts, open/close/terminate accounts, manage customer relationships by providing point-of-contact and resolution for customer issues and problems, etc.
  
  – *Contract management*: Manage service contract, setup/close/terminate contract, etc.
  
  – *Accounting and Billing*: Manage customer billing information, send billing statements, process received payments, etc.
  
  – *Inventory Management*: Set up and manage service catalogs.
  
  – *Reporting and Auditing*: Monitor and evaluate user operations, generate reports.
  
  – *Pricing and Rating*: Evaluate cloud services and determine prices.

• Ref:
  
  – IBM, “Cloud Computing: Save Time, Money, and Resources with a Private Test Cloud”,
  
Cloud Service Providers – Business Support

Cloud Service Providers

Cloud Service Distributors

Cloud Service Consumers

Cloud Service Providers

Customer Management

Contract Management

Accounting & Billing

Reporting & Auditing

Pricing & Rating

Inventory Management

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Cloud Service Providers – Operational Support (1)

- Cloud service providers should also support a set of operational management and technical-related services to provide cloud services.

- **Provisioning/Configuration**
  - *Rapid provisioning*: Provide requested service/resources/capabilities rapidly and elastically
  - *Resource change*: Adjust configuration/resource assignment upon request/necessary
  - *Monitoring and reporting*: Discover and monitor the virtual resources, monitor cloud operations, and generate reports.
  - *Metering*: Provide a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts)
  - *SLA management*: SLA Management encompasses the SLA contract definition (basic schema with the QoS (quality of service) parameters), SLA negotiation, SLA monitoring, and SLA enforcement, according to defined policies.
Cloud Service Providers – Operational Support (2)

- **Portability/Interoperability**
  - **Data portability**
    - *Copy data to-from*: Copy data objects into/out of a cloud.
    - *Bulk data transfer*: Use a disk for bulk transfer.
  - **Cloud interoperability**
    - *Cloud brokerage*: Provide cloud service consumers a unified and enhanced management interface to multiple cloud service providers.
    - *Cross cloud transfer*: Copy data objects from one cloud provider’s system to another provider’s system.
  - **Data/System migration**
    - *VM images migration*: Migrate a fully-stopped VM instance or machine image from one provider to another provider.
    - *Application/Service migration*: Migrate application/service and current contents from one service provider to another provider.
Cloud Service Providers – Operational Support (3)

• **Security**
  - *Identity management*: Enforce identity and access control policies on users accessing cloud.
  - *Authentication and Authorization*: Authenticate and authorize cloud service consumers using credentials that have been established previously.
  - *Confidentiality and Privacy*: Protect the confidentiality and privacy of the data objects written into clouds
  - *Security monitoring*: Conduct ongoing automated monitoring of the cloud-provider infrastructure to demonstrate compliance with cloud-subscriber security policies and auditing requirements
  - *Auditing*: Implement a governance and audit management program, maintain an audit trail of administrative actions, maintain a configuration data store to enable auditability and general security understanding.

• **Ref**
Cloud Service Providers – Operational Support (4)

Provisioning/Config
- Rapid Provisioning
- Resource Change
- Monitoring & Reporting
- Metering
- SLA Management

Portability/Interoperability
- Data Portability
- Copy Data To-From
- Bulk Data Transfer
- Cloud Interoperability
- Cloud Brokerage
- Cross Cloud Transfer
- Data/System Migration
- VM Images Migration
- Application/Svc Migration

Security
- Identity Management
- Security Policy Mgmt
- Authentication and Authorization
- Confidentiality, Privacy
- Security Monitoring
- Auditing

Cloud Service Consumers

Cloud Service Developers, Vendors
Cloud Service Developers

- Cloud Service Developers design and implement the components of a service. The developers interact with the providers to deploy the service components.
  - *Service creation*: SaaS developers usually write code for an environment hosted by a cloud provider. Applications written by IaaS and PaaS developers will subsequently be used by SaaS developers and cloud providers.
  - *Service publishing*: For SaaS application, service publishing is to deploy onto the cloud provider’s infrastructure.
  - *Service analysis/monitor*: Include remote debugging to test the service during service creation, and monitor the performance of their service after service publishment.

- Ref:
  - Cloud Computing Use Cases White Paper, [http://groups.google.com/group/cloud-computing-use-cases](http://groups.google.com/group/cloud-computing-use-cases)
  - DMTF, “Interoperable Clouds White Paper”, [http://www.dmtf.org/about/cloud-incubator/DSP_ISO101_1.0.0.pdf](http://www.dmtf.org/about/cloud-incubator/DSP_ISO101_1.0.0.pdf)
Cloud Service Developers
Cloud Service Distributors

• Cloud service distributors provide connectivity and transport for applications and services between cloud service providers and cloud service consumers.
  – Provide access to consumers through network and telecommunication access devices
    • Example network access devices include computers, laptops, mobile phones, mobile internet devices (MIDs), etc.
  – Distribution normally provided by Network and Telecomm Carriers
    • Cloud service providers may need to set up SLAs with cloud service distributors to have consistent level of SLAs.

• Ref: