A Strawman Model

NIST Cloud Computing Reference Architecture and Taxonomy Working Group

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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 subdomains - 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



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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 Taxonomy, <u>http://cloudtaxonomy.opencrowd.com/</u>
 - GSA, "Cloud Computing Initiative Vision and Strategy Document (DRAFT)", <u>http://info.apps.gov/sites/default/files/Cloud_Computing_Strategy_0.ppt</u>



Cloud Service Consumers



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
 - laaS 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 Computing Use Cases White Paper, <u>http://groups.google.com/group/cloud-computing-use-cases</u>



Cloud Service Providers - Top-level View



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.

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- Ref:
 - NIST definition of cloud computing v15, <u>www.nist.gov/itl/cloud/upload/cloud-def-v15.pdf</u>.

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:
 - Lee Badger & Tim Grance, "Standards Acceleration to Jumpstart Adoption of Cloud Computing (SAJACC)", presentation.



Cloud Service Providers – Service Orchestration



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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", <u>www.redbooks.ibm.com/redpapers/pdfs/redp4553.pdf</u>.
 - GSA, "Cloud Computing Initiative Vision and Strategy Document (DRAFT)", <u>http://info.apps.gov/sites/default/files/Cloud_Computing_Strategy_0.ppt</u>



Cloud Service Providers – Business Support



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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.
 - Security policy management: Configure/generate/enforce/audit/update security policies on users accessing clouds.
 - 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
 - IBM, "Cloud Computing: Save Time, Money, and Resources with a Private Test Cloud", <u>www.redbooks.ibm.com/redpapers/pdfs/redp4553.pdf</u>.
 - GSA, "Cloud Computing Initiative Vision and Strategy Document (DRAFT)", <u>http://info.apps.gov/sites/default/files/Cloud_Computing_Strategy_0.ppt</u>

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Cloud Service Providers – Operational Support (4)



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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, <u>http://groups.google.com/group/cloud-computing-use-cases</u>
 - DMTF, "Interoperable Clouds White Paper", <u>http://www.dmtf.org/about/cloud-incubator/DSP_IS0101_1.0.0.pdf</u>



Cloud Service Developers



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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:
 - Juniper Networks, "Cloud-ready Data Center Reference Architecture", <u>www.juniper.net/us/en/local/pdf/reference-architectures/8030001-en.pdf</u>
 - NIST definition of cloud computing v15, <u>www.nist.gov/itl/cloud/upload/cloud-def-v15.pdf</u>.

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