

Introduction to Cloud Computing



What is Cloud Computing

Definitions:

- * Webopedia[1]
 - * Cloud Computing {noun} Cloud computing is typically defined as a type of computing that relies on sharing computing resources rather than having local servers or personal devices to handle applications.
- * IBM [2]
 - * Cloud computing, often referred to as simply "the cloud," is the delivery of on-demand computing resources—everything from applications to data centers—over the Internet on a pay-for-use basis.
- * Merriam Webster [3]
 - * The practice of storing regularly used computer data on multiple servers that can be accessed through the Internet. First known use 1996.



What is Cloud Computing

Definitions:

- National Institute of Standards and Technology (USA) [4]
 - * Cloud computing is a model for enabling <u>ubiquitous</u>, <u>convenient</u>, <u>ondemand</u> network access to a <u>shared pool</u> of <u>configurable computing resources</u> (e.g., networks, servers, storage, applications, and services) that can be <u>rapidly provisioned and released</u> with minimal management effort or service provider interaction.
 - * This cloud model is composed of five essential characteristics, three service models, and four deployment models.
 - * Characteristics: On-demand Self-service, Broad network access, Resource Pooling, Rapid Elasticity, Measured Service
 - * Service Models: SaaS, PaaS, IaaS (Software, Plarform, Infrastructure)
 - * **Deployment Models:** Private Cloud, Community Cloud, Public Cloud, Hybrid Cloud



Evolution of Computing[26]

Computing has progressed through 5 key phases, over last 6 decades:





Advantages of Cloud Computing[26]

Scalability/Elasticity

Capability to handle most sudden, temporary peaks in application demand on cloud infrastructures

Cost saving/less capital expenditure

 Reducing up-front IT cost or capital expenditure to buy server machines, no need for hiring/training manpower.

* Higher resource Utilization

* Reduces the time required to provision resources to minutes, allowing applications to quickly scale under-utilization both up and down, as the workload changes.

* Business agility

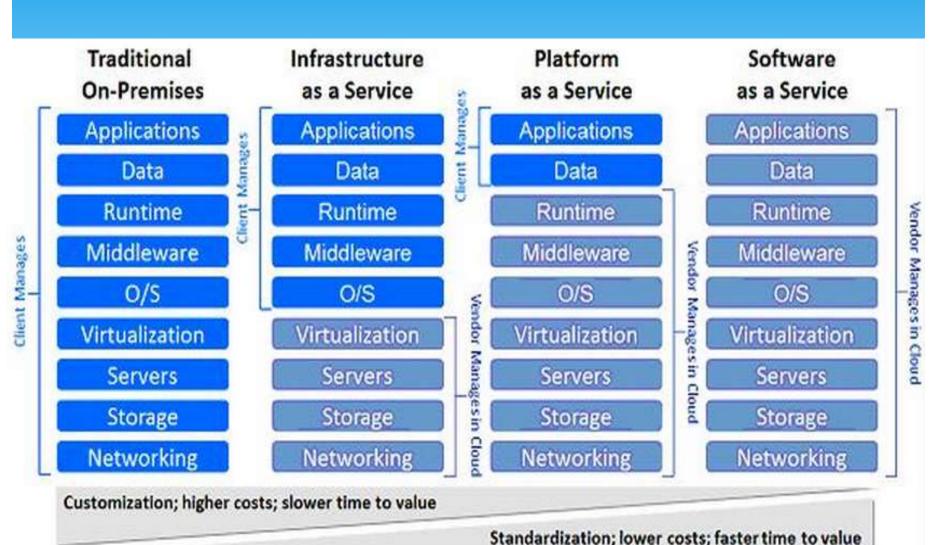
* Allows business to respond to peaks/lows in demands better. E.g. Online shops, which have to handle their peak loads at festival times. University websites, which have to handle their peak loads during exam result time.

Disaster recovery and Back up

 Cloud Services have very high availability of ~99.9999%, by proactively by taking backups, having stand-by virtual resources in place and moving failed instances of Virtual resources across seamlessly



Cloud Services Models [12]

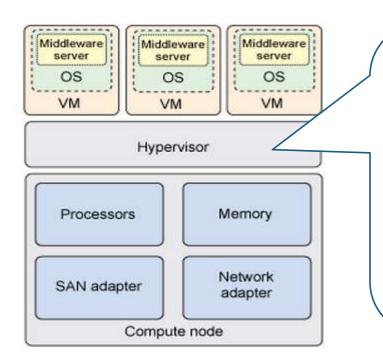




Infrastructure As A Service (IaaS)

IaaS also known as HaaS (Hardware as a Service) provides access to computing resource in a virtualised environment:

- Virtual server space, network connections, bandwidth, IP addresses and load balancers.
- * Physically, the pool of hardware resource is pulled from a multitude of servers and networks usually distributed across numerous users/clients.



Hypervisor - also known as a virtualization manager, virtual machine monitor (VMM), or platform virtualizer - is a specialized operating system that only runs virtual machines. A hypervisor running multiple virtual machines enables what seems like multiple computers to run in a single physical computer, enabling the virtual computers to share the physical computer's hardware resources.



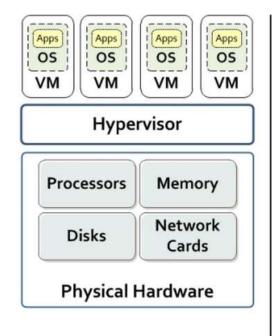
Virtualization [15]

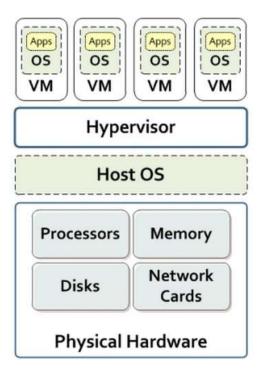
- * Virtualization is the creation of *flexible substitutes* for actual resources. The substitutes, called virtual resources, have the same functions and external interfaces as their actual counterparts but that differ in attributes such as size, performance, and cost.
- * Virtualization is commonly applied to physical hardware resources by combining multiple physical resources into shared pools from which users receive virtual resources. With virtualization, you can make one physical resource look like multiple virtual resources. The virtual resources can have functions or features that are not available in their underlying physical resources.
- * System virtualization is most commonly implemented with **hypervisor** technology.



Hypervisors[13]

- * Hypervisors are software or firmware components that can virtualize system resources
- * There are broadly two types of hypervisors:
 - * Type 1: Also called 'Native' or 'bare metal' Hyper visors that run directly on HW. E.g. Oracle VM Server for SPARC, Oracle VM Server for x86, the Citrix XenServer, VMware ESX/ESXi and Microsoft Hyper-V 2008/2012.
 - * **Type 2: Also called 'Hosted' Hypervisor** that require a Host OS to run. E.g. VMware Workstation, VirtualBox, bhyve and KVM.





Type 1

Type 2



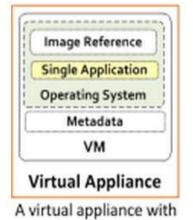
Virtual Machine and Virtual Appliances [14]

- * Virtual Machine: A virtual machine behaves like a real machine, so that an OS, or other program written to run alone on a real machine, when running on the Virtual Machine, acts as if it is running on a real bare machine by itself.
- * Virtual Appliance: A virtual appliance or virtual application represents a pre-configured VM, or a collection of pre-configured, interdependent VMs, each bundled with a fully-functional OS (operating system), known as a guest OS, and one or more applications.



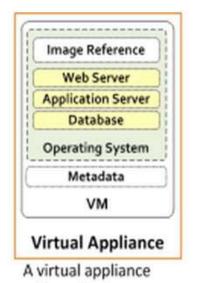
Virtual Appliances contd.. [14]

Virtual appliances are portable, self-contained configurations of a software stack. They are also called virtual images and are usually built to host a single business application. The industry standard for the format of virtual appliances is the Open Virtualization Format (OVF), published by the Distributed Management Task Force (DMTF). Member companies such as IBM, VMware, Citrix, Microsoft, and Oracle all support OVF in their products.



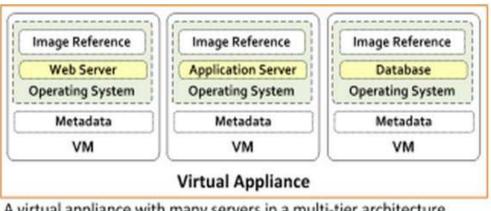
a single, self-contained

application



single-tier architecture

with multiple applications in a



A virtual appliance with many servers in a multi-tier architecture



Example Video: VMware Vsphere[35]

Introduction





Cloud Mechanism: Auto Scaling[20]

* Auto Scaling

* 1. User creates a Virtual Server.

consumers

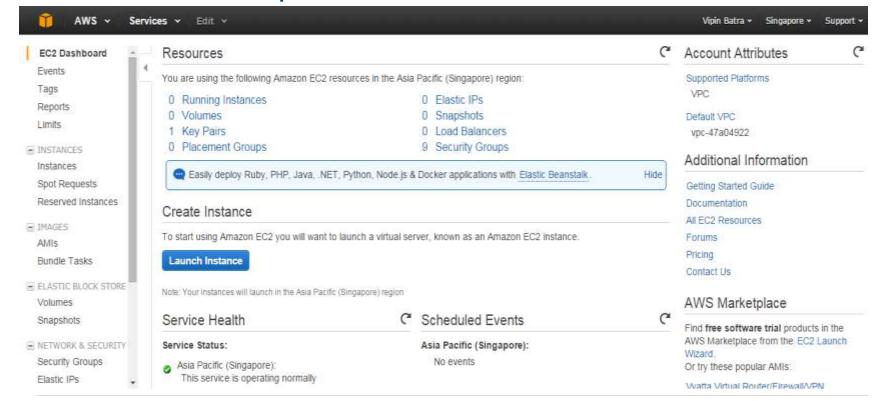
- * 2. Virtual Infrastructure Manager (VIM) allocates Physical Server
- * 3. Virtual Server usage increases above 80% of CPU capacity > 60 Sec
- 4. Automated Scaling Listner running at Hypervisor detects need to scale-up and commands VIM accordingly Physical Physical 2. Allocate Physical Resources hypervisor automated 4. Scale up/down scaling 4 scaling listeners listeners **Physical resources** 3. Resource usage I servers virtual servers exceeds above/drops usage and administration below Thresholds 1. Create Virtual Resource cloud service cloud

consumer



IaaS Examples

- Amazon Elastic Cloud Compute (Amazon EC2), Amazon Simple Storage Service (Amazon S3), Rackspace Cloud Servers, GoGrid, Joyent, and AppNexus
- * Amazon EC2 example:





Platform as a Service[16] – 1/

- PaaS is a category of cloud computing that provides a platform and environment to allow developers to build applications
 - * Allows users to create software applications using tools supplied by the provider. PaaS services can consist of preconfigured features that customers can subscribe to; they can choose to include the features that meet their requirements
 - * The infrastructure and applications are managed for customers and support is available.
 - * Services are constantly updated, with existing features upgraded and additional features added.
 - * PaaS providers can assist developers from the conception of their original ideas to the creation of applications, and through to testing and deployment.



Platform as a Service[16] – 2/

* Key PaaS Offerings:

- Operating system
- Server-side scripting environment
- * Database management system
- * Server Software
- * Support
- Storage
- * Network access
- Tools for design and development
- Hosting
- PaaS Advantages
 - * No investiment in Infrastructure:
 - Being able to 'rent' virtual infrastructure has both cost benefits and practical benefits.
 - * No need to purchase hardware or employ the expertise to manage it. Focus on the development of applications.
 - * Makes Development/Quality Content Creation possible for 'non-experts'
 - * With some PaaS offerings anyone can develop an application. They can simply do this through their web browser utilising one-click functionality.
 - Salient examples of this are one-click blog software installs such as WordPress.



Platform as a Service[16] – 3/

- PaaS Advantages contd...
 - * Flexibility
 - * Customers can have control over the tools that are installed within their platforms or create a platform that suits their specific requirements.
 - * Allows to 'pick and choose' the features that are necessary.

* Adaptability

- * Features can be changed if circumstances dictate that they should.
- * Teams in various locations can work together; as an internet connection and web browser are all that is required
- * Developers spread across several locations can work together on the same application build.

* Security

* Security is provided, including data security and backup and recovery.

* PaaS examples

* AWS Elastic Beanstalk, Cloud Foundry, CloudControl, Cloudera, Engine Yard, Google App Engine

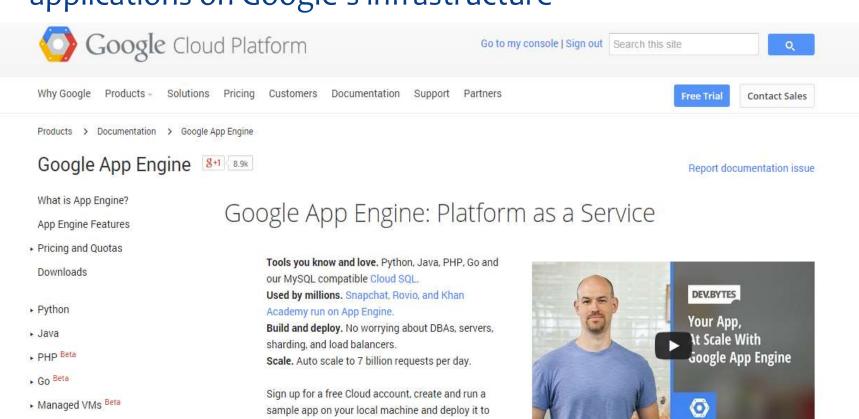


Managing Your App

Sample Code, Tutorials and Videos

PaaS Example: Google App Engine [17]

Google App Engine offers users the ability to build and host web applications on Google's infrastructure



the cloud - in five minutes.

Try it now



Software as a Service [18]

- * Software as a Service (SaaS) is a software distribution model in which applications are hosted by a vendor or service provider and made available to customers over the network.
- * Software vendors host and maintain the servers, databases and code that constitute an application
- * Allows buyers to pay an annual or monthly subscription fee, which typically includes the software license, support and most other fees. A major benefit of SaaS is being able to spread out costs over time
- * Key Characteristics:
 - * A multitenant architecture: in which all users and applications share a single, common infrastructure and code base that is centrally maintained.
 - * Easy Customization: The ability for each user to easily customize applications to fit their business processes without affecting the common infrastructure
 - * **Better Access:** Improved access to data from any networked device while making it easier to manage privileges, monitor data use, and ensure everyone sees the same information at the same time



Software as a Service [19]

* SaaS characteristics Contd...

- * Harnesses Web: Anyone familiar with Amazon.com or My Yahoo! will be familiar with the Web interface of typical SaaS applications.
- * Updates are automated: whenever there is an update it is available online to existing customers, often free of charge. No new software will be required as it often is with other types of applications and the updates will usually be deployed automatically by the cloud provider.
- * Cross device compatibility: SaaS applications can be accessed via any internet enabled device, which makes it ideal for those who use a number of different devices, such as internet enabled phones and tablets, and those who don't always use the same computer.
- * Accessible from any location: rather than being restricted to installations on individual computers, an application can be accessed from anywhere with an internet enabled device



SaaS Examples

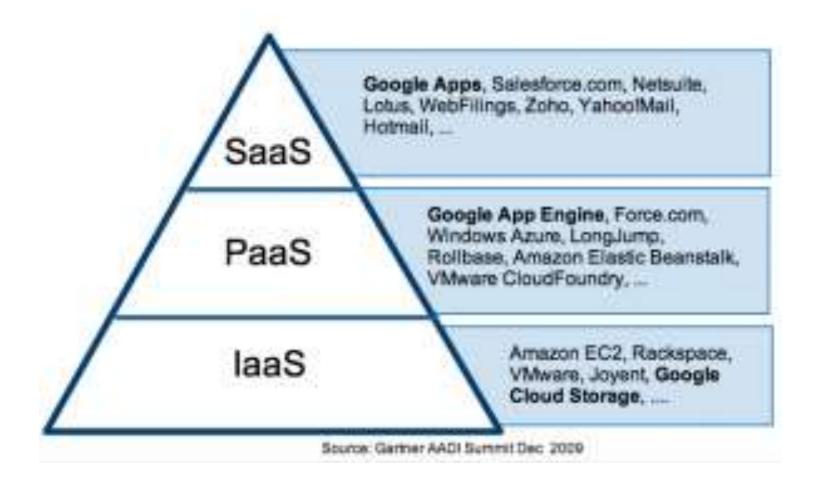
* Google – Mail, Drive Calendar etc., Twitter, Facebook and Flickr etc. are all examples of SaaS, with users able to access the services via any internet enabled device. Enterprise users are able to use applications for a range of needs.





Example Cloud Services

* Cloud Services



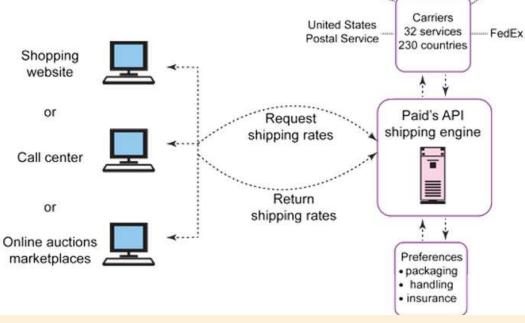


REST(REpresentational State Transfer*) APIs – 1/3[33]

 Typically, web services (including all Cloud based services) provide and consume APIs.

* REST (REpresentational State Transfer) is an architectural style, and an approach to communications used in the development

of Web services





REST was proposed by Dr. **Roy T. Fielding** - in his Ph.D. Thesis. He was one of the principal authors of HTTP specification, is an authority on computer network architecture and co-founder of the Apache HTTP Server Project.



REST(REpresentational State Transfer) APIs – 2/3

- * Complying with the REST architectural constraints, enables any kind of distributed hypermedia system to have desirable emergent properties, such as performance, scalability, simplicity, modifiability, portability, and reliability:
 - * Client-server
 - Uniform Interface separates Client/Servers
 - * Stateless
 - * No client context stored on servers between requests
 - * Cacheable
 - * Clients can cache responses. Responses must define themselves as cacheable, or not, to prevent clients from reusing stale data
 - * Layered
 - * Client doesn't know exact path to server, so intermediary can route different requests over different path to same server

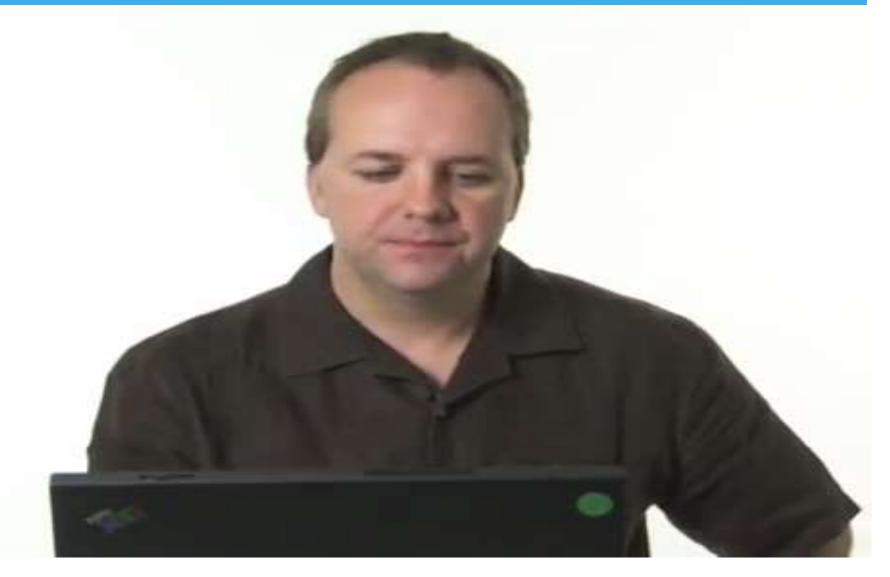


REST(REpresentational State Transfer) APIs – 3/3

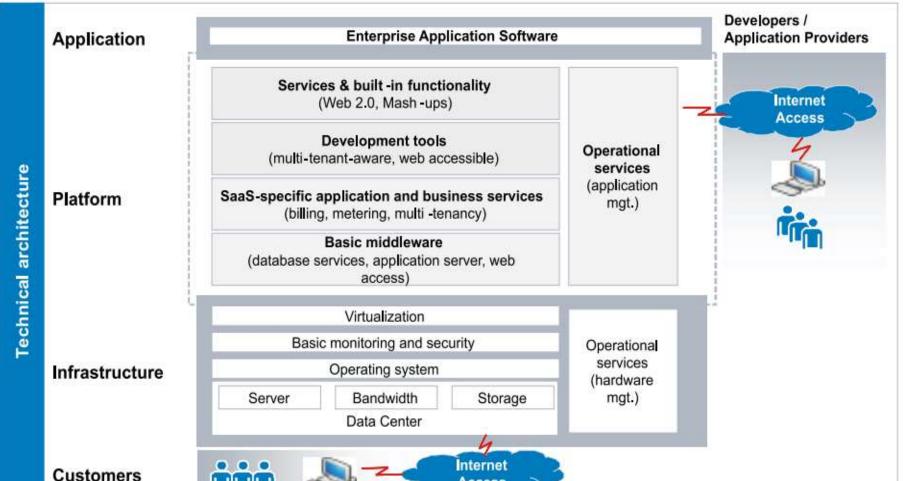
- * RESTful Architectural Constraints contd...
 - * Uniform Interface
 - * Identification of individual resources in request e.g. URI. The representation of data in XML, HTML, JSON formats
 - * Manipulation of resources through these representations
 - * Self descriptive messages
 - * Each message includes enough information to describe how to process message
 - * Hypermedia as engine of application state
 - * Clients make state transitions only through actions that are dynamically identified within hypermedia by the server (e.g., by hyperlinks within hypertext).



Video on RESTful APIs[34]



Cloud Computing Architecture[11]

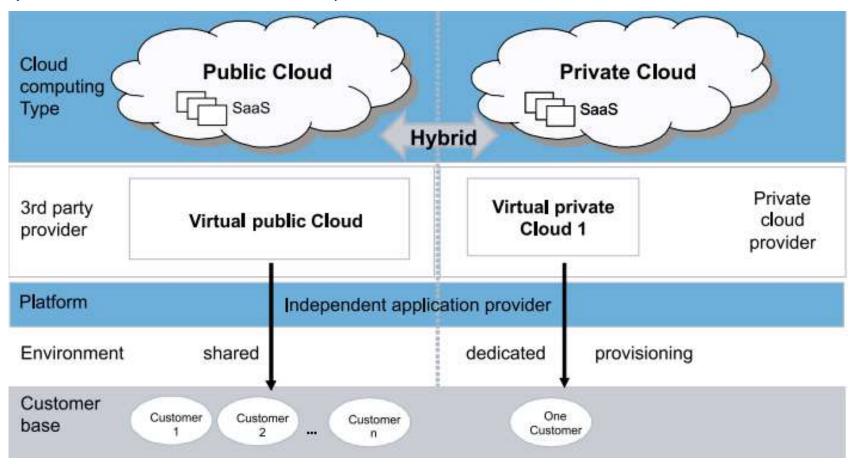


Access



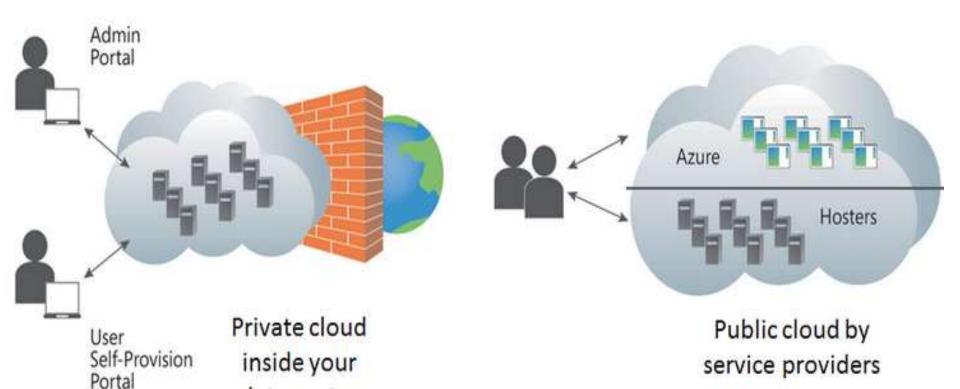
Cloud Deployment Models

 Cloud Deployment can be Private, Community, Public or Hybrid (both Private and Public)





Public vs Private Cloud

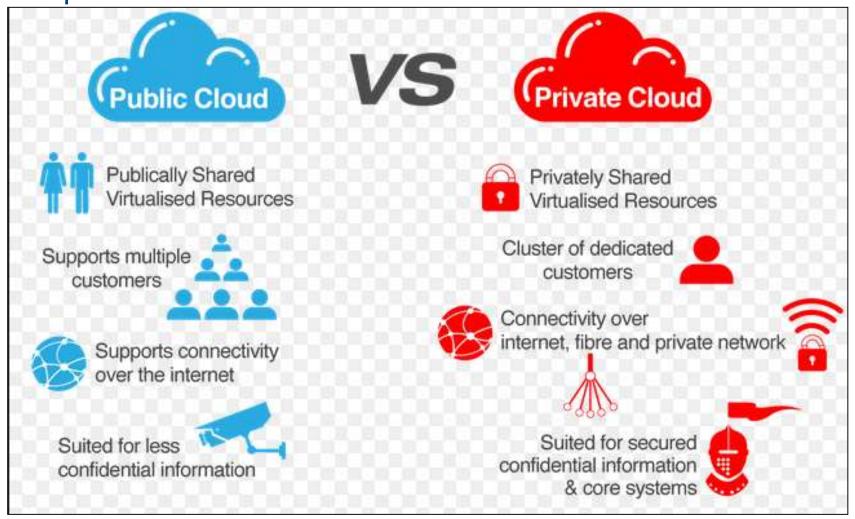


data center



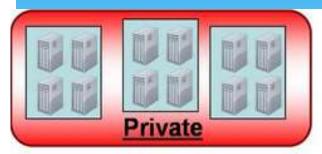
Public and Private Cloud

Comparison of Public vs Private Cloud

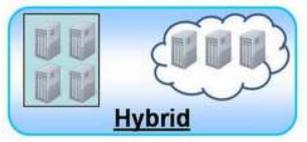




Public, Private and Hybrid Clouds







Private

You purchase the sole use of a server.

Pros - shared overheads, 'ring fenced' servers

Cons - inflexible so likely to pay for unused resource

Public

You purchase capacity on a usage basis.

Pros - shared overheads, purchase capacity on demand

Cons - no control of resources used or who shares them

Hybrid

You can purchase the use of a mix of dedicated physical servers and virtual servers

Pros – tailor mix to suit capacity and security requirements

Cons – May still pay for unused resource







Cloud Deployment Models – Advantages and Characteristics

Private Cloud

- Leverages existing CapEx
- Can help reduce OpEx
- Intended for a Single Tenant

Hybrid Cloud

- Bridges one or more Private, Public or Community clouds
- Allows manipulation of CapEx and OpEx to reduce costs
- Supports Resource Portability

Cloud

- Allows sharing of CapEx and OpEx to reduce costs
- Brings together groups or organizations with a common goal/interest
- Supports Resource
 Portability

Public Cloud

- Shifts CapEx to OpEx
- Offers a Pay as you go (Utility Billing) Model
- Supports Multiple Tenants



Challenges to Cloud Computing[25]

- Many customers are still reluctant to deploy their business in the cloud. Security issues in cloud computing has played a major role in slowing down its acceptance.
- * Two conflicting views exist in industry for Cloud Security:
 - * For: Security could improve due to centralization of data and increased security-focused resources.
 - * **Against:** Concerns persist about loss of control over certain sensitive data, and the lack of security for data/software entrusted to cloud providers.
 - * If providers are unable to secure their own environments, the consumers could be in trouble.
 - * Measuring the quality of cloud providers' approach to security is difficult because many cloud providers will not expose their infrastructure to customers.



Challenges to Cloud Computing[25]

* Key Challenges are:

* Security

* Various security issues, possible in cloud computing are: availability, integrity, confidentiality, data access, data segregation, privacy, recovery, accountability, multi-tenancy issues and so on

* Difficult to migrate

 It is not very easy to move the applications from an enterprise to cloud computing environment or even within different cloud computing platforms

Internet dependency – performance and availability

* Cloud computing services relies fully on the availability, speed, quality and performance of internet

* Lack of control over resources

* Concerns related to lack of physical control of data, applications



Cloud Security Concepts[20] – 1/2

- * Confidentiality: Restricting access to data in transit and storage only to authorized parties.
- * Integrity: Ensuring the data sent and received is same, i.e. Data integrity is not compromised during transit and storage
- * Authenticity: Information is provided by authorized source only. It encompasses non-repudiation (inability of attacker to deny or challenge authentication of an interaction)
- * Availability: Accessibility and usability of a resource during a specified time. Its shared responsibility of cloud provider and user.
- * Measuring Security: Confidentiality, Integrity, Authenticity and Availability characteristics are required to measure and assess security.



Cloud Security Concepts[20] – 2/2

- * Threat: Is a potential security violation that can challenge defenses in an attempt to breach privacy and or cause harm.
- * **Vulnerability:** Is a weakness that can be exploited either because it has insufficient security controls or those can be overcome by attack e.g. configuration deficiencies, security policy weaknesses, user errors, hardware or firmware flaws, software bugs, poor security architecture etc.
- * **Risk:** Is possibility of a loss or harm arising from a activity. It is determined by probability of a **threat** occurring to exploit **vulnerabilities** and *impact* expectation of loss of resources.
- * **Security Control:** Countermeasures to prevent or respond to **Threats** and to reduce or avoid **Risks**.
- Security Mechanisms: Defensive framework that protect resources, information and services.
- * Security Policies: Establishes security rules and regulations: e,g positioning and usage of security controls and mechanisms
- * Security Controls, Mechanisms and Policies are associated with establishing countermeasures and safeguards for improving security.



Cloud Security [22]

- * Cloud Security Alliance (CSA) A Consortium of key players in Cloud Services like Microsoft, Amazon, Google, HP, SAP etc., does research on cloud security issues, shares best practices, publishes guidelines and recommendations to mitigate cloud security risks. It also provides trainings and certifications.
- CSA has identified nine critical threats to cloud security:
 - Data Breaches
 - Data Loss
 - 3. Account Hijacking
 - 4. Insecure APIs
 - 5. Denial of Service
 - Malicious Insiders
 - 7. Abuse of Cloud Services
 - 8. Insufficient Due Diligence
 - Shared Technology Issues





Cloud Security - Mitigating Security Threats[23]

* Mitigations:

- * Risk Assessments
 - * Assess the risks properly and decide security mechanisms needed to secure the data and resources
- * Use of most appropriate Security Mechanisms/Policies in accordance with the risk assessments
 - * Encryption Key Management
 - Remote User Multi-factor authentication
 - Identity, Entitlement, and Access Management
 - * Data Security/Integrity Checks
 - * Incident Response
 - Disaster Recovery
 - Security as a Service



Cloud Security – SecaaS and SSDLC [23, 24]

- * SecaaS: Security as a Service: Is facilitated security assurance, incident management, compliance attestation, and identity and access oversight.
 - * Involves **delegation** of detection, remediation, and governance of security infrastructure **to a trusted third party** with the **proper tools and expertise**.
 - * Users of this service gain the benefit of dedicated expertise and cutting edge technology in the fight to secure and harden sensitive business operations.
- * A Secure Software Development Life Cycle (SSDLC) has assumed increased importance when migrating and deploying applications in the cloud[23].
 - * In implementing a SSDLC, organizations must adopt best practices for development. Some maturity models recommended are:
 - Building Security In Maturity Model (BSIMM2)
 - Software Assurance Maturity Model (SAMM)
 - * Systems Security Engineering Capability Maturity Model (SSE-CMM)



Quiz (Match The Following)

- * GMAIL is example of what Cloud Service?
- * Role of Hypervisors in Cloud Computing is to provide?
- * Monitors Virtual Machines?
- * AWS Elastic Cloud Compute is an example of what service?
- * This cloud service provides a programming Environment in addition to basic servers, storage, network etc./
- * Multi-tenant cloud deployment model where each of them is independent of other?

- * Virtual Infrastructure Manager
 - Public Cloud
- Private Cloud
- Community Cloud
- * Hybrid Cloud
 - Hypervisor
 - laaS
 - PaaS
 - SaaS
 - Virtual Resources

Cloud Computing – Business Trends

How Cloud Computing is Redefining every aspects of business



Key Cloud Services Providers

- * Amazon
 - * Amazon Web Services (aws.amazon.com)
- * Google
 - Google Cloud (cloud.google.com)
- * Microsoft
 - * Microsoft Azure (azure.microsoft.com)





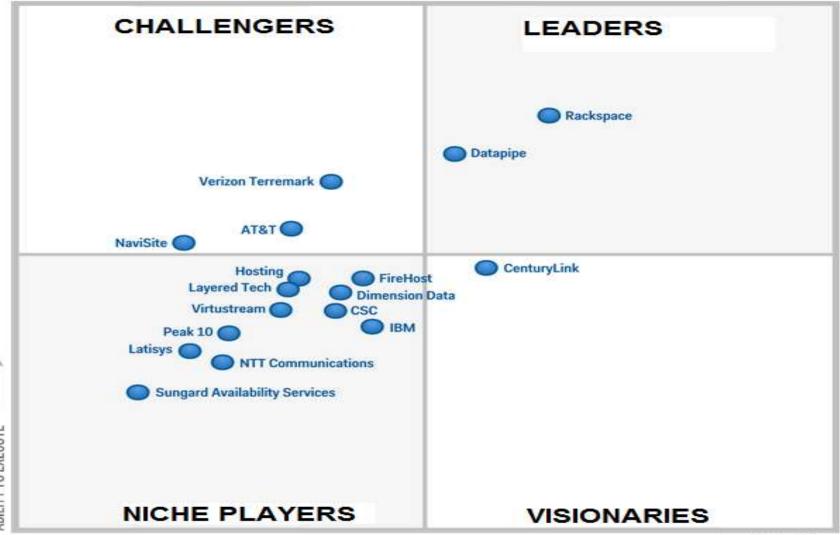


- * Open Solution: penstack Based
 - * RackSpace (www.rackspace.com)
 - * Uses OpenStack/DevStack (www.openstack.org)





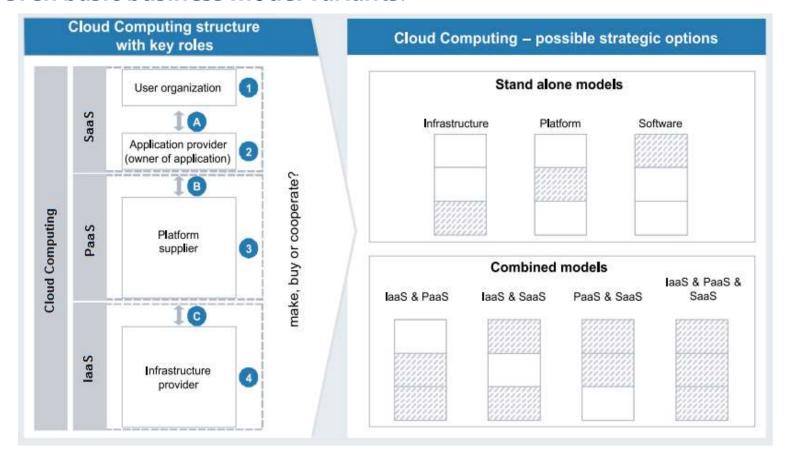
North America's Cloud Hosting Providers Comparison [30]





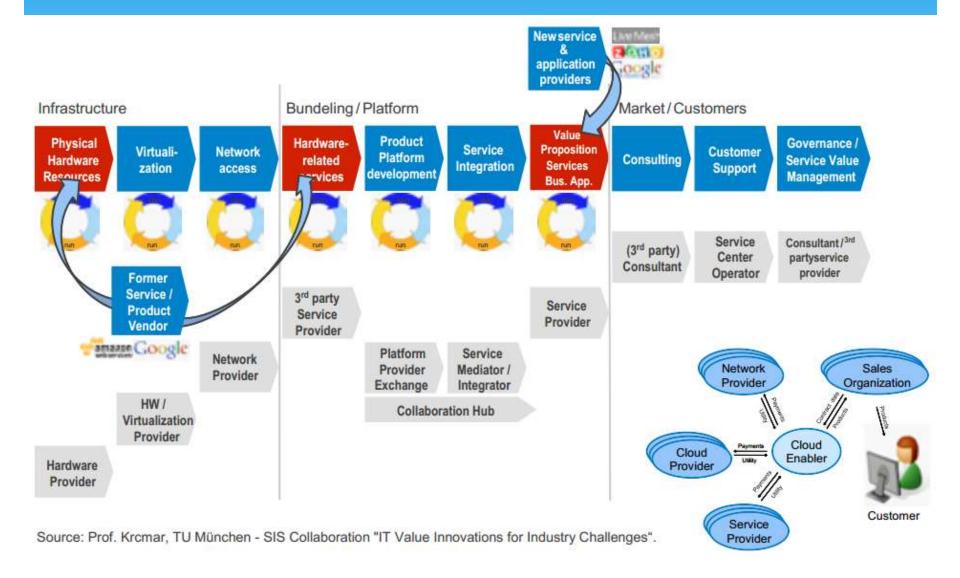
Cloud Computing Solutions Provider Strategies

For developing feasible cloud computing business models is the fundamental cloud computing structure with the elements SaaS, PaaS and IaaS. The result is seven basic business model variants.





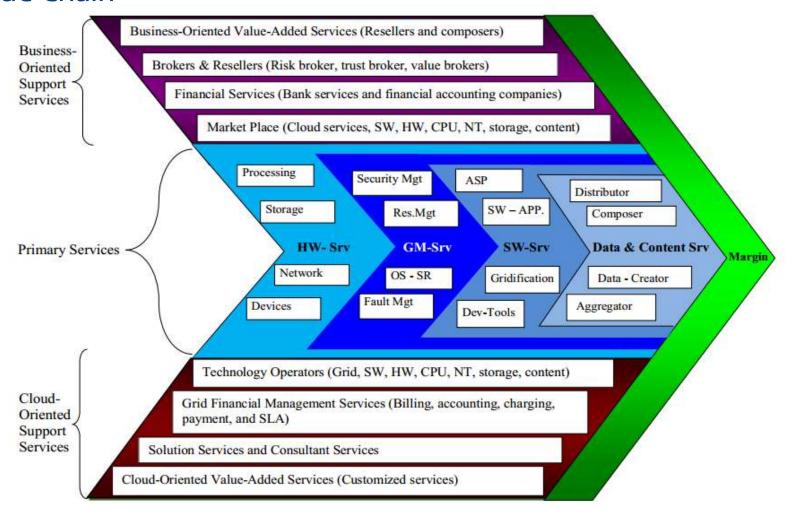
Cloud Computing: Value Chain[11]





Cloud Computing Value Chain [21]

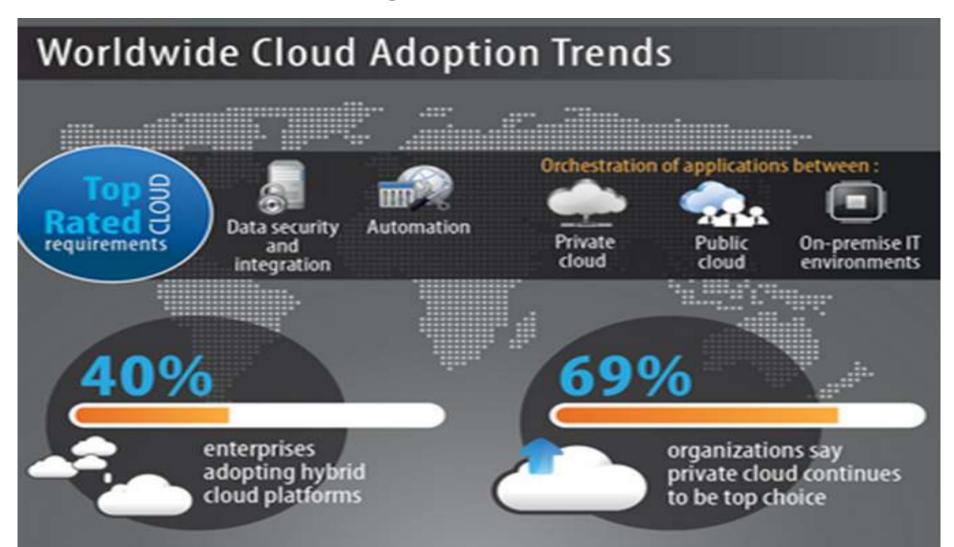
* Value Chain





Worldwide Trends

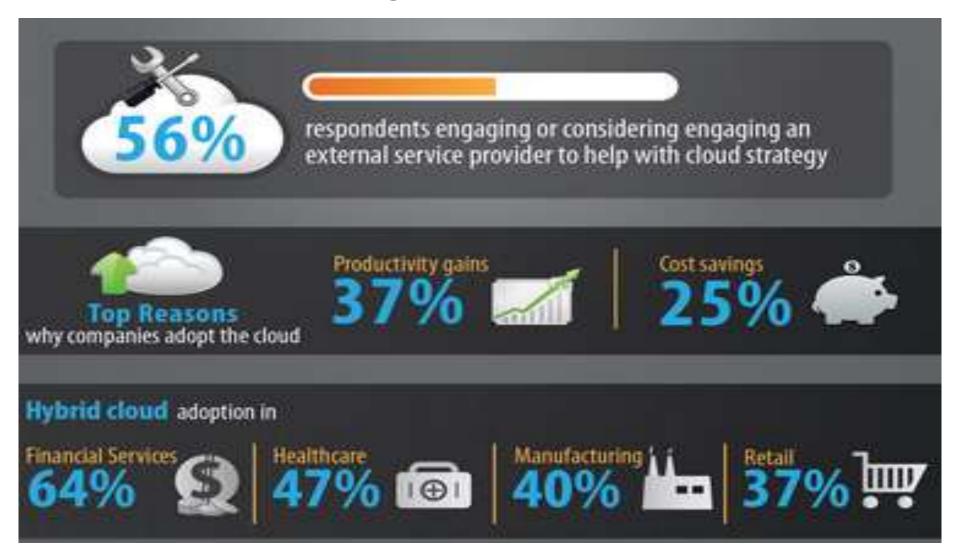
* Infosys-IDC Study Findings





Worldwide Trends

* Infosys-IDC Study Findings





Cloud Adoption [7] – 1/2

A Few Enterprise Cloud Adoption Stats

Large, Accelerating Market

4-6x

growth rate of on-premise IT

20-27% CAGR \$20-40B market

(Forrester, IDC, Gartner, 451Group)

60%

of all companies using SaaS w/in 12 months SaaS

largest category

PaaS

fastest growing

84%

of net new software is now SaaS Led by Large Enterprises

76%

enterprises have a formal cloud strategy

74%

using cloud will increase cloud spend > 20% **Driven by IT**

90%

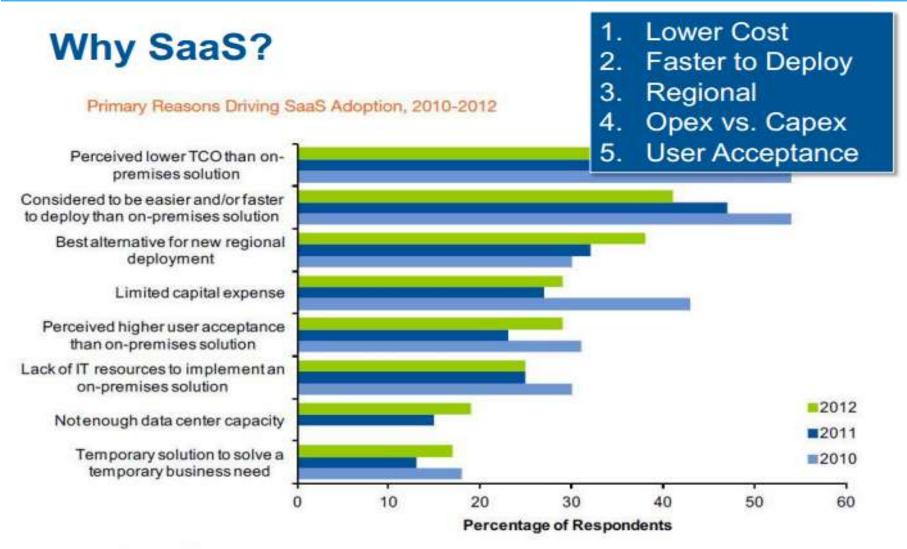
Cloud decisions and operations involve IT

66%

SaaS POs signed by IT



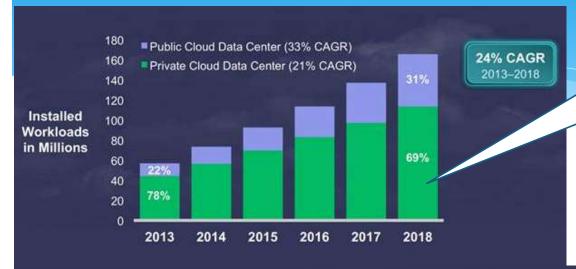
Cloud Adoption [7] – 2/2



Source: Gartner (October 2012)



Cloud Adoption [31]



Private Cloud 69% by 2018 Public Cloud 31% by 2018

Source: Cisco Global Cloud Index 2013-2018

SaaS: 59% by 2018

laaS: 28% by 2018

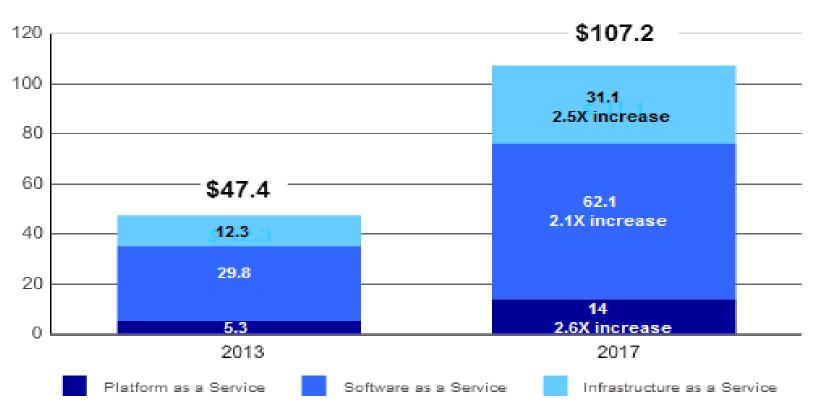
PaaS: 13% by 2018





IT Moving to Cloud Trends [8]

Worldwide Public IT Cloud Services Spending by Segment (in \$ billion)





Cloud Adoption [31]

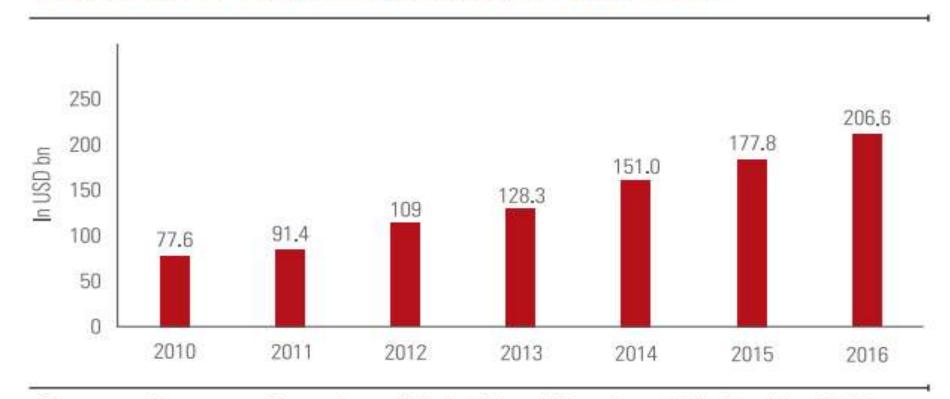
* Cloud Storage Users across the Regions by 2018:

Region	Consumer Internet Users in Millions (% of Population)	Average Number of Devices per Consumer Internet User	Consumer Cloud Storage Users in Millions (% of Internet Users)
Asia Pacific	2,015 (49%)	3.80	1,174 (58%)
Central and Eastern Europe	322 (66%)	4.00	125 (39%)
Latin America	355 (55%)	3.87	109 (31%)
Middle East and Africa	410 (27%)	4.19	57 (14%)
North America	309 (84%)	8.42	252 (81%)
Western Europe	337 (80%)	6.34	267 (79%)



Public Cloud Market Size

Global cloud computing market, in USD billion

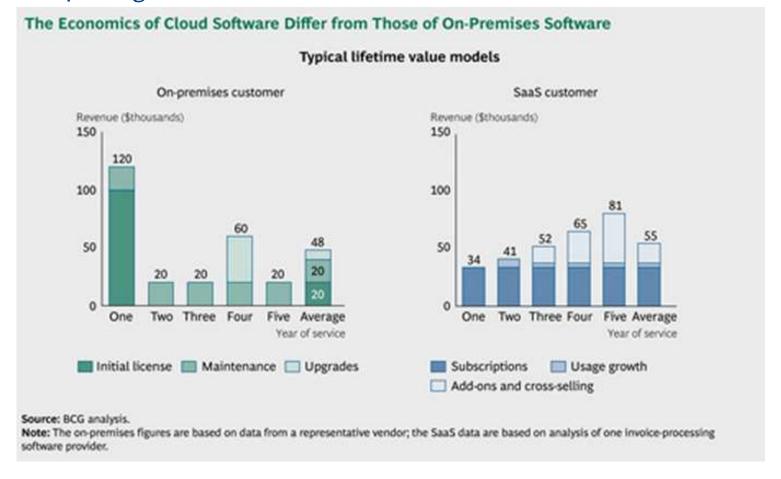


Source: Forecast Overview: Public Cloud Services, Worldwide, 2011-2016, 2Q12 Update", Gartner, September 2012



Changing Revenue Model[9]

* For cloud services provider, the revenues for a service provider is very low in first year and increases gradually as they cross-sell and add new features/packages.





Cloud Services Sales Model [9]

Parameters	Traditional Software	Cloud Services
Affected		
_	can be worth millions of dollars in the first	Companies need a model that emphasizes growth from a smaller initial base, a more patient and incremental building of the relationship, and a tenacious focus on customer retention
Lower discounts to account for higher marginal costs.	With large enterprise software, discounts of 70 to 90 percent are not uncommon when companies really need that big deal.	Cloud Services cost more per user, as vendor now has to pay to data centers to provide reliable services. So, for SaaS offers to be profitable, discount ranges for smaller deals should be close to zero, and they should typically be no more than 30 to 50 percent even for large, competitive deals.
Unbundle products so they are easy to	A company usually sells a large order with a host of bells and whistles that most	Instead of designing a product that offers all things to all people, cloud software vendors
try	companies don't use. In this scenario, the	should offer layers of extras that the customer can easily understand.
Make it simple for customers to	Traditional software companies often pay too little attention to one of their biggest sources	They should make sense for a customer who wants an integrated solution that bundles cloud
combine cloud and on-premises software		and on-premises products. Customers should also know how SaaS offerings fit and connect with on-premises products/solutions.



Emerging Trends in Cloud Computing

- * MCC Mobile Cloud Computing[27]: MCC has defined as that in MCC all the data, its storage and its processing takes place at the cloud infrastructure instead of mobile device. The mobile cloud applications running on the mobile use the computational power and data storage capabilities of the cloud.
 - 6.1. Mobile Commerce
 - * The applications like finance, shopping, ticketing etc become possible by MCC
 - * 6.2. Mobile Learning
 - * The hybrid of electronic learning and mobility gave birth to mobile learning (m-learning). cloud provides large storage and high processing capabilities
 - * 6.3. Mobile Healthcare
 - * m-healthcare helps the mobile users to access medical resources in efficient way because of the availability of on-demand services on the cloud.
 - * 6.4. Mobile Gaming
 - * Mobile gaming (m-gaming) helps cloud service providers in terms of revenue generation. Usually, but this require high computing resources like, graphic rendering. m-game can now off-load game engine which requires graphic rendering to the cloud server.



Emerging Trends in Cloud Computing – Complementary Technologies

* NFV/SDN technologies are evolving as a result of advances in cloud computing [28].

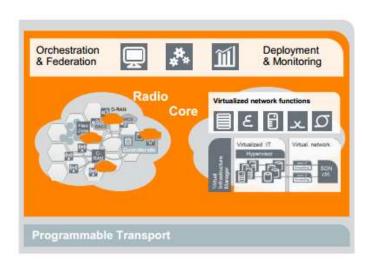
Cloud computing, NFV, and SDN are complementing each other forming a powerful triple with future upside potential

On-demand resources

- Pooling
- Elasticity

Experience

- Decentralization when needed
- Quality guarantee



Automation

- Abstraction
- Unification
- Concentration

Agility

- Programmability
- Open interfaces
- · Design for failure





Key Take-aways

- * Cloud Computing has emerged as a mature technology in itself. It is finding uses in more and more applications and complementing many new ICT technologies, and is evolving to tackle newer challenges and business cases.
- * Despite multiple challenges in Cloud Computing, and potent security threats, its deployments are increasing due to number of reasons:
 - Enhanced Understanding of threats and better solutions to tackle those
 - * Experience with existing cloud deployments
 - Compelling business cases:
 - * No upfront cost to setup, pay per use
 - Scenarios like Online products selling to handle huge peak loads etc.
 - * Improved utilization of IT resources and manpower in general, reducing wasted resources/locked-in capital
 - Emerging technologies utilizing cloud computing
 - * SDN/NFV/Big Data/Mobile Cloud Computing e.g. m-commerce, m-gaming, m-health /IoT etc.



Terms[6] – 1/

- * Airframe: An open source cloud computing platform targeted at organizations in the thinking stage of adopting a private cloud services model or evaluating options and alternatives for private cloud solutions.
- * Amazon EC2: Short for Amazon Elastic Computer Cloud, Amazon EC2 is a commercial Web service that lets customers "rent" computing resources from the EC2 cloud.
- * Anything-as-a-Service: Anything-as-a-service, or XaaS, refers to the growing diversity of services available over the Internet via cloud computing as opposed to being provided locally, or on premises.
- * Apache CloudStack: An open source cloud computing and Infrastructure-as-a-Service (IaaS) platform developed to help make creating, deploying and managing cloud services easier by providing a complete "stack" of features and components for cloud environments



Terms [6] – 2/

- * Cloud App (Cloud Application): Short for cloud application, cloud app is the phrase used to describe a software application that is never installed on a local computer. Instead, it is accessed via the Internet.
- * Cloud Application Management for Platforms (CAMP): CAMP, short for Cloud Application Management for Platforms, is a specification designed to ease management of applications -- including packaging and deployment -- across public and private cloud computing platforms.
- * Cloud Backup: Cloud backup, or cloud computer backup, refers to backing up data to a remote, cloud-based server. As a form of cloud storage, cloud backup data is stored in and accessible from multiple distributed and connected resources that comprise a cloud.
- * Cloud Backup Service Provider: A third-party entity that manages and distributes remote, cloud-based data backup services and solutions to customers from a central data center.



Terms [6] – 3/

- * Cloud Computing: A type of computing, comparable to grid computing that relies on sharing computing resources rather than having local servers or personal devices to handle applications. The goal of cloud computing is to apply traditional supercomputing, or high-performance computing power, normally used by military and research facilities, to perform tens of trillions of computations per second, in consumer-oriented applications such as financial portfolios or even to deliver personalized information, or power immersive computer games.
- * Cloud Computing Accounting Software: Cloud computing accounting software is accounting software that is hosted on remote servers. It provides accounting capabilities to businesses in a fashion similar to the SaaS (Software as a Service) business model. Data is sent into "the cloud," where it is processed and returned to the user. All application functions are performed off-site, not on the user's desktop.
- * Cloud Computing Reseller: A company that purchases hosting services from a cloud server hosting or cloud computing provider and then re-sells them to its own customers.



Terms [6] – 4/

- * Cloud Database: A database accessible to clients from the cloud and delivered to users on demand via the Internet from a cloud database provider's servers. Also referred to as Database-as-a-Service (DBaaS), cloud databases can use cloud computing to achieve optimized scaling, high availability, multi-tenancy and effective resource allocation.
- * Cloud Enablement: The process of making available one or more of the following services and infrastructures to create a public cloud computing environment: cloud provider, client and application.
- * Cloud Management: Software and technologies designed for operating and monitoring the applications, data and services residing in the cloud. Cloud management tools help ensure a company's cloud computing-based resources are working optimally and properly interacting with users and other services.
- * Cloud Migration: The process of transitioning all or part of a company's data, applications and services from on-site premises behind the firewall to the cloud, where the information can be provided over the Internet on an on-demand basis.



Terms [6] – 5/

- * Cloud OS: A phrase frequently used in place of Platform as a Service (PaaS) to denote an association to cloud computing.
- * Cloud Portability: In cloud (cloud computing) terminology, the phrase "cloud portability" means the ability to move applications and its associated data between one cloud provider and another -- or between public and private cloud environments.
- Cloud Provider: A service provider who offers customers storage or software solutions available via a public network, usually the Internet.
- * Cloud Provisioning: The deployment of a company's cloud computing strategy, which typically first involves selecting which applications and services will reside in the public cloud and which will remain on site behind the firewall or in the private cloud. Cloud provisioning also entails developing the processes for interfacing with the cloud's applications and services as well as auditing and monitoring who accesses and utilizes the resources.



Terms [6] – 6/

- * Cloud Server Hosting: Cloud server hosting is a type of hosting in which hosting services are made available to customers on demand via the Internet. Rather than being provided by a single server or virtual server, cloud server hosting services are provided by multiple connected servers that comprise a cloud.
- * Cloud Storage: Cloud storage means "the storage of data online in the cloud," wherein a company's data is stored in and accessible from multiple distributed and connected resources that comprise a cloud.
- * Cloud Testing: Load and performance testing conducted on the applications and services provided via cloud computing -- particularly the capability to access these services -- in order to ensure optimal performance and scalability under a wide variety of conditions
- * Community Cloud [4]: The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises



Terms [6] – 7/

- * Enterprise Application: The term used to describe applications -- or software -- that a business would use to assist the organization in solving enterprise problems. When the word "enterprise" is combined with "application," it usually refers to a software platform that is too large and too complex for individual or small business use.
- * Enterprise Cloud Backup: Enterprise-grade cloud backup solutions typically add essential features such as archiving and disaster recovery to cloud backup solutions.
- * **Eucalyptus:** An open source cloud computing and Infrastructure-as-a-Service (IaaS) platform for enabling private clouds.
- * Hybrid Cloud[4]: The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds)
- * **Hybrid Cloud Storage:** A combination of public cloud storage and private cloud storage where some critical data resides in the enterprise's private cloud while other data is stored and accessible from a public cloud storage provider.



Terms [6] – 8/

* IBM Cloud: IBM Cloud refers to a collection of enterprise-class technologies and services developed to help customers assess their cloud readiness, develop adoption strategies and identify business entry points for a cloud environment. IBM's cloud computing strategy is based on a hybrid cloud model that focuses on integrating the private cloud services of a company with the public cloud.

* IBM CloudBurst (CloudBurst): CloudBurst is a OTS (Over The Shelf) solution from IBM that's designed to provide resource monitoring, cost management and services availability in a cloud. IBM CloudBurst is a key component in the company's lineup of cloud computing solutions, which also includes IBM Smart Business Storage Cloud, IBM Smart Desktop Cloud and IBMSmartCloud Enterprise.



Terms [6] – 9/

- * **Desktop-as-a-service:** Desktop-as-a-service (DaaS) is a form of virtual desktop infrastructure (VDI) in which the VDI is outsourced and handled by a third party. Also called hosted desktop services, desktop-as-a-service is frequently delivered as a cloud service along with the apps needed for use on the virtual desktop.
- * Infrastructure-as-a-Service: IaaS is defined as computer infrastructure, such as virtualization, being delivered as a service. IaaS is popular in the data center where software and servers are purchased as a fully outsourced service and usually billed on usage and how much of the resource is used compared to the traditional method of buying software and servers outright. May also be called enterprise-level hosting platform.
- * Intercloud: The Intercloud is an interconnected global "cloud of clouds" and an extension of the Internet "network of networks" on which it is based. It became popular in early 2009 and also used to describe the data center of future
- * Internal Cloud: Another name for a private cloud.
- * Mobile Cloud Storage: A form of cloud storage that applies to storing an individual's mobile device data in the cloud and providing the individual with access to the data from anywhere.



Terms [6] – 10/

- * **Multi-Tenant:** In cloud computing, multi-tenant is the phrase used to describe multiple customers using the same public cloud.
- * Online Backup: In storage technology, online backup means to back up data from your hard drive to a remote server or computer using a network connection. Online backup technology leverages the Internet and cloud computing to create an attractive off-site storage solution with little hardware requirements for any business of any size.
- * OpenStack Grizzly: The follow-up to the Folsom release of the OpenStack open source cloud computing platform, OpenStack Grizzly debuted in April 2013 as the seventh release of OpenStack. With OpenStack Grizzly, the OpenStack Foundation has focused on adding broader support for compute, storage and networking technologies as well as greater scalability and ease of operations.
- * Personal Cloud Storage: A form of cloud storage that applies to storing an individual's data in the cloud and providing the individual with access to the data from anywhere. Personal cloud storage also often enables syncing and sharing stored data across multiple devices such as mobile phones and tablet computers.



Terms [6] – 11/

- * **Private Cloud[4]:** The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units). It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.
 - * The phrase used to describe a cloud computing platform that is implemented within the corporate firewall, under the control of the IT department. A private cloud is designed to offer the same features and benefits of cloud systems, but removes a number of objections to the cloud computing model including control over enterprise and customer data, worries about security, and issues connected to regulatory compliance.
- * Private Cloud Project: Companies initiate private cloud projects to enable their IT infrastructure to become more capable of quickly adapting to continually evolving business needs and requirements. Private cloud projects can also be connected to public clouds to create hybrid clouds.
- * **Private Cloud Security:** A private cloud implementation aims to avoid many of the objections regarding cloud computing security. Because a private cloud setup is implemented safely within the corporate firewall, it remains under the control of the IT department.



Terms [6] – 12/

- * **Private Cloud Storage:** A form of cloud storage where the enterprise data and cloud storage resources both reside within the enterprise's data center and behind the firewall.
- * Public Cloud[4]: The cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider
 - * Public Cloud Storage: A form of cloud storage where the enterprise and storage service provider are separate and the data is stored outside of the enterprise's data center.
- * **Red Hat Cloud Computing:** Red Hat Cloud Computing refers to solutions for private clouds, hybrid clouds, and public clouds offered by Red Hat.
- * Red Hat CloudForms: Red Hat CloudForms is an Infrastructure-as-a-Service (IaaS) offering that builds upon a collection of more than 60 open source projects. CloudForms include application lifecycle management capabilities as well as the capability to create hybrid public and private clouds from the broadest range of computing resources with unique portability across physical, virtual and cloud computing resources.



Terms [6] – 13/

- * Red Hat OpenShift: OpenShift provides developers with a choice in languages, frameworks, and clouds to build, test, run, and manage Java, Ruby, PHP, Perl and Python applications. Developers can also choose the cloud provider the applications will run on.
- * Software as a Service: SaaS is a software delivery method that provides access to software and its functions remotely as a Web-based service. Software as a Service allows organizations to access business functionality at a cost typically less than paying for licensed applications since SaaS pricing is based on a monthly fee.
- * **Software Plus Services:** Software Plus Services (Software + Services) is Microsoft's philosophy for complementing the software company's on-premises software offerings with cloud-based remote computing software options.
- * **Storage Cloud:** Storage cloud refers to the collection of multiple distributed and connected resources responsible for storing and managing data online in the cloud.



Terms [6] – 14/

- * Virtual Private Cloud: Virtual Private Cloud (VPC) is an on demand configurable pool of shared computing resources allocated within a public cloud environment, providing certain level of isolation between the different users using the resources. In VPC, providing isolation within the cloud, is accompanied with a VPN function (again, allocated per VPC user) that secures, by means of authentication and encryption, the remote access of the organization to its VPC cloud resources. With the introduction of the described isolation levels, an organization using this service is in effect working on a 'virtually private' cloud (i.e. as if the cloud infrastructure is not shared with other organizations), and hence the name VPC.
- * Vertical Cloud Computing: A vertical cloud, or vertical cloud computing, is the phrase used to describe the optimization of cloud computing and cloud services for a particular vertical (e.g., a specific industry) or specific use application.
- * VMware vCloud Connector: The VMware vCloud Connector is a tool that facilitates hybrid cloud computing for organizations. The vCloud Connector essentially helps to orchestrate and administer the migration of VMs across different data centers and clouds.



Terms [6] – 14/

- * Vertical Cloud Computing: A vertical cloud, or vertical cloud computing, is the phrase used to describe the optimization of cloud computing and cloud services for a particular vertical (e.g., a specific industry) or specific use application.
- * VMware vCloud Connector: The VMware vCloud Connector is a tool that facilitates hybrid cloud computing for organizations. The vCloud Connector essentially helps to orchestrate and administer the migration of VMs across different data centers and clouds.



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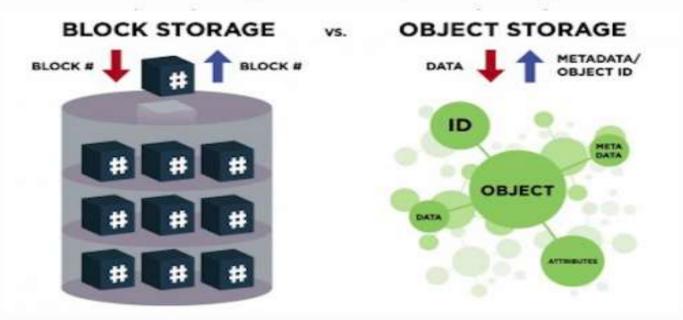
THANKS!!

BACKGROUND READING MATERIAL



Block Vs Object Store[32]

How block storage and object storage differ



With *block storage*, files are split into evenly sized blocks of data, each with its own address but with no additional information (metadata) to provide more context for what that block of data is.

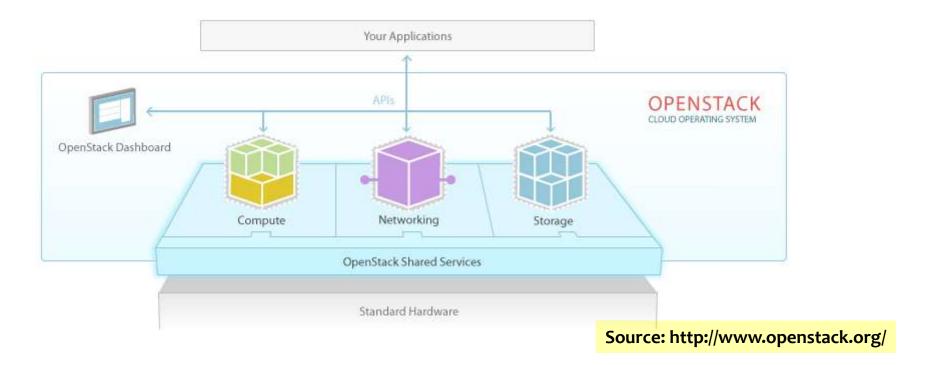
Object storage, by contrast, doesn't split files up into raw blocks of data. Instead, entire clumps of data are stored in, yes, an *object* that contains the data, metadata, and the unique identifier.



Architecture Example: Open Stack – High Level Architecture

Open Stack is a open source solution for providing Cloud based Services.

OpenStack: The Open Source Cloud Operating System





Architecture Example: Open Stack

* Architecture for a sample Open Stack

