Cloud Computing

Summary
One of the most talked about topics today is Cloud Computing ? the new phenomenon set to change the way we use computers forever. Cloud computing refers to the delivery of software and other technology services over the Internet by a service provider and has been widely acknowledged as a viable way to reduce capital expenditures and operational costs. Although many companies have embraced this technology, some are unwilling to switch from internally owned and managed IT systems to cloud computing technologies due to fears of security threats and loss of control over company systems and data.

With its growing popularity, a large number of firms have started providing this service. We tried to compare some of these offerings on various parameters like infrastructure, data storage system, supported applications/frameworks, scalability, security etc.

The worldwide market for cloud services is expected to grow from $46.4 billion in 2008 to reach $150.1 billion in 2013 with a CAGR of 26.5%. Among the various cloud services, business process services alone have contributed 84% of the total revenue generated in 2008.

In this report, we mention some of the industry segments which have successfully utilized cloud computing. We also take a brief look into how some of the photo-sharing websites like SmugMug are using cloud computing.

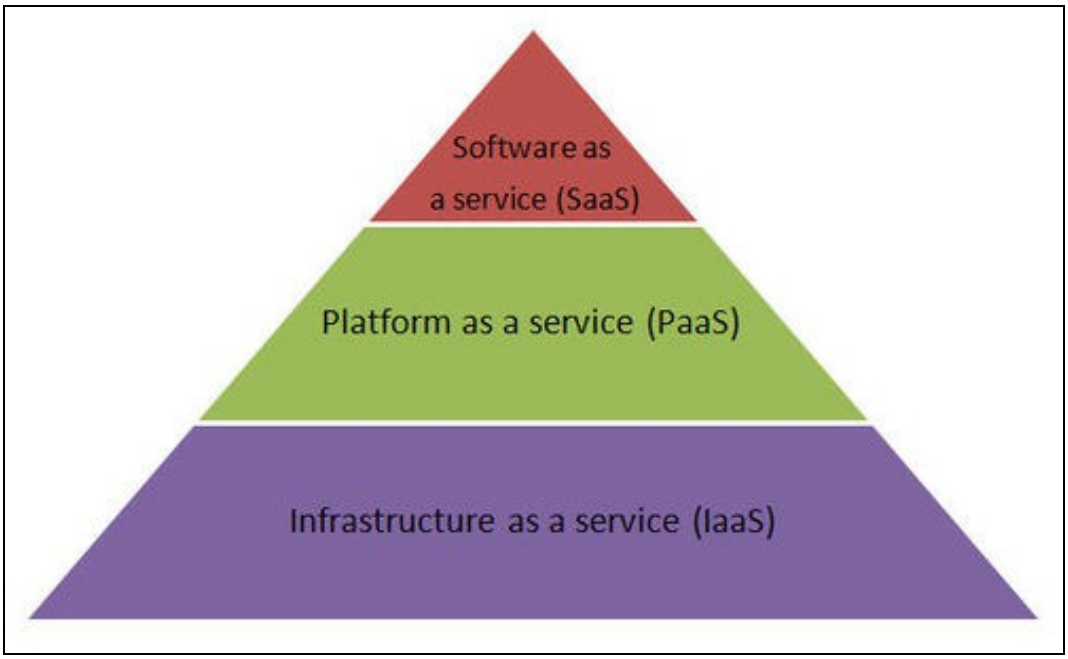
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Overview

- Cloud computing is a style of computing in which dynamically scalable and often virtualized resources are provided as a service over the Internet.
- Users need not have knowledge of, expertise in, or control over the technology infrastructure in the "cloud" that supports them.
- Cloud computing services often provide common business applications online that are accessed from a web browser, while the software and data are stored on the servers.

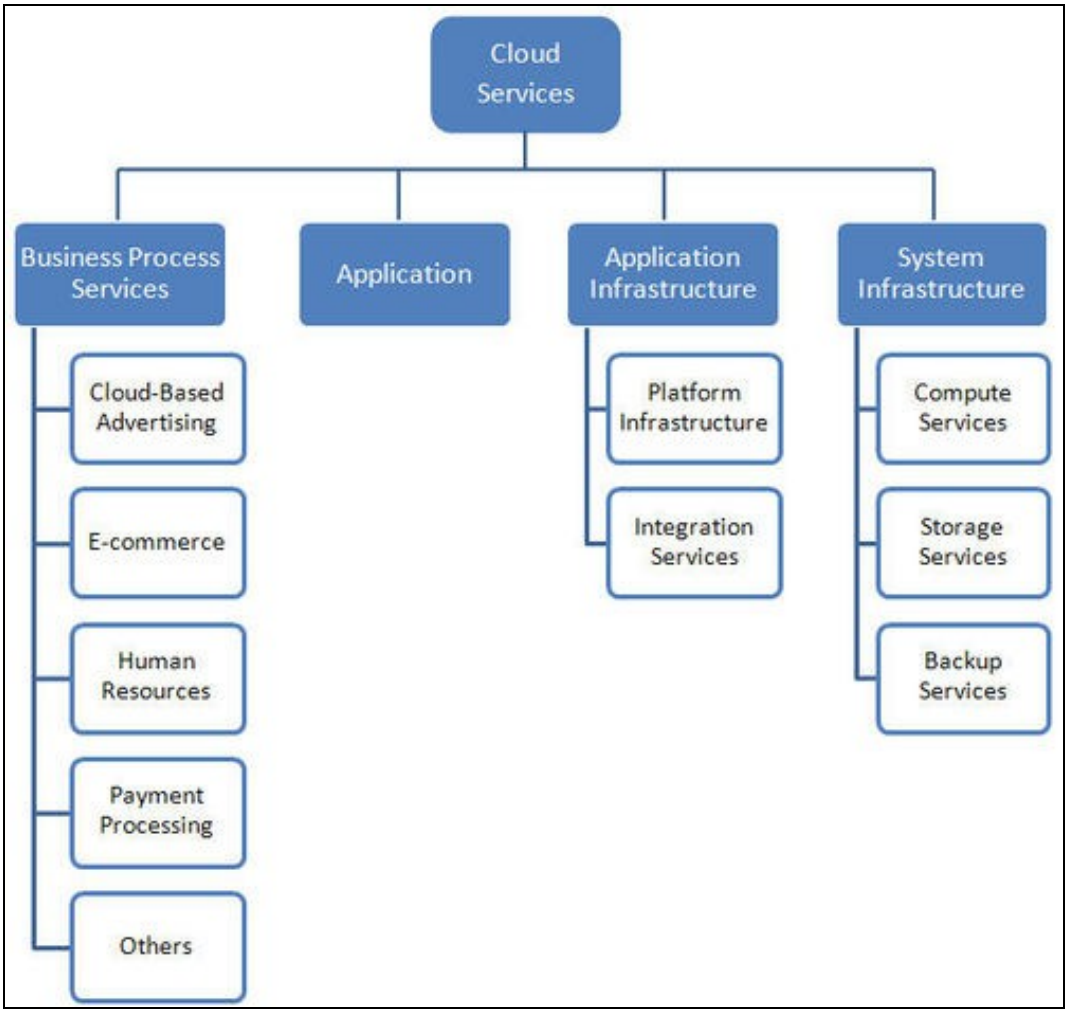
The concept generally incorporates combinations of the following:



Source: wikipedia

Market overview

Cloud services provided worldwide are:



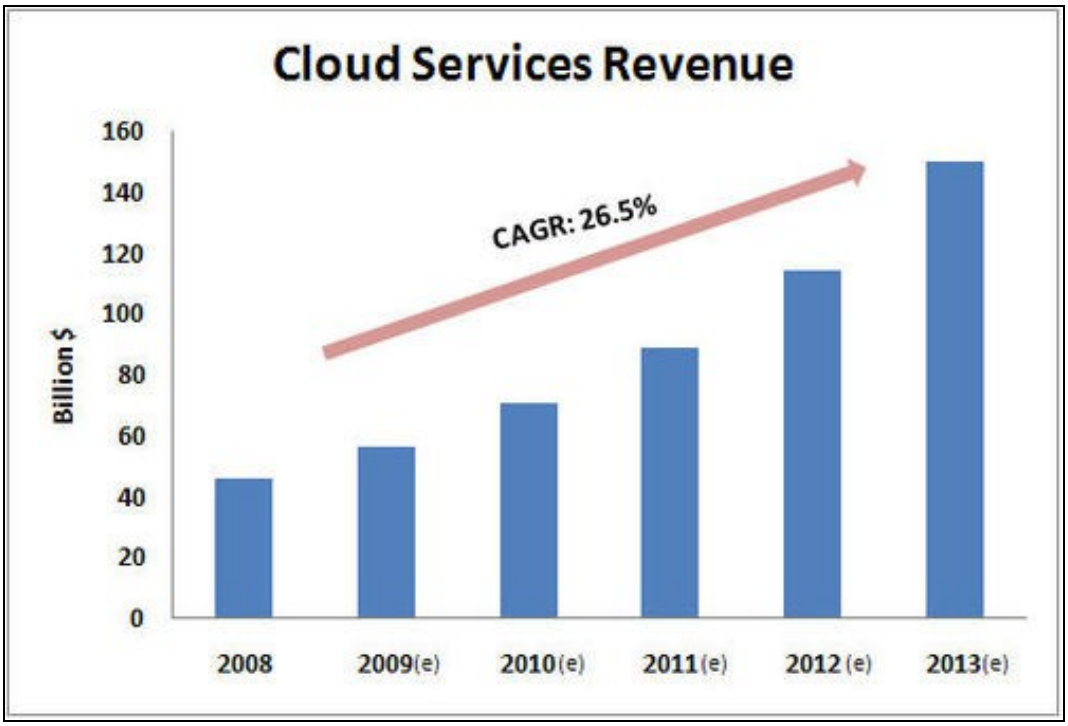
Source: Gartner report

Companies providing cloud computing technology

Technology category	Subcategory	Examples (not exhaustive)
1. Infrastructure-as-a-Service platforms		Amazon Web Services EC2, The Rackspace Cloud, GoGrid
2. Software Platform-as-a-Service		Windows Azure, Google App Engine, Force.com
3. Cloud Infrastructure Services		Infrastructure IT services delivered from the cloud
	• Storage-as-a-Service	Nirvanix, Amazon S3
	• Disaster Recovery-as-a-Service	SunGard Virtual Server Replication
	• Backup-as-a-Service	Iron Mountain LiveVault, i365 Evault, IBM Business Continuity and Resiliency Services
4. Cloud Application Services		Application services delivered from the cloud
	• Database-as-a-Service	Google BigTable, Amazon SimpleDB, MS SQL Data Services
	• Cloud billing services	Google Payment, Amazon DevPay, Zuora Zcommerce
	• Integration-as-a-Service	Amazon Simple Queuing Service, Boomi, CastIron, Informatica, Linxster, Online MQ, OpSource Connect, Pervasive
	• Business Process Management-as-a-Service	Appian Anywhere, Intensil, Skemma
5. Cloud Management Software		Appistry, CloudSwitch, Elastra, RightScale
6. Cloud Labs		Citrix C3 Lab, Electric Cloud, SkyTap, Surgient Cloud
7. Desktop-as-a-Service		Desktone, MokaFive, Simtone

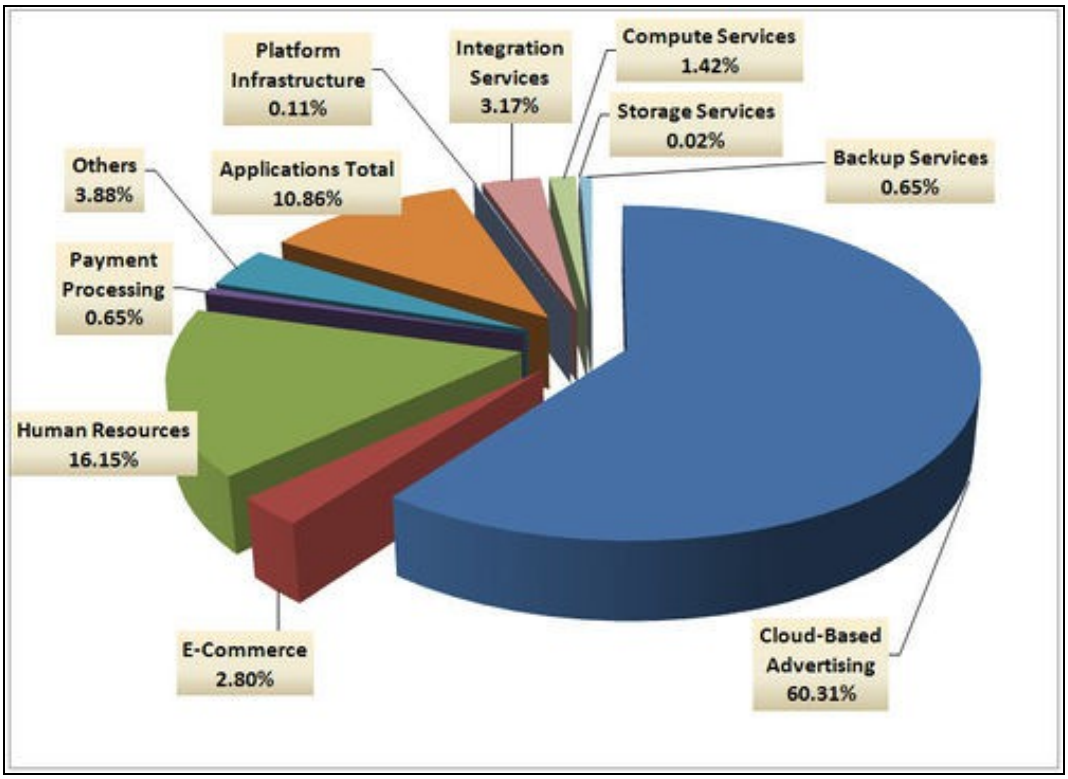
Source: blogs.znet.com

Y-on-Y revenue from cloud services



Source: Gartner report

Cloud services - revenue breakup



Source: Gartner report

Pros and cons of cloud computing



Source: blogs.znet.com

Key drivers of cloud computing

Economic downturn forcing companies to reduce fixed cost
Less funding available to startup companies trigger them to find a way to reduce infrastructure cost
Increasing emphasis to reduce processing time
Need to store and retrieve real time data
Applications with seasonal implications like retail, tax applications, Olympics etc leading to variation in utilization of resources
Increasing scale of business giving rise to storage requirements

Source: srtsolutions

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Primary research - Amazon Web Services

In our primary research, we talked to an AWS executive to gain insights about how startups and enterprise companies are using cloud computing and, drivers and constraints for the same. Valuable insights have been summarized below:

Startups

Drivers	• Reduce capex and use this money in operations • Quick scale is possible
e.g.	Smugmug is using Amazon S3 for storage



Enterprise

Business Units	Drivers: • Short run computationally heavy projects • IT team permissions are difficult to take for additional infrastructure
IT	Drivers: • Cost of managing infrastructure is high e.g. electricity/power, backup etc • Reduced hassle of licensing softwares Constraint: • If the company has already invested in hardware then they are unlikely to move to cloud
Apps	Companies are building apps on cloud e.g. • Salesforce.com provide CRM and ERP applications using cloud • Zoho.com build cloud apps on Microsoft's sharepoint
Customized services on cloud	Companies are providing customized services on cloud e.g. • Infosys may get into offering custom SAP/ERP services on the cloud



Cloud computing comparison of different vendors

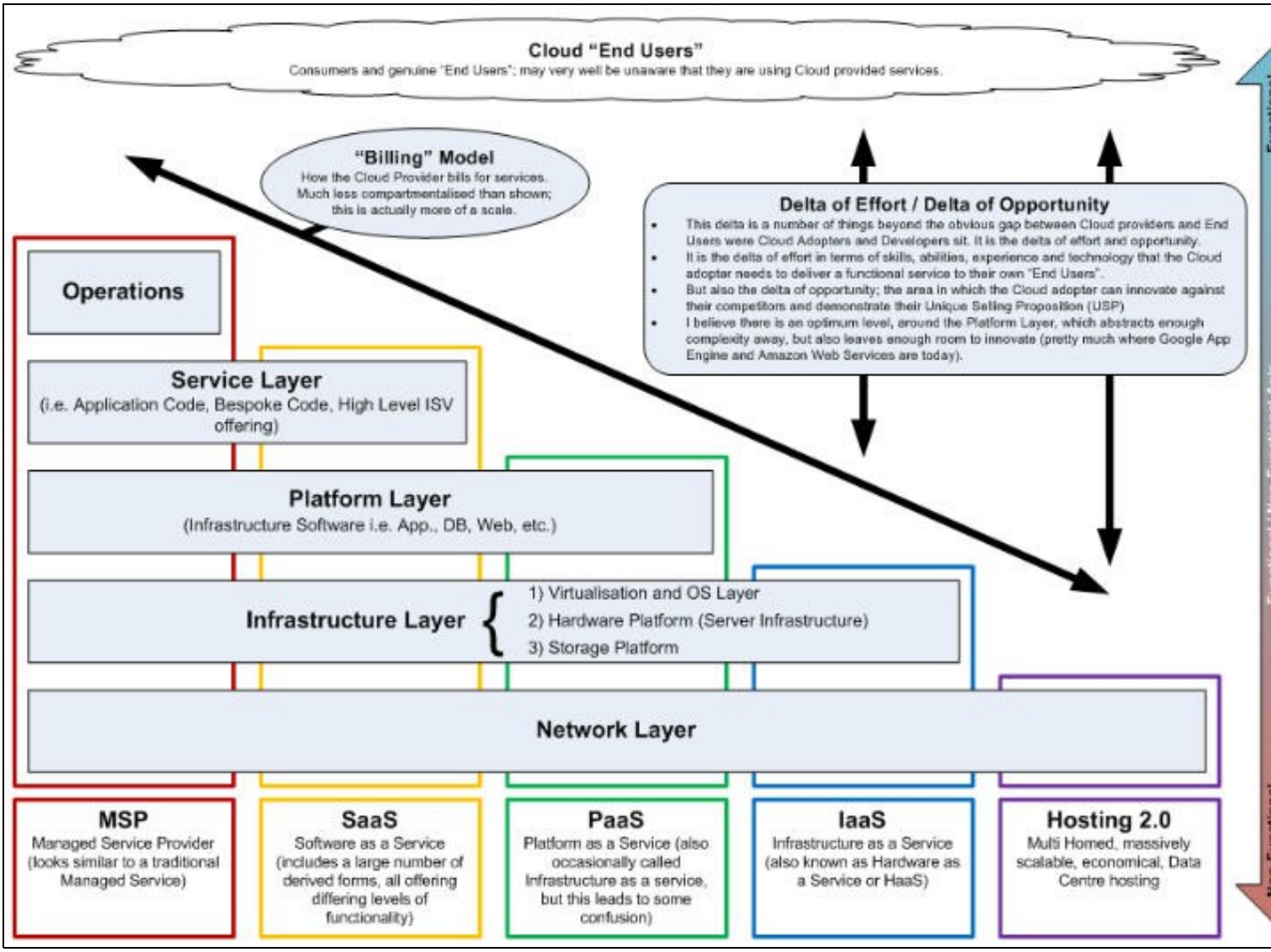
	Amazon.com Inc.	Microsoft	GoGrid (ServePath LLC)	Google	Joyent Inc.	Layered Technologies Inc. (3tera Inc. Partner)	Mosso (Rackspace US Inc.)
Offerings	EC2 (Elastic Compute Cloud) plus S3 (Simple Storage Service)	Windows Azure	GoGrid	Google App Engine	Accelerator	GridLayer	The Hosting Cloud
Provider?s Infrastructure	Runs on Amazon.com?s infrastructure. Each availability zone runs on its own physically distinct,	Microsoft?s infrastructure	GoGrid uses the ServePath network, including OC?12 and GB connections from UUNet, Level 3 Communications Inc., NTT Communications/Verio Inc. and AboveNet Inc	Google?s infrastructure	AMD Opteron x64 multicore servers with 4GB RAM per core. Joyent operates two carriergrade datacenters	Uses other providers? networks, including SAVVIS Inc.?s backbone IP network, which is based on Juniper core routers and Cisco	Built on Rackspace?s Superstructure, including its T1, SAS70?certified datacenters

	independent infrastructure and is engineered to be highly reliable					Communications Inc. carrier?class equipment and has OC?48/OC?192 backbone trunks; the DataBank IP network. Runs 3tera?s AppLogic grid OS	
Provider?s Data?Storage System	Amazon S3 Web service	Azure Data Storage REST APIs, data storage functionality through three services BLOB, TABLE and QUEUE	Storage is part of the server image; vendor plans to offer additional storage options	Persistent storage with queries, sorting and transactions	Sun Microsystems Sun Fire X4500 NAS storage	Storage is built into the Grid; data is stored on multiple hard drives across multiple machines for redundancy	Uses network?attached storage devices
Supported Operating Systems	Linux	Communication protocols such as SOAP, REST and XML allows use of other OS	Linux, Microsoft Windows, CentOS and Red Hat Enterprise	Linux, Microsoft Windows and Mac OS X	OpenSolaris	Linux and Solaris; plans to support Windows	Linux and Microsoft Windows
Supported Languages	Linux and Red Hat Enterprise	.NET, Eclipse, Ruby, PHP, Java and Python	Java, .NET, Perl, PHP, Python, Ruby on Rails and most shell?scripting languages	Python	Java, PHP, Python and Ruby on Rails	Grid nodes will run any software that runs on a normal dedicated compute	.NET, Perl, PHP, Python and Ruby on Rails
Supported Applications/ Framework	MySQL Enterprise and OpenSolaris	ASP.NET and WCF (Windows communications foundation)	Apache, Facebook applications, IIS, MySQL Enterprise, PostgreSQL and Windows Serve	Django. Services include URL Fetch, Memcache and image manipulation	Ruby on Rails	Apache, Jboss, MySQL Enterprise; anything that runs under a supported OS	Apache, Microsoft SQL and MySQL Enterprise
Scalability	Limited to 20 virtual computer instances during beta period; additional instances are allowed	No limits on scalability, additional VMs are allocated as processing load increases	No limits on scalability	Up to 5 million page views per month with preview release	Contact vendor	Up to 43 nodes. Bandwidth, RAM and CPU are changed on?the?fly. Process can be resized (2 minutes per 1GB of data)	Unlimited. Current users are pushing hundreds of millions of requests on single domains
Security	Provides Web?service interfaces to configure firewall settings that control network access to and between groups of instances	Execute applications in dedicated virtual machines, each VM provides a 64-bit windows server 2008 environment, VMs prevent data leakage from one to the other application executing on same server hardware	Provided via ServePath?s secure infrastructure and telecom facility	Service runs on Google?s secure infrastructure. App Engine provides a secure sandbox environment	Spam protection; advanced traffic security, SSL acceleration and Advanced DNS available as add?ons	All grid nodes are locked down to maintain access only when firewalls and other security features are put in place. Also, a front?end DDoS (distributed denial of service) mitigation service is available	Enterprise firewalls; email accounts include anti?virus and spam protection. SSL capabilities available as an add?on service
Virtualization Technology	Xen	Modified Hyper-V hypervisor	Xen	Undisclosed	Solaris Zones	Based on 3tera AppLogic	Undisclosed
Redundancy Features	Ability to place server instances in multiple locations and elastic IP addresses	Triple-layer redundancy to keep data safe and availability of services high	RAID servers; plans to offer server snapshots and cloning	Fault?tolerant servers	Undisclosed	Backup and snapshot feature for customer?s data	Clusters
Load Balancing	Undisclosed	Yes, route traffic to active nodes only	Yes; F5 Network BigIP load balancers.	Yes	Yes; F5 Network BigIP load balancers	No. Customers can set up their own load balancing	Yes; load?balancing layer includes logic for multiple IP addresses for each customer site

Control Panel	Web?service interface	Web interface	Yes; proprietary multiserver hosting control panel lets you manage servers and scale Web applications and networks	Proprietary, the Administration Console	Undisclosed	all servers, storage, applications and users are managed from a single, browser?based management console	Proprietary to Mosso
Development Tools	Command?line tools for building AMIs	Integration into Visual Studio, support for any .NET languages, complete command-line SDK tools	No, not necessary; plans to release public API with the same control as the Web interface	Python runtime environment,	Sandbox accelerators, central development and deployment, version control, unit test site and staging site available as add?ons	AppLogic has a scriptable command?line interface for provisioning and scaling applications	None
Additional Cloud?Storage Service	Included in cloud service	Undisclosed	No	Datastore, a distributed data?storage service	Additional storage available for $.15 per GiB	DynaVol; ranges from $15/month to $1,300/month	Limited; CloudFS is in private beta

Technical overview

Cloud computing architecture



Source: blogs.sun.com

Three major participants in cloud:

1. Cloud Providers; building out clouds, for instance Google, Amazon, etc. effectively technology providers.
2. Cloud Adopters / Developers; those developing services over the Cloud and some becoming the first generation of Cloud ISVs.
3. Cloud "End" Users; those using Cloud provisioned services, often without knowing that they are cloud provisioned, e.g. Facebook users have no idea that their favorite FB app is running on AWS.

Various architectural layers:

1. Operations: it supports functional business processes rather than supporting the technology itself.
2. Service layer: it is made up of application code, bespoke code, high-level ISV offerings.
3. Platform layer: it is made up of standard platform software i.e. app. servers, DB servers, web servers, etc., and an example implementation would be a LAMP stack.
4. Infrastructure layer: it is made up of

    (i) infrastructure software (i.e.virtualisation and OS software)
    (ii) the hardware platform and server infrastructure
    (iii) the storage platform

1. Network layer: it is made up of routers, firewalls, gateways, and other network technology.

Delta of Effort / Delta of Opportunity

The gap between the cloud providers and the end cloud users is known as the delta of effort and also the delta of opportunity.

It is the delta of effort in terms of skills, abilities, experience and technology that the cloud adopter needs to deliver a functional service to their own ?End Users?. This will be potentially a major area of cost to the cloud adopters. But it's also the delta of opportunity in terms of 'room' to innovate.

Cloud computing applications in different industry segments

Pharmaceutical

- Historically, most large pharmaceutical firms have run fully integrated vertical business models, doing all they can in-house and choosing to selectively outsource where appropriate
- Firms now seek to reduce the time and cost through sharing an integrated platform which is cheaper, less time consuming, and more supportive of a networked business model
- Pharma companies exploring cloud computing have reported positive experiences through

    ◊ Easier implementation
    ◊ More computational transparency
    ◊ A clear-cut IP policy
    ◊ Scalable invoicing

Pfizer

- Protein engineers and informaticians at Pfizer?s Biotherapeutics and Bioinnovation Center faced the challenging task of antibody docking that presented enormous computational roadblocks.
- Each antibody model requires the respectable models of the protein?s three-dimensional structure to be generated on Rosetta++ platform which carries out refinement of antibody docking.
- Refinement involves small local perturbations around the binding site followed by evaluation with Rosetta?s energy function ? an iterative process using 200-nodes cluster that requires a massive amount of computing.
- An array of Rosetta workers are spun up on Amazon?s EC2. The S3 stores inputs and outputs, SimpleDB tracks job meta-data, and the Simple Queue Service glues it all together with message passing and the entire process is completed overnight which previously took months.
- Consequently, the research staff is focusing more on results without pushing their projects on back-shelf.

Source: bio-itworld

Eli Lilly

- Eli Lilly is using cloud computing services to support scientists with on-demand processing power and storage.
- The firm uses Amazon Web Services and other cloud services to provide high-performance computing, as needed, to hundreds of its scientists.
- Eli Lilly foresees the possibility of using cloud services from a half dozen different vendors and need for an ?orchestration layer? that sits between Eli Lilly and the various cloud services.
- It would comprise algorithms that determine the best cloud service for a particular job based on lowest cost, highest performance, or other requirement. Such an approach would make it possible for Eli Lilly and other users to write to a single API rather than many, while optimizing service usage.
- The firm is also exploring the potential to use cloud computing for external collaboration between Eli Lilly and outside researchers.

Source: undertheradarblog

Johnson and Johnson

- Johnson and Johnson is seeking to complement its high performance grid architecture with cloud computing, mainly in the area of drug discovery modeling applications, according to Rick Franckowiak, director for systems engineering at the Pharmaceutical Research & Development IT organization at Johnson & Johnson.
- Require enhanced computing and storage capabilities and address spike-type processing demand.

Source:fiercebiotechit

Indigo BioSystems Inc.

- Indigo BioSystems Inc., a privately held company offering data management and automated analysis solutions for life science researchers with a focus on the pharmaceutical industry.
- It has deployed IBM's Compute on Demand cloud services to provide clients with a highly secure, scalable and compliant environment for data exchange.
- IBM?s cloud services has been able to meet the clients? requirements for a scalable and globally accessible platform for data exchange alongwith the security and regulatory compliances of the pharmaceutical industry.

Source: prdomain

Hospitality

Cloud computing is used in hospitality industry to provide

- Disaster recover infrastructure for mission critical applications
- For online reservation system
- Purchase of a dedicated pool of computing resources and allocating them as needed
- Facilitating in responding to real-time situations

e.g. Preferred Hotel Group is using Terremark's Enterprise cloud services

Source: phx.corporate-ir.net

Web applications

Cloud computing is used in various web applications such as Microsoft's Hotmail, Google's Gmail and YouTube, and Yahoo's Flickr photo-sharing service etc

- Consumers run only their browsers on local computers
- The rest of the software along with users' email messages, photos or videos are on remote machines the user can't see and doesn't have to know anything about it

e.g. Microsoft's Hotmail is using Azure (cloud computing platform from Microsoft) and Google's Gmail is using Google Apps

- Google Docs - online versions of word processor and spreadsheet applications is also using cloud computing

Source: www.htrends.com

Consumer electronics

Cloud computing is being used in consumer electronics at various levels:

- In Laptop computers for Wireless communication and access to the Internet
- Laptops require minimum hardware to reduce cost and a internet connection
- Gaming industry, that will allow iPhones and other thin-client devices to have really high-end graphics without having a big, expensive hot video card in them that draws battery life

e.g Netbook, a general purpose laptop, works on cloud computing and is available at a price of US$400 and some even in US$50-100 range.

Source: www.htrends.com

Retail

- Cloud services allow retailers to plan for demand peaks in online services dynamically without worrying about provisioning for high availability
- Pay-as-you-model helps them save cost rather than paying for expensive hardware to meet these peaks while they are under used for the rest of the year
- Increases productivity and help companies serve their customers better.

e.g. Amazon is using cloud computing for its online retail services

Source: www.onwindows.com

Financial Services

Cloud computing is used by financial services firms:

- To Store and analyze large amount data related to stock market or historical data
- Build and evaluate new risk analysis programs
- Allows companies to bring application to the market quickly and deployed within a limited budget

e.g. NASDAQ Market Replay application uses Amazon's S3 cloud for data storage but the application part is not running in cloud presently. It has plans to develop future applications in Amazon's EC2.

Companies using cloud computing

The New York Times

- The company decided to make all the *public domain articles* from 1851-1922 available free of charge.
- These articles are all in the form of images scanned from the original paper, all 11 million articles are available as images in PDF format.
- It had been using Amazon S3 service and in late 2006 it begun playing with Amazon EC2.
- The idea was to upload 4TB of source data into S3, write some code that would run on numerous EC2 instances to read the source data, create PDFs, and store the results back into S3.
- S3 is used to serve the PDFs to the general public.



Source: ope.blogs.nytimes

Major League Baseball

- MLB has baseball covered from pitch-by-pitch accounts of games to streaming audio and video plus news, schedules, statistics and more.
- The company needs additional capacity (memory and processors) when the *playoffs* and *world series* came around so that fans could chat about the playoff races and use it during the playoffs.
- It is using Joyent service that provides hosting using virtual zones and virtual storage.
- Soon after the world series is over MLB gets its capacity scaled down and pay for the utilization.



Source: networkworld

ESPN

- For *Perfect10 Bracket Challenge* contest, ESPN needed to scale up its application while keeping the operational costs managable.
- ESPN launched the contest using Amazon's EC2 cloud infrastructure.
- OpenCrowd designed and developed the scalable solution for the contest.
- This helped ESPN to reduce their technology costs while increasing flexibility in their business.



Source: opencrowd

Hasbro

- Hasbro, the mega producer of games and toys, introduced an *online marketing campaign.*
- The campaign web site allowed game-lovers worldwide to vote for their city to be included in the game's new edition.
- Hasbro approached Digitaria for this, who used AWS and open source software to produce the site's back-end infrastructure from a single Amazon EC2 image.
- With this, they created and launched a new database, application server, caching server, and load balancer instances in much less time.



Source: aws.amazon.com

Chicago

- West Monroe Partners has created and launched an innovative, interactive map to support the City of Chicago's *annual Taste of Chicago* event.
- West Monroe Partners utilized Microsoft Silverlight and its Deep Zoom technology to deliver rich interactive applications for the Web.
- Microsoft cloud platform Windows Azure is used to host the application.
- Azure is also used to handle website's users load which provides equivalent capacity of 25 purchased servers, with no infrastructure investment required by the City of Chicago.



Source: news.prnewswire

Cybernet Slash Support (CSS)

- In an initiative to reduce cost/time and improve productivity of its payroll system, CSS labs shifted its payroll system on EC2.
- Earlier CSS *payroll system* took about 5 to 10 seconds to calculate a pay check per employee and approximately 6 hours for 4500 employees.
- Now running payroll on AWS, processing time has been reduced considerably from 5 hours to approximately 1 hour.
- Payroll solution is now scalable as well to withstand increasing head count day by day.



Source: cssinnovations.blogspot

Intuit

- Intuit was keen on ensuring the TurboTax online site was able to support high continuous use, as well as surges in user traffic as tax day neared.
- Intuit contacted SOASTA for the same and they used Amzon EC2 cloud service.
- As a result TurboTax online site performed perfectly on tax day.



Source: soasta.com

Activision

- Activision prepared to launch the newest edition of its biggest selling game *Guitar Hero III: Legends of Rock* Just before the holiday season.
- As the shopping season was approaching, the company had less time and lacked resources who could test the web site.
- Activision used SOASTA CloudTest automated testing solution which runs on Amazon EC2.
- Activision was able to implement the required changes in time to meet their marketing kickoff as a result the game *Guita Hero III* was named the best selling video game in a single calendar year.



Source: soasta.com

Cloud computing in online photo sharing

Cloud computing advantages like scalability, reduced hardware costs and extensive reach is being utilized by some leading photo sharing websites.

SmugMug

- SmugMug is a premium photo sharing web site with an emphasis on professional photography.
- Members are allowed to upload unlimited number of photos, create new functionality, tagging and uploading from Picasa, iPhoto and other software packages.

  Source: Wikipedia

- SmugMug is using Amazon S3 mainly as a storage solution for customers? photos which can be accessed anywhere, anytime while also providing real-time backup and failover systems.

The architecture basically consists of three software components:



Render workers	• These are basically CentOS 5 AMIs (Amazon Machine Images) with a single extra script on them. • Script sends an authenticated request to get software, extracts the bundle and starts self-updating software. • "User-data" launch parameter is used to specify the EC2 instances and send instructions that give the software all the details needed to choose a role, get software, and launch it. • A worker instance gets the directive from queue service, completes work and stores the result on S3.
Batch queuing piece	• Batch queuing supports job types (new upload, rotate, watermark, etc) and priorities. • Logs historical data such as time to completion. • Supports time-based re-queuing in the event of a worker outage, miscommunication and error.
Controller	• Controller aka Skynet consumes historical data to make smart decisions. • Skynet looks into several parameters like nature, priority and complexity of jobs, load of the EC2 cluster and average time per job per sample to make an EC2 decision. • Decisions maybe semi-predictable like uploading of photos or non-predictable like watermarking an entire gallery.
MySQL database servers are run in-house in order to stay physically close to the hot photos	

Source: blogs.smugmug.com

TweetPhoto

TweetPhoto is a free photo-sharing service that compliments the social-media service Twitter which is utilizing Rackspace Hosting?s cloud-computing unit **Mosso** and allowing users to easily upload as many photos as they want and automatically share them with Twitter followers and Facebook friends. It also allow users to conduct photo searchers, subscribe to RSS media feeds, geotagging from GPS-enabled smartphones or transfer bio and friend information from Twitter as well as monitor which other users are viewing and commenting on their photos.

Source: www.bizjournals.com

TweetPhoto utilizes the ***Cloud Site*** and ***Cloud File*** services from Rackspace.

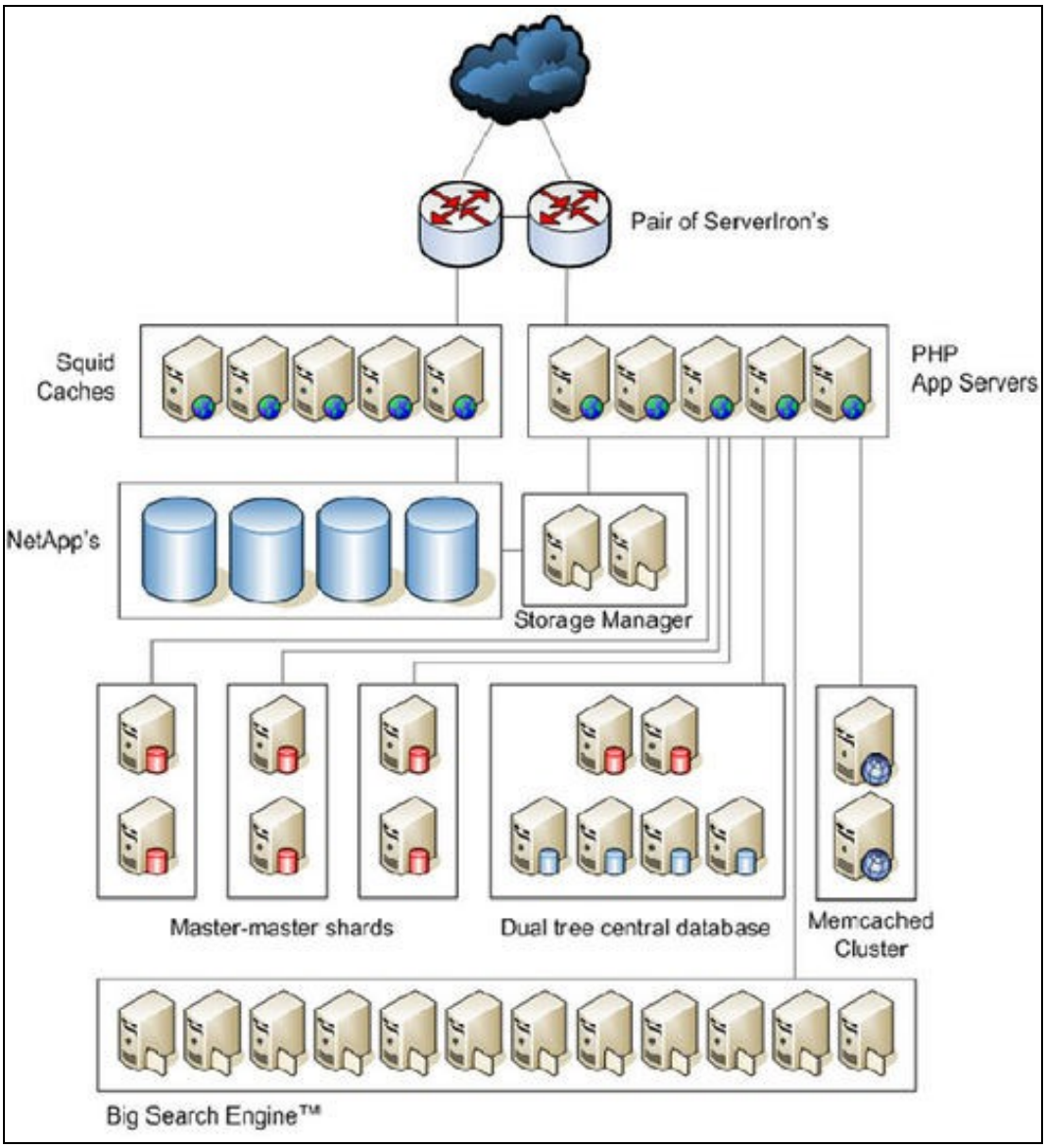
- Cloud Site is a scalable platform which can store and recall countless amount of metadata in real-time and has the ability to run Windows or Linux applications across hundreds of servers.
- Cloud File Provides unlimited online storage for media which is served out via Limelight Networks' Content Delivery Network **(CDN)**
- CDN is a system of computers networked together on the internet and works on the principle that the capacity sum of strategically placed servers can be higher than the network backbone capacity. Strategically placed edge servers
    - ◊ Decrease the load on interconnects, public peers, private peers and backbones
    - ◊ Free up capacity
    - ◊ Lower delivery costs
    - ◊ Offloads traffic from peer link and redirects traffic to edge servers

Source:Wikipedia,businesswire.com, blog.mosso.com

Flickr

- Flickr is an image and video hosting website, web services suite, and online community platform.
- Used to share personal photographs and also widely used by bloggers as a photo repository.

Flickr architecture:



Source:www.iamcal.com
The platform for Flickr is:

- PHP
- MySQL
- Shards
- Memcached for a caching layer.
- Squid in reverse-proxy for html and images.
- Smarty for templating
- Perl
- PEAR for XML and Email parsing
- ImageMagick, for image processing
- Java, for the node service
- Apache
- SystemImager for deployment
- Ganglia for distributed system monitoring
- Subcon stores essential system configuration files in a subversion repository for easy deployment to machines in a cluster.
- Cvsup for distributing and updating collections of files across a network.

Source:highscalability.com

Barriers to the adoption of cloud computing

Security	Companies and industries have to maintain strict watch on their data either because of govt. regulations such as HIPAA, Gramm-Leach Bliley Act or because they are super paranoid
Logging	Putting data in the cloud makes it hard to log for compliance purposes, though startups are working on products that make it possible to log conversation between virtualized servers
Platform agnosticism	Most clouds force participants to rely on a single platform or host only one type of product and to support multiple platforms manageability is major concern
Portability	Getting data from one to another cloud is not easy as it leave data in a format that few or no other cloud accepts
Physical location of servers	Physical location of servers is important under many nation's law. E.g. Canada is concerned about its public sector projects being hosted on U.S.-based servers because under the U.S. Patriot Act, it could be accessed by the U.S. government



Source: gigaom

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