INTRODUCTION
TO
CLOUD COMPUTING

BY

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Introduction to Cloud Computing

1. Cloud introduction and overview
2. Cloud Computing Technology
3. Hardware & software Infrastructure
4. Different clouds
5. Risks
6. Cloud Services
7. Applications
8. Regulatory Issues & Limitations

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Cloud introduction and overview

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Cloud Computing Definition

"A model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."

By National Institute of Standards and Technology (NIST), 2011.

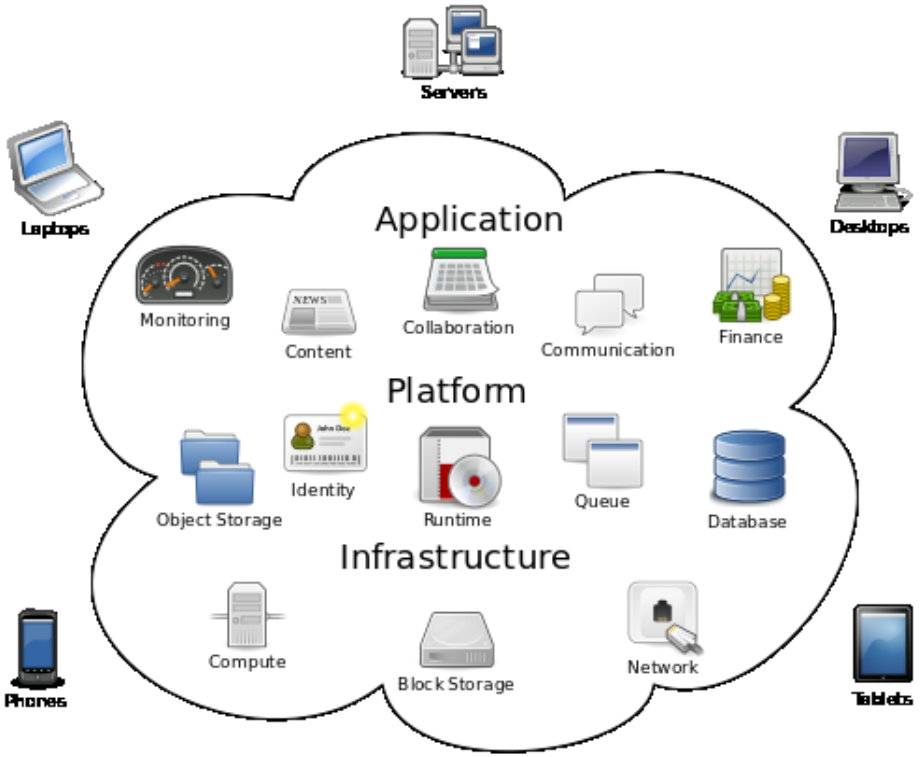
"A large-scale distributed computing paradigm that is driven by economies of scale, in which a pool of abstracted, virtualized, dynamically-scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet."

By Foster, Y. Zhau, R. Ioan, and S. Lu. "Cloud Computing and Grid Computing: 360-Degree Compared." Grid Computing Environments Workshop, 2008.

Cloud Computing

- **Cloud computing** (Utility and Grid Computing).
- Clouds are of three types
  - public, private or hybrid.

Creating a groups of scalable hardware and software that allow remote computation, data storage and access using "Services".



Cloud Computing

Whether cloud stands on existing technology?

Yes, Hypervisor, Virtualization, Load Balancing, VPN, SAN, SOA, Web Service and many more are the technologies behind Cloud.

Larry Ellison, CEO, Oracle (Wall Street Journal, Sept. 26, 2008) "we have redefined Cloud Computing to include everything that we already do.... change the wording of some of our ads."

Richard Stallman, Founder, Free Software Foundation (The Guardian, Sept. 29, 2008). *said* "it's marketing hype. Somebody is saying this is inevitable ..... it's very likely to be a set of businesses campaigning to make it true."

Mell, Peter, and Tim Grance. "The NIST definition of cloud computing. "*National Institute of Standards and Technology* 53.6 (2009): 50.

Overview

- Cloud computing in computer science is analogous to electricity grid over a electric network.
- Concept of converged infrastructure and shared services.
- Maximizing the effectiveness of the shared resources.
- Resources are shared by multiple users.
- Resources are dynamically reallocated as per demand.
- Efficient use of computing power thus being eco-friendly (less power, air conditioning, rackspace, etc.).
- Multiple users can work on a machine.
- Users can retrieve and update the data with flexible licenses for different applications.

CAPEX to OPEX

- CAPEX model → buy the dedicated hardware over a period of time.
- OPEX model → use a shared cloud infrastructure and pay as one uses it.
- **Moving to cloud:** CAPEX →→→ OPEX model
- Business in profit.

CAPEX to OPEX

- **Benefit of OPEX and why cloud?**
  1. Sharing of resources to achieve coherence and economies of scale.
  2. Avoid upfront infrastructure costs
  3. Focus on code development instead of infrastructure.
  4. Applications can run faster, with improved manageability and less maintenance, and enables IT.
  5. Adjustment with fluctuating and unpredictable business demand.
  6. Cloud providers use "pay as you go" model. Charges may be high if administrators do not used cloud.
  7. Reason for the growth of cloud computing: availability of high-capacity networks, low-cost computers and storage devices, hardware virtualization, service-oriented architecture, utility computing.
- **Results:** Cloud vendors are experiencing high growth rates annually

History

- **Origin of the term** is unclear.
  - *Cloud* was used as a metaphor for the Internet
- **The 1950s**
  - large-scale mainframe computers
  - Practice of sharing CPU time on a mainframe became known in the industry as time-sharing.
- **Mid 70s**
  - time-sharing was popularly known as RJE (Remote Job Entry) by IBM and DEC.

http://en.wikipedia.org/wiki/Cloud_computing

History

➔ **Since 1990s**

- Telecommunications companies, provided point-to-point data circuits, Virtual Private Network (VPN).
- Efficient bandwidth.
- Big servers and network infrastructure.
- Scientists and technologists need for large-scale computing through time-sharing.
- Codes to optimize the infrastructure.
- Better OS platform, and applications to prioritize CPUs.

http://en.wikipedia.org/wiki/Cloud_computing

History

➔ **Since 2000**

In early 2008

- Eucalyptus became the first open-source,
- AWS API-compatible platform for deploying private clouds.
- OpenNebula, became the first open-source software for deploying private and hybrid clouds, and for the federation of clouds.
- Quality of service guarantees in cloud-based infrastructures.

In 2006 Amazon.com introduced the Elastic Compute Cloud.

In July 2010, Rackspace Hosting and NASA jointly launched OpenStack.

On March 1, 2011, IBM SmartCloud framework to support Smarter Planet project.

On June 7, 2012, Oracle announced the Oracle Cloud

http://en.wikipedia.org/wiki/Cloud_computing

Turing Award 2013

- "Leslie Lamport, a Principal Researcher at Microsoft Research, as the recipient of the 2013 ACM A. M. Turing Award." Lamport's proposed widely used algorithms and tools that have applications in cloud computing.
- His 1978 paper "Time, Clocks, and the Ordering of Events in a Distributed System" is one of the most cited in the history of computer science.
- "Turing Award for imposing clear, well-defined coherence on the seemingly chaotic behavior of distributed computing systems, in which several autonomous computers communicate with each other by passing messages. He devised important algorithms and developed formal modeling and verification protocols that improve the quality of real distributed systems. These contributions have resulted in improved correctness, performance, and reliability of computer systems."

http://www.acm.org/press-room/news-releases/2014/turing-award-13

Turing Award 2013

- "Google Vice President of Research Alfred Spector noted that "with the growing shift to ever-larger scale distributed systems and cloud computing, Lamport's work has taken on a significantly increased role. His results have benefited many research communities including those in parallel and high performance computing systems, concurrent algorithms, and software reliability. And, his work has had implications not just in the theoretical community, but also with the engineers and programmers who design and implement many types of systems."
- Harry Shum, Microsoft executive vice president of Technology and Research: "I really started to appreciate the incredible contribution his work has made to our industry, especially in cloud computing and distributed systems, when I worked at Bing. At Bing, we studied his paper on Paxos and applied his technology to build the distributed systems that we still use today."

http://www.acm.org/press-room/news-releases/2014/turing-award-13
http://research.microsoft.com/en-us/news/features/lamport-031814.aspx

Cloud Computing Technology

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Technologies involved in Cloud

- SaaS
- Inexpensive storage
- Inexpensive and plentiful client CPU bandwidth to support significant client computation
- Sophisticated client algorithms, including HTML, CSS, AJAX, REST
- Client broadband
- SOA (service-oriented architectures)
- Large infrastructure implementations from Google, Yahoo, Amazon, and others that provided real-world, massively scalable, distributed computing
- Commercial virtualization
- Cloud computing is upgraded version kind of grid computing
- Cloud has evolved by addressing the QoS (quality of service) and reliability problems.
- Cloud computing provides the tools and technologies to build data/compute intensive parallel applications.

Creeger, Mache. "Cloud Computing: An Overview." *ACM Queue* 7.5 (2009): 2.

Terminologies

Supercomputers

Grid Computing

Utility Computing

- pay-as-you-go computing
- Illusion of infinite resources
- Demanded billing like hourly, daily, number of users

Software as a Service (SaaS)

(Hardware, Platform, Software) as a service → "X as a service"

Virtualization & Services

- Cloud computing is a combination of existing technologies. User can use this combination without the technical knowledge or expertise.
- **Virtualization:** It is a process of creating a illusion of a physical computing device, into one or more low-configuration virtual device, such that they can easily be used and managed.
- **Service-oriented Architecture (SOA):** Cloud computing adopts concepts of SOA that to create services for sub-problems and these services can be integrated to solution the problem. Moreover, these services are further divided into individual operations (procedures).
- Cloud computing provides its resources in the form of services. Use the well-established technology domains like SOA and Virtualization. This results in globalized and user friendly technology.

Other relevant technologies

- Mainframe computer — Powerful computers used for critical applications for bulk data processing.
- Peer-to-peer — Distributed Architecture without central coordination. Participants are both suppliers and consumers of resources (in contrast to the traditional client–server model).
- Grid computing — computer are composed into a cluster using networked, cluster is acting as converged resource.
- Utility computing — The package of computing resources (CPUand storage) are charged according to the pay-as-you-go.
- Service oriented Computing: This organize and utilize the distributed services offered by different owners. It gives a formal way of offering, discover, interaction with the flexibility to orchestrate according to requirement.

Hardware & software Infrastructure

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Scale of Cloud in industries?

10s of CPUs?

100s of CPUs?

Scale of Cloud in industries?

Example Large scale log processing

- Clusters vary from 1 to 100 nodes.
- More than 100,000 CPUs
- >36,000 computers
- Biggest cluster has 4000 nodes
- 2*4cpu boxes
- 4*1TB disk
- 16GB RAM

Can we practice it in our lab?

Yes we can practice with few machines.

- Install *Eucalyptus*, *OpenStack*, *OpenNebula* and *Nimbus*
- Develop a *Google app* with *Google web tool-kit* and deploy it on *Google App Engine*. Similarly for *Ruby on Rails* on *Engine yard*.
- *Hadoop*, *Storm* etc
- Services Oriented Computing
- Grid Clusters
- And many more

Data Centers

- A **data center** is a facility used to house computer systems and associated components, such as telecommunications and storage systems.
- Includes backup power supplies, redundant data communications connections, environmental controls (e.g., air conditioning, fire suppression) and various security devices.
- Large data centers are industrial scale operations using as much electricity as a small town.

Cloud Engines

- Eucalyptus
- Open Stack
- Nimbus
- Open Nebula

Web Services

Web Service: Interoperable machine-to-machine interaction over a network with WSDL using SOAP messages, conveyed using HTTP with XML standards.

WSDL: Description of a web service in XML

SOAP: Packet of messages in XML

Hypervisors

Virtualization: A virtual machine (VM) is a software implementation of a machine (i.e., a computer) that executes programs like a physical machine.

- Hypervisor: provides a uniform abstraction of the underlying physical machine.
- Hypervisor Types
- Type 1
  - Bare Metal : Runs directly on Hardware. On top Hypervisor the OS is loaded. Example Mircrosoft Hyper V, Citrix Xen Server,
- Type2
  - Hosted : The Hypervisor runs on a guest OS. Example KVM.

Big Data

- Batch processing of big data
  - Google File System (GFS)
  - Hadoop Distributed File System (HDFS)
- Real time Stream processing
  - Storm

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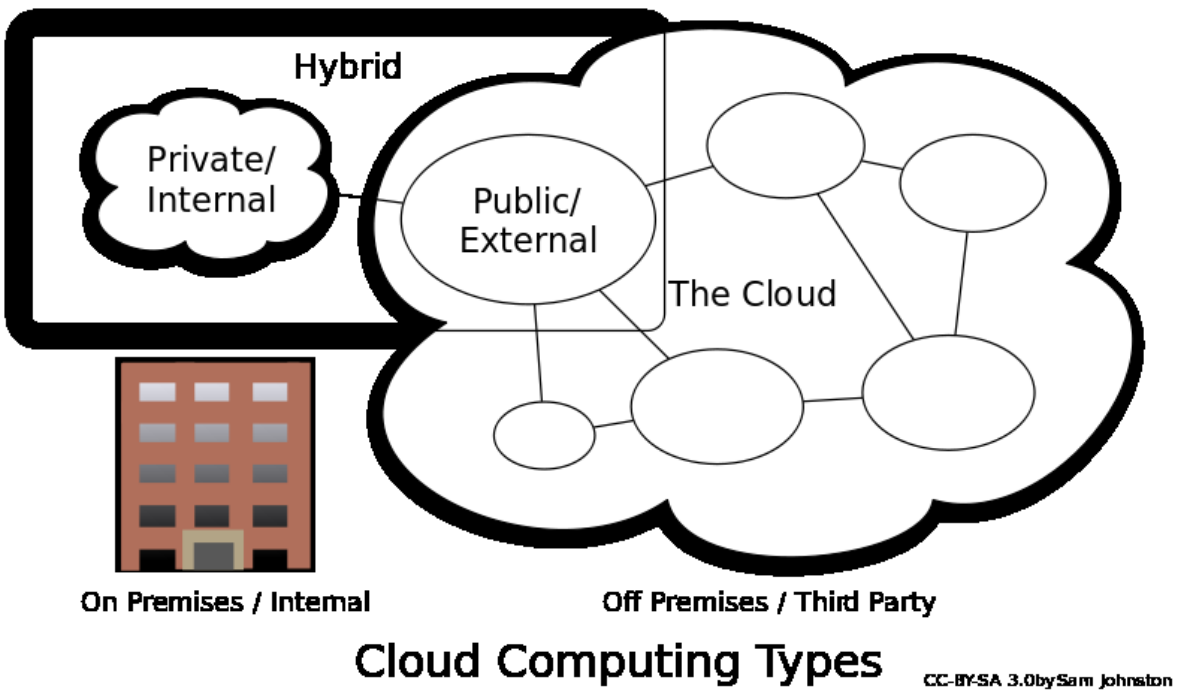
Different clouds



Private, Public and Hybrid Cloud

- **Private cloud:** "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".
- **Public cloud:** "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".
- **Hybrid cloud:** "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)".
- **Community cloud:** "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".

The NIST Definition of Cloud Computing

Public cloud

- Public cloud services may be free or offered on a pay-per-usage model.
- Mostly similar public and private cloud architecture. But difference is for security, storage, and other resources that are usually better in public cloud.
- Examples: Amazon AWS, Microsoft and Google operate the infrastructure at their data center .
- AWS and Microsoft offers direct connect services called "AWS Direct Connect" and "Azure ExpressRoute", customers requires to purchase or lease a connection.

Private cloud

- Private cloud establishment requires effort by an organization to and also intelligence to take decisions regarding the resources.
- It improves business and also raises security issues that must be addressed.
- Private data centers are generally capital intensive. They requires space, hardware, environmental controls and electricity.
- Operational expenses as well as Capital expenditures for renewable.
- Issues "buy, build, manage and expertise".

Hybrid cloud

- Hybrid cloud will help in extension of the capacity or the capability of a cloud service, by aggregation, integration or customization with another cloud service. Ability to connect, managed or dedicated services with both private and public cloud resources.

1. If an organization have some client data on a private cloud application, but want to interconnect that application to a business intelligence application provided on a public cloud as a software service.
2. If an organizations use public cloud computing resources to meet temporary capacity needs that can not be met by the private cloud.

- **Cloud bursting:** when the demand for computing capacity increases then an application deployment model in a private cloud or data center will "bursts" to a public cloud. During spike in processing demand requirement private cloud infrastructure that supports average workloads will start using cloud resources from public or private clouds together.
- **Advantage:** payment only for the extra compute resources when they are needed.

Other Deployment models

- **Distributed cloud:** Computing done by distributed set of machines that are running at different locations and they are connected to a single network. Examples
  BOINC and Folding@Home. Example: voluntarily shared resources.
- **Multicloud:** When multiple cloud vendors provides service together in heterogeneous architecture. This will help in reducing reliance on single vendors, increase flexibility through choice, mitigate against disasters, etc.
- **Intercloud** is an interconnected cloud i.e. "cloud of clouds" similar to Interconnected network (Internet) "network of networks". Mainly inter cloud helps in interoperability between public cloud service providers (as is the case for hybrid- and multi-cloud).

Risks

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Cloud computing privacy concerns

- Service provider may access the data.
- Accidental or deliberated alteration or deletion of information.
- Many cloud providers may share information with third parties if necessary for purposes of law and order even without a informing clients. It is legal because client need to accept the privacy policies before they start using the cloud services.
- Possible solutions strict auditing and inclusion of privacy policy and legislation. Users can encrypt data before storing it in the cloud to prevent read operation.
- Legal ownership of the data (How is the owner of data cloud provider or consumer). Many terms of service agreements are required for this.

Cloud computing privacy concerns

- Physical control on the computers in private cloud is more secure than in public cloud.
- Public cloud service needs to make secure building to maintain secure services. Useful for small businesses (specially non-expertise in IT security).
- Naive users do not understand or read the terms of service and "Accept" the agreement.
- Private cloud is normally secure. But public cloud is flexible, on up-front cost and with less time to start.

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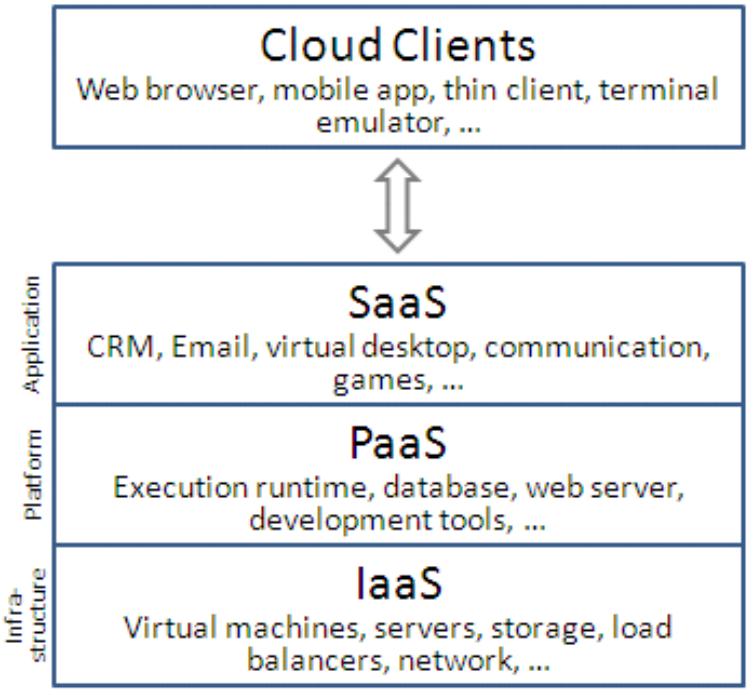
Cloud Services



Cloud Services

- Cloud services means on demand services available to users via the network from a vendor servers.
- Cloud services are easy to use, scalable and are fully managed by a services provider.
- Services which are dynamically scale to meet the needs of its users with the help of giant hardware and software. A user does not require to provision or deploy resources or allocate IT staff.
- Examples: Data storage and backup solutions, Web-based e-mail, and document collaboration, database processing, and many more.

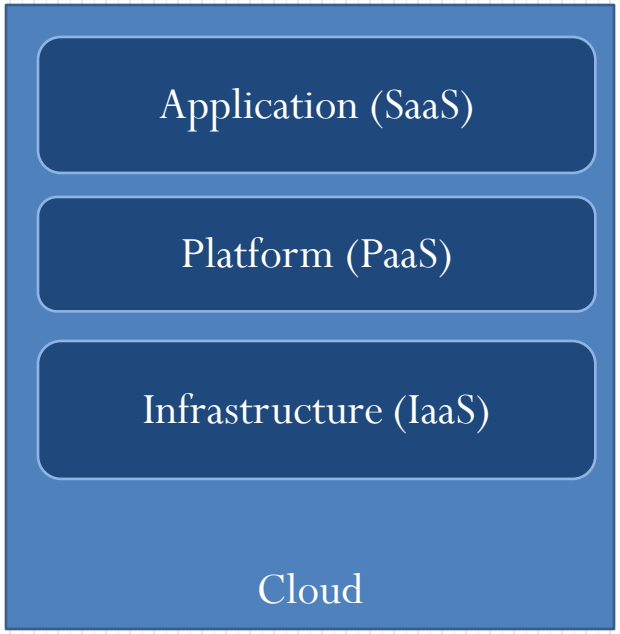
Classification and Vendors

- Infrastructure as a service (IaaS) offers hardware environment services. Kind of storage services (database or disk storage) or virtual servers. Some vendors are Amazon EC2, Amazon S3,Rackspace Cloud Servers and Flexiscale.
- Platform as a Service (PaaS) offers development (platform) environment services. PaaS offered by different vendors are generally not compatible. Typical players in PaaS are Google Application Engine, Microsofts Azure, Salesforce.com .
- Software as a service (SaaS) offers software. Application are based on 'pay-as-you-go' basis. Vendors Salesforce.coms in Customer Relationship Management (CRM), Gmail and Hotmail, Google docs and BPOS (Business Productivity Online Standard Suite) a MS Office online.

Different “X as a Service”

- Application-as-a-service
- Platform-as-a-service
- Integration-as-a-service
- Storage-as-a-service
- Database-as-a-service
- Information-as-a-service
- Process-as-a-service
- Security-as-a-service
- Testing-as-a-service
- Infrastructure-as-a-service
- Management/Governance-as-a-service

Applications



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Cloud Application

- Cloud computing applications, are also known as Software as a Service (SaaS).
- Similar to the software's installed on computers, additionally they are available online with or without credentials (username and password).

Benefits

- Global accessibility ➔ collaborative working with multiple users.
- Automatic Up gradation ➔ all user on same version.
- Equal benefits to all ➔ New developments to every user at same time.
- Safety ➔ Wallet + Money Bank + Funds

  Similarly, Data + cloud application.

  Here reference of Wallet is in context of better arrangement and bank for security

Example of Cloud Applications

- Some of the important applications
  - Twitter - twitter.com
  - Facebook - facebook.com
  - Bonus – Chatter.com! - chatter.com
  - Google Apps for Business - google.com (text documents, spreadsheets, slide shows, Google Docs and many more)
  - Skype - skype.com
- There are many cloud application please refer to http://en.wikipedia.org/wiki/Category:Cloud_applications

Regulatory Issues and Limitations

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Regulating Issues

Now almost every part of computer science is influenced by Cloud Computing. Concerns related to

1. Infrastructure
2. Access control, Identity management & Integrity control
3. Risk management
4. Legislative compliance & Jurisdiction
5. Auditing and logging
6. Loss of control over data, data protection, international data transfer (specially sensitive data).
7. Dependence on the Cloud Computing provider & Vendor dependent risks.
8. Fair information practices

Hölbl, Marko. "Cloud Computing Security and Privacy Issues."
The Council of European Professional Information Societies (CEPIS) (2011).

10 Obstacles and Opportunities

1. Availability of Service
2. Data Lock-In
3. Data Confidentiality and Auditability
4. Data Transfer Bottlenecks
5. Performance Unpredictability
6. Scalable Storage
7. Bugs in Large-Scale Distributed Systems
8. Scaling Quickly
9. Reputation Fate Sharing
10. Software Licensing

Mell, Peter, and Tim Grance. "The NIST definition of cloud computing." *National Institute of Standards and Technology* 53.6 (2009): 50.

Availability of a Service

- Successful concept "no single source of failure", but single company is in fact a single point of failure.
- What if the company may even go out of business?
  - Then Multiple datacenters in different regions does not work.
- Thus, Cloud vendor must fulfill a business-continuity strategy agreements.
- A **distributed denial-of-service** (**DDoS**) attack is one in which a multitude of compromised systems attack a single target, thereby causing **denial of service** for users of the targeted system.

Mell, Peter, and Tim Grance. "The NIST definition of cloud computing." *National Institute of Standards and Technology* 53.6 (2009): 50.

Data Lock-In

- Customers cannot easily extract their data and programs from one site to run on another. Concern about the difficult of extracting data from the cloud is preventing some organizations from adopting Cloud Computing.
- Suppose an online storage service is shut down user will loss access to its data.
- Solution: Standardize the APIs so that a SaaS developer could deploy services and data across. Put the data on multiple cloud providers so that the failure of a single company would not take all copies of customer data.
- The solution will result in "reduction in cloud pricing and flatten the profits". But still the quality of a service matters as well as the price.
- Standard API will result in usage of same software in a Private Cloud and Public Cloud.

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Data Confidentiality and Audit

- Organization sensitive data are rarely in cloud.
- Need of proper encrypted storage, Virtual Local Area Networks, and network middleboxes (e.g. firewalls, packet filters).
- Encrypt data before placing it in a Cloud may be even more secure than unencrypted data in a local data center.
- Auditability could be added as an additional layer.
- Many nations have laws requiring SaaS providers to keep customer data and copyrighted material within national boundaries.
- Some businesses may not like the ability of a country to get access to their data.
- European customer might be concerned about using SaaS in the United States.
- Flexibility to place the storage. Like Amazon allowing providers to keep data in whichever they choose physically in United States and Europe,.

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Data Transfer Bottlenecks

For data-intensive application, data placement and transport across the boundaries of clouds, may be complicate.

Data transfer costs is an important issue

- Overcome the high cost of Internet transfers is to ship disks.
  - Assume that we want to ship 10 TB from X to Y. Suppose measured bandwidth average found to be 20 Mbit/sec.

  It would take

  10 * 10^12 Bytes /(20 × 10^6 bits/second)

  = (8 × 10^13) /(2 × 10^7) seconds = 4,000,000 seconds,

  = 45 plus days.

  Very high network transfer fees for this data.

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Data Transfer Bottlenecks cont..

Put data in cloud, provide services that needs to purchase of Cloud Computing cycles. Thus reduce bottlenecks, For example

1. **Host large public datasets** (like Census data, images etc) for free, these datasets may "attract" customers to purchase cloud computing cycles.
2. **For backup services.** Companies have more data to send than as compared they receive, in weekend they can move full backups by shipping physical disks.
3. **For archived data** is in the cloud, service could result in selling Cloud Computing cycles, like creating search index of archival data or performing image recognition on archived photos.

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Performance Unpredictability

- Sharing of CPUs and memory through VM can be done easily, but when we need to share I/O efficiently, then it is not easy.
- Scope of improvement in interrupts and I/O management in Cloud Computing. Using flash (semiconductor memory) is a possible solution.
- Scope of improvement in batch processing deployment at VMs.
- Scope of implementation of a visual Cloud process monitor, that can show the running threads of a program concurrently.

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Scalable Storage

- How to apply "*short-term usage, no up-front cost, and infinite capacity on-demand*" to Persistent storage.

1. Varying in the richness of the query and storage API's
2. Performance guarantees
3. Complexity of data structures that are directly supported by the storage system (e.g., schema-less blobs vs. column-oriented storage).
4. Create a storage system would not only meet these needs but combine them with the cloud advantages of scaling arbitrarily up and down on-demand, as well as meeting programmer expectations in regard to resource management for scalability, data durability, and high availability.

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Bugs in Large-Scale Distributed Systems

- Difficult challenges in Cloud Computing is removing errors in these very large scale distributed systems.
- These bugs are not easily be reproduced in smaller configurations. Thus most of time debugging occur at datacenters.

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Scaling Quickly

- Pay-as-you-go certainly applies to CPU, storage and network bandwidth. Scales in response to load increases or decreases without violating service level agreements.
- For example
  - Google AppEngine: users are charged by the cycles.
  - AWS user are charges by the hour for the number of instances.
- Reason for scaling is to conserve resources as well as money. Idle computer uses about two-thirds of the power of a busy computer. Thus, optimize idle computers can reduce datacenters cost.
- Programmers need to pay attention to efficiency per cycle.
- Sometime it is better to leave machines idle overnight to avoid reconfiguring the work next day.

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Reputation Fate Sharing

- Bad behavior of a customer's can affect the reputation of the cloud.
- Create reputation-guarding services similar to the "trusted email" services.
- Company sending the spam should be held liable, not the cloud vendor.

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Software Licensing

- Some Cloud providers are dependent on open source software because open source licensing model are more flexible than for commercial software.
- Licensing changes needed for open source or commercial software to remain popular with Cloud.
- Two companies may collaborate to offer pay-as-you-go software licensing on Cloud.

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Opportunities in Cloud

1, 2, 3 are technical obstacles to *adopt* Cloud Computing, 4, 5, 6, 7, 8 are technical obstacles to the *growth* of Cloud Computing after adoption and 9, 10 are *policy and business* obstacles to the *adoption* of Cloud Computing.

	Obstacle	Opportunity
1	Availability of Service	Use Multiple Cloud Providers to provide Business Continuity; Use Elasticity to Defend Against DDOS attacks
2	Data Lock-In	Standardize APIs; Make compatible software available to enable Surge Computing
3	Data Confidentiality and Auditability	Deploy Encryption, VLANs, and Firewalls; Accommodate National Laws via Geographical Data Storage
4	Data Transfer Bottlenecks	FedExing Disks; Data Backup/Archival; Lower WAN Router Costs; Higher Bandwidth LAN Switches
5	Performance Unpredictability	Improved Virtual Machine Support; Flash Memory; Gang Scheduling VMs for HPC apps
6	Scalable Storage	Invent Scalable Store
7	Bugs in Large-Scale Distributed Systems	Invent Debugger that relies on Distributed VMs
8	Scaling Quickly	Invent Auto-Scaler that relies on Machine Learning; Snapshots to encourage Cloud Computing Conservationism
9	Reputation Fate Sharing	Offer reputation-guarding services like those for email
10	Software Licensing	Pay-for-use licenses; Bulk use sales

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Conclusion

- We had seen how other technology had contributed in the evolution of cloud computing technology.
- We had seen strength of hardware's & impact of new type of distributed software infrastructure's.
- We can differentiate clouds main in private, public, hybrid and community.
- We explore some risk issues with security and privacy involved with cloud.
- We had seen various cloud services available in the public.
- We gone through introduction of applications layer.
- We had seen regulatory issues in cloud with their limitations.
- Finally, we discussed some obstacle as well as opportunity in those obstacles.

https://sites.google.com/site/animeshchaturvedi07/academic-teaching/cloudcomputing

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Note: All the links were accessed in this slide is in the duration of Jan 2015.

https://sites.google.com/site/animeshchaturvedi07/academic-teaching/cloudcomputing

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English

Merci

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Tamil

Tamil

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