

Cloud Computing - Overview

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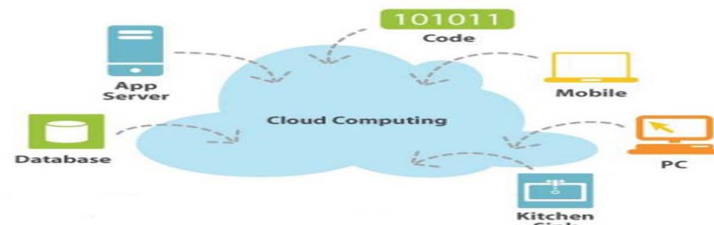
Cloud Computing

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Cloud Computing

US National Institute of Standards and Technology (NIST) defines Computing as:

“ Cloud computing is a model for enabling ubiquitous, 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. ”



<http://www.smallbiztechnology.com/archive/2011/09/wait-what-is-cloud-computing.html>

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Essential Characteristics

- **On-demand self-service**
 - A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.
- **Broad network access**
 - Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations).
- **Resource pooling**
 - The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand.

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Cloud Characteristics

- **Measured Service**
 - Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be
 - monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service.
- **Rapid elasticity**
 - Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time.

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Common Characteristics

- Massive Scale
- Resilient Computing
- Homogeneity
- Geographic Distribution
- Virtualization
- Service Orientation
- Low Cost Software
- Advanced Security

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“History” of Cloud Computing

Timeline

- Cloud computing: evolved through number of phases
 - Grid & Utility computing
 - Application Service Provision (ASP)
 - Software-as-a-Service (SaaS)
- Delivering computing resources as service through global network: concept first introduced in 1960s
- **1960: John McCarthy** opined that “computation may someday be organized as a public utility”
- **1966: Douglas Parkhill’s** book, “The Challenge of the Computer Utility” explained all the modern-day characteristics of cloud computing
- **1969: J.C.R. Licklider** developed ARPANET (Advanced Research Projects Agency Network)
 - ARPANET vision: everyone on the globe to be interconnected and accessing programs and data at any site, from anywhere

Timeline Contd...

- **1970:** ARPANET transformed itself into Internet
- **1990:** Internet age started offering significant bandwidth
- **1991:** CERN released Internet for general use
- **1993-94:** Browsers such as **Mosaic** & **Netscape** launched
- **1995:** Foundation of **eBay** & **Amazon.com**
- **1997:** “Cloud Computing” term coined
 - **Ramnath Chellappa** defined it as a new “computing paradigm where the boundaries of computing will be determined by economic rationale rather than technical limits alone.”
- **1999:** **Salesforce.com** launched as a company specializing in software as a service (SaaS)

Timeline

Contd...

- **2000:** **Dot com** bubble bursts
 - Amazon played a key role in the development of cloud computing by modernizing their data centers.
 - Initiation of a new product development effort to provide cloud computing to external customers.
- **2002:** Development of **Amazon Web Services (AWS)**
 - Provides a suite of cloud-based services including storage, computation and even human intelligence through the *Amazon Mechanical Turk*.
- **2006:** Amazon launched its *Elastic Compute cloud (EC2)* and *Simple Storage Service (S3)* as a commercial web service that allows small companies and individuals to rent computers on which to run their own computer applications.
- **2006:** **GoogleDocs** launched

Timeline Contd...

- **2007: Salesforce** launches *Force.com*, a web productivity tool. *Force.com* is a cloud computing platform as a service system from Salesforce.com.
 - Industry-wide collaboration between Google, IBM and a number of universities across the United States
- **2008: Eucalyptus** became the first open-source, AWS API-compatible platform for deploying private clouds.
- **2008: OpenNebula** (sponsored by C12G) became the first open-source software for deploying private and hybrid clouds.
 - C12G Labs is an enterprise software company which provides OpenNebula-based software and services. C12G (numeronym for Cloud Computing) was founded in April 2010.
- **2009: Web 2.0** hit its stride, and **Google** and others started to offer browser-based enterprise applications, though services such as **Google Apps**.

Timeline Contd...

- **2007-2010:** Launch of Apple's iPhone, HTC's first Android phone, Android-Apps, Samsung's Smartphone
 - Enterprise market saw huge transformation that scripted a completely different IT market story driven totally by consumers.
 - Cloud services got much needed boost with the launch of i-services for iPhone and iPad costumers.
 - Marks the golden era of cloud computing and services based upon "as a service" delivery-model.
- **2011:** Several start-ups were founded that leveraged the cloud services
- ...

Cloud Services Models

- **Software as a Service (SaaS)**

- The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based email), or a program interface.
- The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.
- e.g: *Google Spread Sheet*

- **Cloud Infrastructure as a Service (IaaS)**

- The capability provided to provision processing, storage, networks, and other fundamental computing resources
- Consumer can deploy and run arbitrary software
- e.g: *Amazon Web Services and Flexi scale.*

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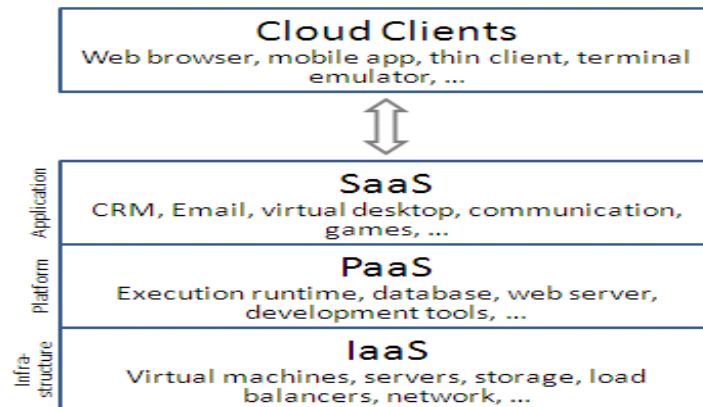
Cloud Services Models

Platform as a Service (PaaS)

- The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider.
- The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.

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Cloud Services Models



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Types of Cloud (Deployment Models)

- **Private cloud**
The cloud infrastructure is operated solely for an organization.
e.g Window Server 'Hyper-V'.
- **Community cloud**
The cloud infrastructure is shared by several organizations and supports a specific goal.
- **Public cloud**
The cloud infrastructure is made available to the general public
e.g Google Doc, Spreadsheet,
- **Hybrid cloud**
The cloud infrastructure is a composition of two or more clouds (private, community, or public)
e.g Cloud Bursting for load balancing between clouds.

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Cloud and Virtualization

- **Virtual Workspaces:**
 - An abstraction of an execution environment that can be made dynamically available to authorized clients by using well-defined protocols,
 - Resource quota (e.g. CPU, memory share),
 - Software configuration (e.g. OS).
- **Implement on Virtual Machines (VMs):**
 - Abstraction of a physical host machine,
 - Hypervisor intercepts and emulates instructions from VMs, and allows management of VMs,
 - VMWare, Xen, KVM etc.
- **Provide infrastructure API:**
 - Plug-ins to hardware/support structures

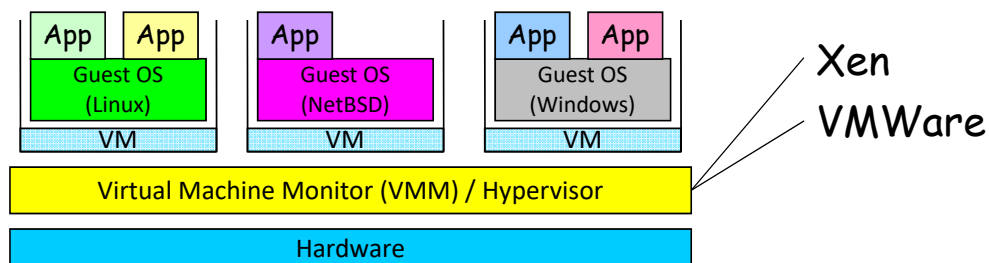


Virtualized Stack

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Virtual Machines

- VM technology allows multiple virtual machines to run on a single physical machine.



- Performance: Para-virtualization (e.g. Xen) is very close to raw physical performance!

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Virtualization in General

- ***Advantages of virtual machines:***

- Run operating systems where the physical hardware is unavailable,
- Easier to create new machines, backup machines, etc.,
- Software testing using “clean” installs of operating systems and software,
- Emulate more machines than are physically available,
- Timeshare lightly loaded systems on one host,
- Debug problems (suspend and resume the problem machine),
- Easy migration of virtual machines (shutdown needed or not).
- Run legacy systems

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Cloud-Sourcing

- **Why is it becoming important ?**

- Using high-scale/low-cost providers,
- Any time/place access via web browser,
- Rapid scalability; incremental cost and load sharing,
- Can forget need to focus on local IT.

- **Concerns:**

- Performance, reliability, and SLAs,
- Control of data, and service parameters,
- Application features and choices,
- Interaction between Cloud providers,
- No standard API – mix of SOAP and REST!
- Privacy, security, compliance, trust...

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Cloud Storage

- Several large Web companies are now exploiting the fact that they have data storage capacity that can be hired out to others.
 - Allows data stored remotely to be temporarily cached on desktop computers, mobile phones or other Internet-linked devices.
- Amazon's Elastic Compute Cloud (EC2) and Simple Storage Solution (S3) are well known examples

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Advantages of Cloud Computing

- **Lower computer costs:**
 - You do not need a high-powered and high-priced computer to run cloud computing's web-based applications.
 - Since applications run in the cloud, not on the desktop PC, your desktop PC does not need the processing power or hard disk space demanded by traditional desktop software.
 - When you are using web-based applications, your PC can be less expensive, with a smaller hard disk, less memory, more efficient processor...
 - In fact, your PC in this scenario does not even need a CD or DVD drive, as no software programs have to be loaded and no document files need to be saved.

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Advantages of Cloud Computing

- **Improved performance:**
 - With few large programs hogging your computer's memory, you will see better performance from your PC.
 - Computers in a cloud computing system boot and run faster because they have fewer programs and processes loaded into memory.
- **Reduced software costs:**
 - Instead of purchasing expensive software applications, you can get most of what you need for free.
 - most cloud computing applications today, such as the Google Docs suite.
 - better than paying for similar commercial software
 - which alone may be justification for switching to cloud applications.

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Advantages of Cloud Computing

- **Instant software updates**
 - Another advantage to cloud computing is that you are no longer faced with choosing between obsolete software and high upgrade costs.
 - When the application is web-based, updates happen automatically available the next time you log into the cloud.
 - When you access a web-based application, you get the latest version without needing to pay for or download an upgrade.
- **Improved document format compatibility.**
 - You do not have to worry about the documents you create on your machine being compatible with other users' applications or OS.
 - There are less format incompatibilities when everyone is sharing documents and applications in the cloud.

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Advantages of Cloud Computing

- **Unlimited storage capacity**
 - Cloud computing offers virtually limitless storage.
 - Your computer's current 1 Tera Bytes hard drive is small compared to the hundreds of Peta Bytes available in the cloud.
- **Increased data reliability**
 - Unlike desktop computing, in which if a hard disk crashes and destroy all your valuable data, a computer crashing in the cloud should not affect the storage of your data.
 - if your personal computer crashes, all your data is still out there in the cloud, still accessible
 - In a world where few individual desktop PC users back up their data on a regular basis, cloud computing is a data-safe computing platform. For e.g. Dropbox, Skydrive

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Advantages of Cloud Computing

- **Universal information access**
 - That is not a problem with cloud computing, because you do not take your documents with you.
 - Instead, they stay in the cloud, and you can access them whenever you have a computer and an Internet connection
 - Documents are instantly available from wherever you are.
- **Latest version availability**
 - When you edit a document at home, that edited version is what you see when you access the document at work.
 - The cloud always hosts the latest version of your documents as long as you are connected, you are not in danger of having an outdated version.

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Advantages of Cloud Computing

- **Easier group collaboration**
 - Sharing documents leads directly to better collaboration.
 - Many users do this as it is an important advantages of cloud computing
multiple users can collaborate easily on documents and projects
- **Device independence**
 - You are no longer tethered to a single computer or network.
 - Changes to computers, applications and documents follow you through the cloud.
 - Move to a portable device, and your applications and documents are still available.

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Disadvantages of Cloud Computing

- **Requires a constant internet connection**
 - Cloud computing is impossible if you cannot connect to the Internet.
 - Since you use the Internet to connect to both your applications and documents, if you do not have an Internet connection you cannot access anything, even your own documents.
 - A dead Internet connection means no work and in areas where Internet connections are few or inherently unreliable, this could be a deal-breaker.
- **Does not work well with low-speed connections**
 - Similarly, a low-speed Internet connection, such as that found with dial-up services, makes cloud computing painful at best and often impossible.
 - Web-based applications require a lot of bandwidth to download, as do large documents.

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Disadvantages of Cloud Computing

- **Features might be limited**
 - This situation is bound to change, but today many web-based applications simply are not as full-featured as their desktop-based applications.
 - For example, you can do a lot more with Microsoft PowerPoint than with Google Presentation's web-based offering
- **Can be slow**
 - Even with a fast connection, web-based applications can sometimes be slower than accessing a similar software program on your desktop PC.
 - Everything about the program, from the interface to the current document, has to be sent back and forth from your computer to the computers in the cloud.
 - If the cloud servers happen to be backed up at that moment, or if the Internet is having a slow day, you would not get the instantaneous access you might expect from desktop applications.

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Disadvantages of Cloud Computing

- **Stored data might not be secured**
 - With cloud computing, all your data is stored on the cloud.
 - The questions is How secure is the cloud?
 - Can unauthorized users gain access to your confidential data ?
- **Stored data can be lost!**
 - Theoretically, data stored in the cloud is safe, replicated across multiple machines.
 - But on the off chance that your data goes missing, you have no physical or local backup.
 - Put simply, relying on the cloud puts you at risk if the cloud lets you down.

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Disadvantages of Cloud Computing

- **HPC Systems**
 - Not clear that you can run compute-intensive HPC applications that use MPI/OpenMP!
 - Scheduling is important with this type of application
 - as you want all the VM to be co-located to minimize communication latency!
- **General Concerns**
 - Each cloud systems uses different protocols and different APIs
 - may not be possible to run applications between cloud based systems
 - Amazon has created its own DB system (not SQL 92), and workflow system (many popular workflow systems out there)
 - so your normal applications will have to be adapted to execute on these platforms.

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Evolution of Cloud Computing

Business drivers for adopting cloud computing

Reasons

- The main reason for interest in cloud computing is due to the fact that public clouds can significantly reduce IT costs.
- From an end user perspective cloud computing gives the illusion of potentially infinite capacity with ability to scale rapidly and pay only for the consumed resource.
- In contrast, provisioning for peak capacity is a necessity within private data centers, leading to a low average utilization of 5-20 percent.

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IaaS Economics

	In house server	Cloud server
Purchase Cost	\$9600 (x86,3QuadCore,12GB RAM, 300GB HD)	0
Cost/hr (over 3 years)	\$0.36	\$0.68
Cost ratio: Cloud/In house	1.88	
Efficiency	40%	80%
Cost/Effective hr	\$0.90	\$0.85
Power and cooling	\$0.36	0
Management Cost	\$0.10	\$0.01
Total cost/effective hr	\$1.36	\$0.86
Cost ratio: In house/Cloud	1.58	

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Benefits for the end user while using public cloud

- High utilization
- High scalability
- No separate hardware procurement
- No separate power cost
- No separate IT infrastructure administration/maintenance required
- Public clouds offer user friendly SLA by offering high availability (~99%) and also provide compensation in case of SLA miss.
- Users can rent the cloud to develop and test prototypes before making major investments in technology

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Benefits for the end user while using public cloud

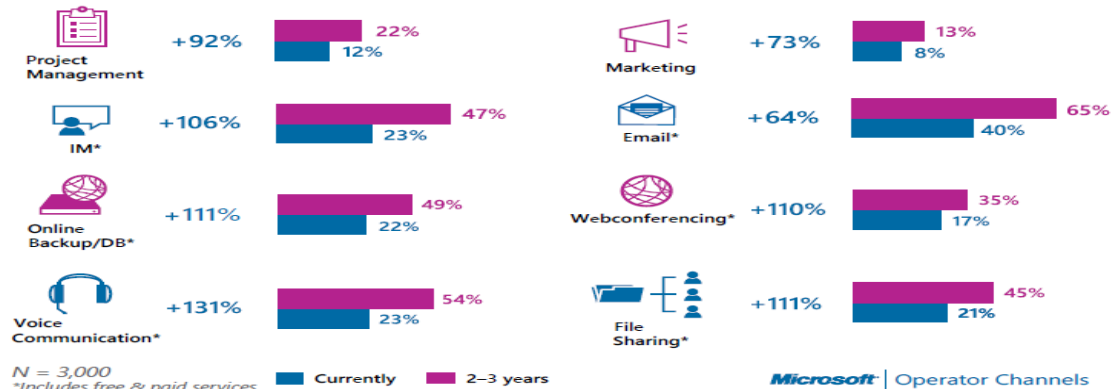
- In order to enhance portability from one public cloud to another, several organizations such as Cloud Computing Interoperability Forum and Open Cloud Consortium are coming up with standards for portability.
- For e.g. Amazon EC2 and Eucalyptus share the same API interface.
- Software startups benefit tremendously by renting computing and storage infrastructure on the cloud instead of buying them as they are uncertain about their own future.

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Benefits for Small and Medium Businesses (<250 employees)

SMBs & Cloud Services

Tasks in cloud services currently and in 2–3 years



Source: <http://www.microsoft.com/en-us/news/presskits/telecom/docs/SMBCloud.pdf>

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Benefits of private cloud

- Cost of 1 server with 12 cores and 12 GB RAM is far lower than the cost of 12 servers having 1 core and 1 GB RAM.
- Confidentiality of data is preserved
- Virtual machines are cheaper than actual machines
- Virtual machines are faster to provision than actual machines

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Economics of PaaS vs IaaS

- Consider a web application that needs to be available 24X7, but where the transaction volume is unpredictable and can vary rapidly
- Using an IaaS cloud, a minimal number of servers would need to be provisioned at all times to ensure availability
- In contrast, merely deploying the application on PaaS cloud costs nothing. Depending upon the usage, costs are incurred.
- The PaaS cloud scales automatically to successfully handle increased requests to the web application.

Source: Enterprise Cloud Computing by Gautam Shroff

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PaaS benefits

- No need for the user to handle scaling and load balancing of requests among virtual machines
- PaaS clouds also provide web based Integrated Development Environment for development and deployment of application on the PaaS cloud.
- Easier to migrate code from development environment to the actual production environment.
- Hence developers can directly write applications on the cloud and don't have to buy separate licenses of IDE.

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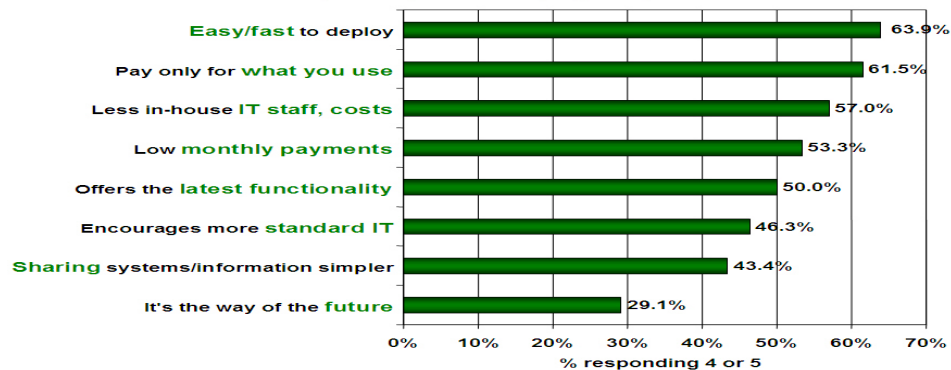
SaaS benefits

- Users subscribe to web services and web applications instead of buying and licensing software instances.
- For e.g. Google Docs can be used for free, instead of buying document reading softwares such as Microsoft Word.
- Enterprises can use web based SaaS Content Relationship Management applications, instead of buying servers and installing CRM softwares and associated databases on them.

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Benefits, as perceived by the IT industry

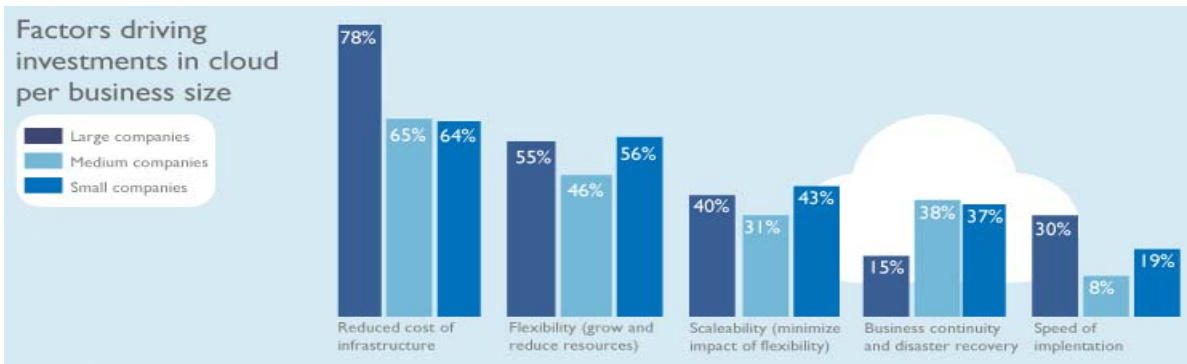
Q: Rate the **benefits commonly ascribed to the 'cloud'/on-demand model**
(1=not important, 5=very important)



Source: IDC Enterprise Panel, August 2008 n=244

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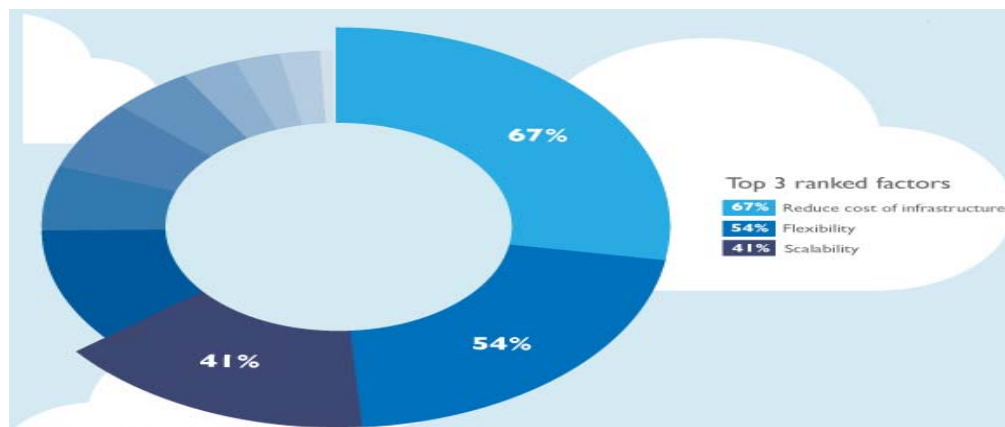
Factors driving investment in cloud



Source: <http://www.cloudtweaks.com/2012/01/infographic-whats-driving-investment-in-cloud-computing/>

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Source: <http://www.cloudtweaks.com/2012/01/infographic-whats-driving-investment-in-cloud-computing/>

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Purpose of cloud computing in organizations

- Providing an IT platform for business processes involving multiple organizations
- Backing up data
- Running CRM, ERP, or supply chain management applications
- Providing personal productivity and collaboration tools to employees
- Developing and testing software
- Storing and archiving large files (e.g., video or audio)
- Analyzing customer or operations data
- Running e-business or e-government web sites

Source: <http://askvisory.com/research/key-drivers-of-cloud-computing-activity/>

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Purpose of cloud computing in organizations

- Analyzing data for research and development
- Meeting spikes in demand on our web site or internal systems
- Processing and storing applications or other forms
- Running data-intensive batch applications (e.g., data conversion, risk modeling, graphics rendering)
- Sharing information with the government or regulators
- Providing consumer entertainment, information and communication (e.g., music, video, photos, social networks)

Source: <http://askvisory.com/research/key-drivers-of-cloud-computing-activity/>

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Top cloud applications that are driving cloud adaptation

- Mail and Messaging
- Archiving
- Backup
- Storage
- Security
- Virtual Servers
- CRM (Customer Relationship Management)
- Collaboration across enterprises
- Hosted PBX (Private Branch Exchange)
- Video Conferencing

Source: <http://www.itnewsafrika.com/2012/09/ten-drivers-of-cloud-computing-for-south-african-businesses/>

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Thank You!

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