IaaS* and PaaS** in cloud computing

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Khưu Minh Cảnh**

HCMC, April, 2012

Content

- PART A. Essential on Cloud
  - When and why cloud
  - Examples and general info
- PART B. IaaS
  - Intro, Elements, Characteristics
  - The View, Caution, Points to consider
- PART C. PaaS
  - Defs, Point of view, FAQ, Top Ten of Paas World
  - Great story: “THE BIG GAME with THEORY”*

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Why Cloud me?

- Problems:
  - Data intensive. The size of data (eg. GIS) files tends to be large. A single file can be hundreds of MB or more.
  - Computation intensive. Analysies, such as market/spatial/network analysis may take an extensive amount of time.
  - Softwares are mostly expensive. Individual users and small organizations can not afford commercial softwares.

Cloud Computing

- A new trend in information technology, moving software from personal computers to the Internet

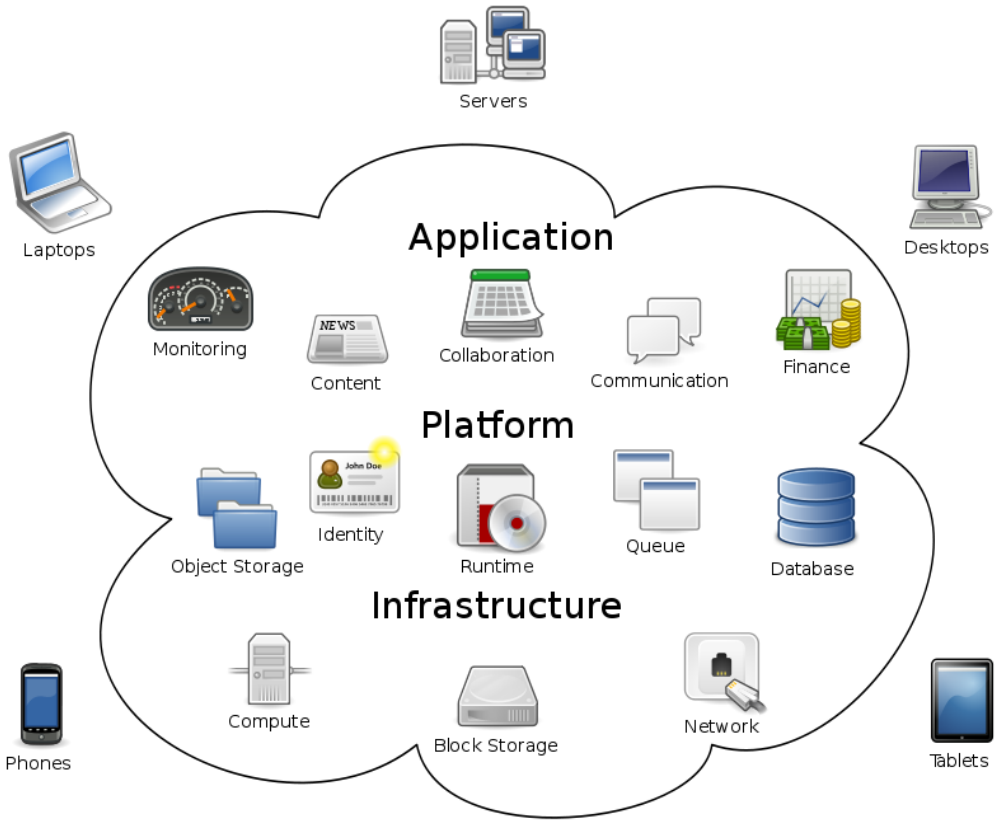
- Put data and software, which are used to be on personal computers, to a giant centralized computer system. This form is called cloud computing. The centralized system is called a cloud system.

- You rent cloud services, such as photo editing, managing and sharing, from them, the same way as you rent textbooks from bookstores

- Cloud services is the use of computer resources in cloud systems

- A cloud system is like a giant centralized computer. It comprises three kinds of resources:
  - Software (Application)
  - Platform
  - Infrastructure

Details in IaaS & PaaS



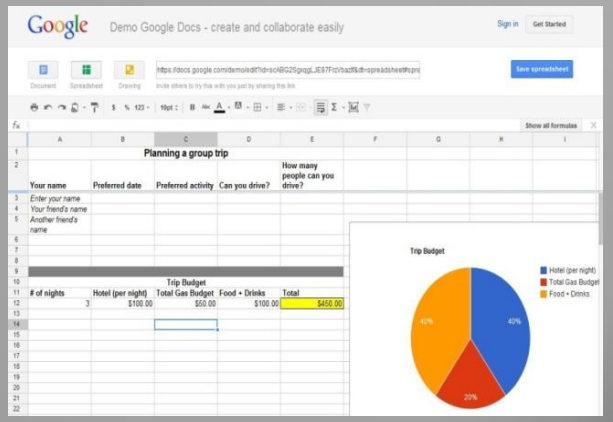
Cloud Computing

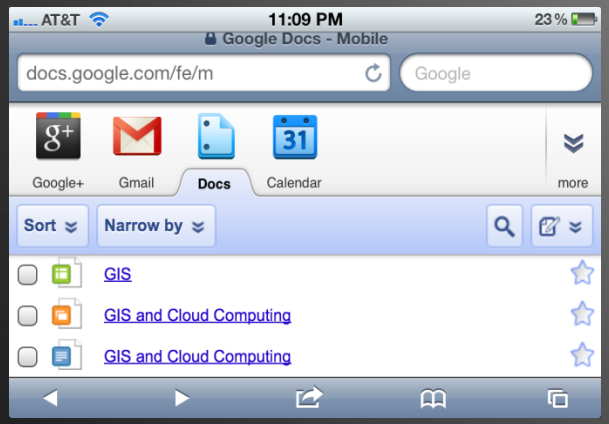
http://en.wikipedia.org/wiki/File:Cloud_computing.svg

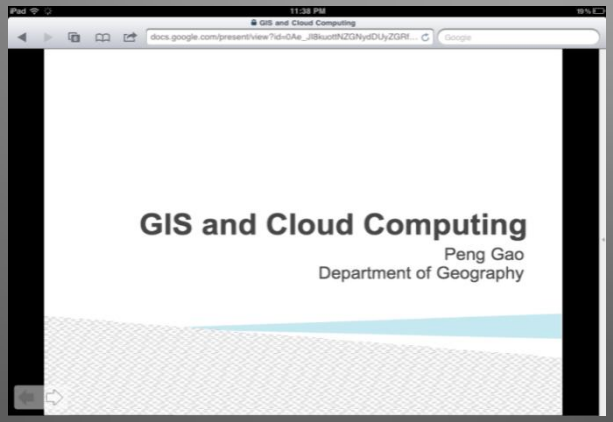
- Popular cloud systems include: Flickr, Google Docs and Amazon Cloud Drive. They perform the functions that were traditionally done with software installed on personal computers.

Google Docs

- A cloud based online Office
- Allow you to create, edit and share documents online using web browsers, iPads or even smart phones.







https://docs.google.com/demo/edit?id=scAAVln2yf3it2VCiVf-DUzGg&dt=document#document

History of Cloud Computing

- The concept of cloud computing dates back to 1961, when Prof. John MacCarthy predicted that “computation may someday be organized as a public utility.”

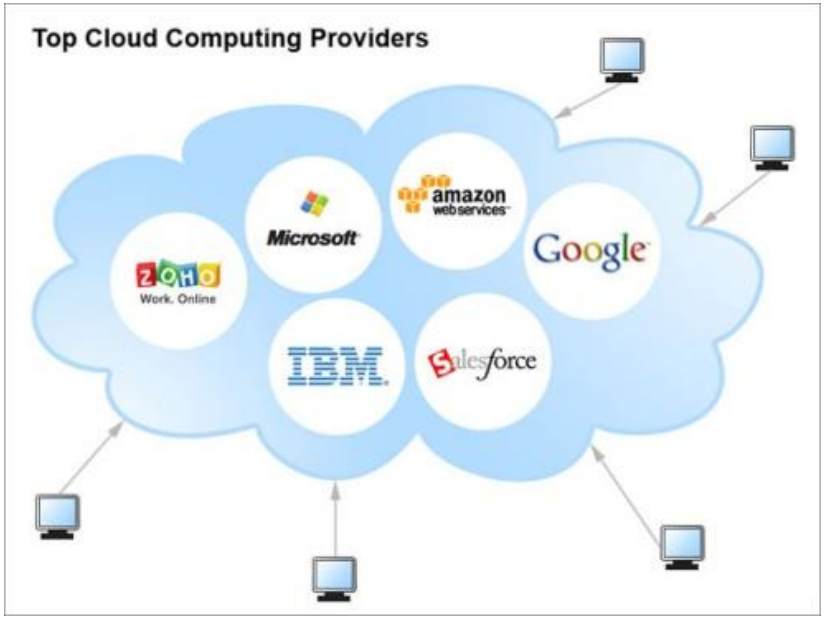
  http://www.complush.com/internet-network-connection/

- In 1991, Salesforce.com, one of the first movers in cloud computing, introduced the concept of delivering enterprise applications via a simple website

- In 2002, Amazon Web Service was launched
- Google brought cloud computing to the forefront of public consciousness by introducing Google Docs in 2006

  http://www.cloudtweaks.com/2011/02/a-history-of-cloud-computing/

- In the following years, IBM, Microsoft, Oracle and a host of companies joined cloud computing



http://eatenbylinux.files.wordpress.com/2011/05/cloud-computing-providers.jpg

Cloud Computing Models

- Software as a Service (SaaS)
- Platform as a Service (PaaS)
- Infrastructure as a Service (IaaS)

- Software as a Service (SaS)
  - As long as Internet access is available, users can connect to the cloud service providers and use the software available on their servers, instead of installing and running the software on your own computers.
  - Examples: Flickr, Google Docs, Siri, Amazon Cloud Drive…

- Platform as a Service (PaaS)
  - PaaS provides application developers with a developing environment, with which they can develop and host cloud applications.
  - PaaS includes software and hardware to build and sustain cloud applications so that developers can build and host applications without worrying about the costs and complexity of buying and maintaining software and hardware.
  - Examples: Google App Engine, Amazon Web Services

- Infrastructure as a Service (IaaS)
  - Cloud services offer clients with storage space, networking equipment and other computing resources. Clients are billed for the amount of resources they consumed.
  - Developers and IT organizations do not need to purchase expensive computers and equipment, but buy computer infrastructure like utilities from cloud service providers (“pay as you go”).
  - Example: Amazon Elastic Compute Cloud (EC2)

Characteristics of Cloud Computing

- Multi-tenancy
  - Resources in cloud systems can be shared among a large number of users.
  - Improve the efficiency of cloud systems and save cost for cloud service providers.

- Scalability
  - Even when the total work load for a cloud system increases dramatically, the system could improve its capacity by adding more hardware to handle the increased load effectively

- Elasticity
  - A cloud system only delivers the minimum amount of computing resources that meet users' need. The amount of resources provided to users increase when they need more, and decrease when they need less. Users only pay for whatever they consumed.

- Device independent
  - Users can utilize cloud services using whatever device they have, should it be a laptop, an iPad or a smartphone, as long as they have access to the Internet.

- Low-cost
  - Computing resources are provided by cloud systems. Users do not need to purchase expensive computers to perform tasks that need high performance computing.
  - If you do not want to keep a book, why don't you rent the book from the UB bookstore or borrow one from the UB library? So you only spend a fraction of the cost of buying the book.

- Reliability
  - Multiple redundant sites are used in cloud systems. There are always backups available when one or more sites are down.

Issues in Cloud Computing

- Security and Privacy
  - Hackers and malicious insiders may hack into users' cloud accounts and access sensitive data stored in cloud systems
  - Companies hosting cloud services have full control on users' data. They may intentionally collect personal information, such as age, interest, and income. These information can be used for personalized ads.

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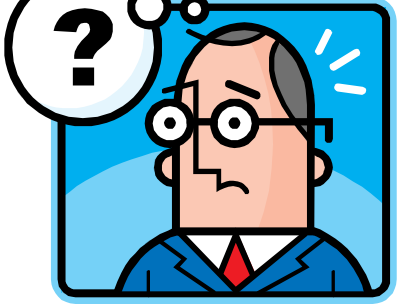
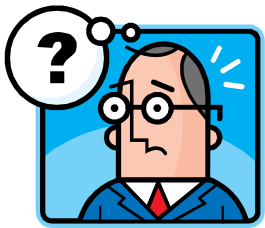
PART B: More on – IaaS



- 1. Introduction
- 2. Infrastructure as a Service operations
- 3. The main characteristics of IaaS
- 4. Logical view of IaaS cloud structure and operation
- 5. Wind of Caution
- 6. Points to consider

B.1. Introduction

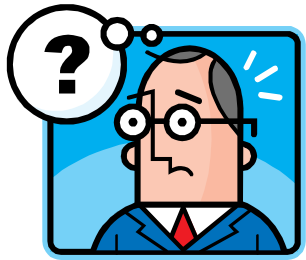
- Infrastructure as a Service is a provision model in which an organization outsources the equipment used to support operations, including storage, hardware, servers and networking components. The service provider owns the equipment and is responsible for housing, running and maintaining it. The client typically pays on a per-use basis.



B.2. Infrastructure as a Service operations

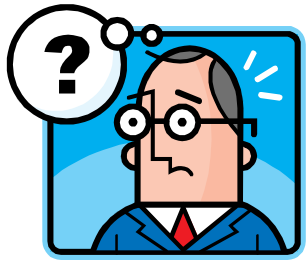
usually include:

- IaaS includes Service Level Agreements (optional)
- IaaS is payable by Utility computing
- IaaS is a Platform virtualization situation for operation of VMs
- IaaS has Computer hardware
- IaaS is usually a Computer network
- IaaS needs web connectivity



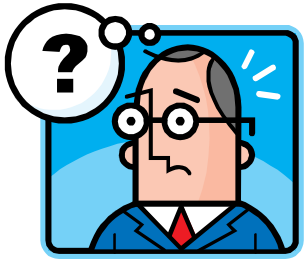
B.3. The main characteristics of IaaS

- IaaS resources are usually distributed as a service. Resources are usually distributed as a service including servers, network equipment, memory, CPU, disk space, etc.
- IaaS has Dynamic scaling
- IaaS has Variable costs
- IaaS usually has many Multiple leaseholders or tenants
- IaaS typically has enterprise grade infrastructure



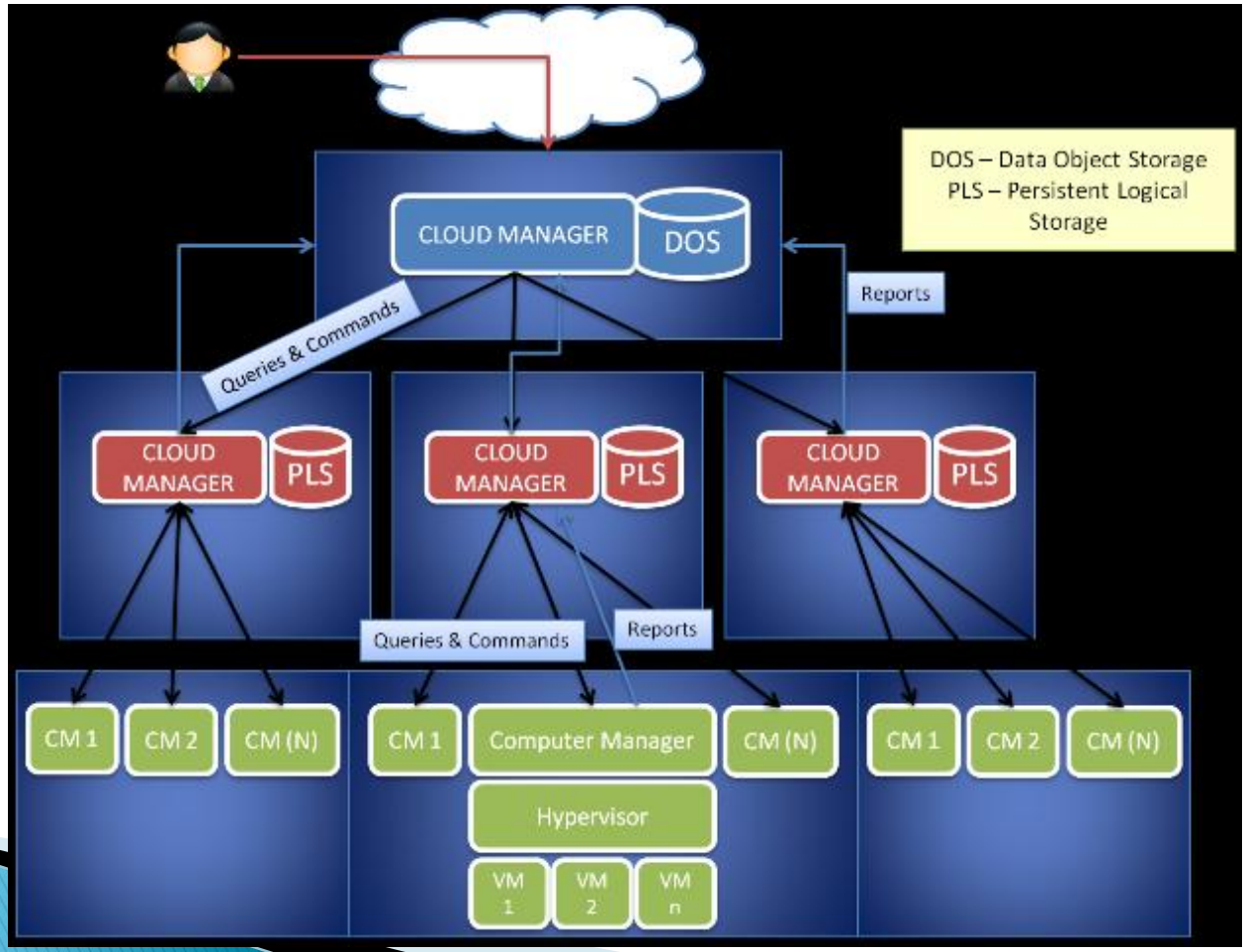
B.4. Logical view of IaaS cloud structure and operation

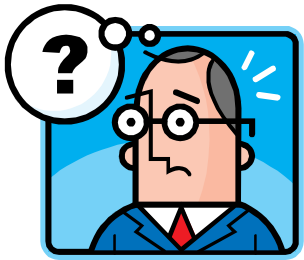
- Following diagram illustrates this layered and abstract model of typical IAAS architecture. A specific implementation may split up and parallelize some components for performance reasons, may introduce more intermediary layers for additional coordination, or may locate storage on networks different from the ones indicated in the model.



B.4. ..

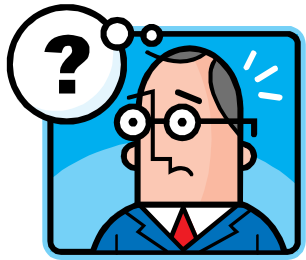
- IaaS clouds must provide with both performance and cost efficiency while maintaining centralized control and the capability to scale up without disrupting service





B.4. ..

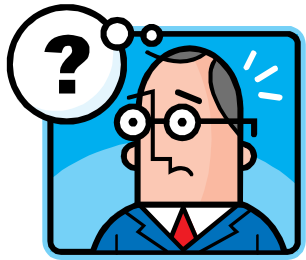
- *Cloud Manager* is the public access point to the cloud where subscribers sign up for accounts, manage the resources they rent from the cloud, and access data stored in the cloud. It also performs top-level resource allocation; determine if the cloud has enough free resources to satisfy the request, and which Cluster Manager (or Managers) have some or all the resources & coordinate the setup of virtual networking. The Cloud Manager will also enforce any cloud-global policies governing resource requests.
- *Cluster Manager* is responsible for the operation of a collection of computers that are connected via high speed local area networks. Cluster Manager receives resource allocation commands / queries from the Cloud Manager and queries/commands the Computer Managers for the computers in the cluster to determine resource availability and perform resource allocation.
- *Computer Manager* cooperates with the hypervisor that runs on each computer system in a cluster. In response to queries from its Cluster Manger, Computer Manager returns status information relating to used and available resources that could be utilized. Computer Manager uses the command interface of its hypervisor to start, stop, suspend, and reconfigure virtual machines, and to set the local virtual network configuration



B.5. Wind of Caution

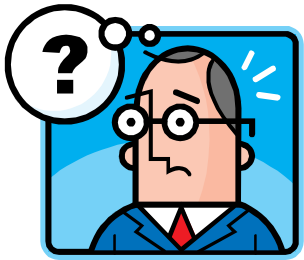
IaaS clouds depend on a secure and reliable network, and also often on a secure and reliable browser for account administration. Following concerns and cautions need to be kept in mind

- **Network Dependence** – Reliable network connectivity is key to peace of mind in cloud
- **Legacy Security Vulnerabilities** – IaaS clouds expose subscribers to all of the existing security vulnerabilities of those legacy software systems.
- **Out-of-Date Virtual Machine**–VMs could remain in various states, e.g. running, suspended, and off. An inactive VM can easily become out of date with respect to important security updates and may become compromised. Maintenance of security updates typically is a subscriber responsibility.
- **VM-level Isolation** – IaaS is a multi-tenant model and subscribers may share the physical servers with other consumers of the cloud. A robust VM-Level isolation is a must and relies on strong security model as well as right configuration.
- **Network-Level Isolation**



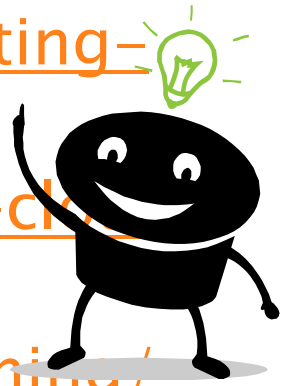
B.5. ..

- **Data Erase Practices** – Virtual machines access disk resources maintained by the provider. When a subscriber releases such a resource, the provider must ensure that the next subscriber to rent the resource does not observe data residue from previous tenants.
- **Secure Data Purge** – Cloud provider need to offer a mechanism for reliably deleting data on a subscriber's request that is auditable. Also keep in mind the backups once you switch the provider or your contract expires.
- **Vendor Lock-in** – Formulate a strategy for future migration of Virtual Machines and their associated storage among alternate cloud providers.
- **Performance, Latency**
- **Risk of Business Continuity**
- **Service Level Agreements**
- **Disaster Recovery Practices**
- **Audit & Compliance with Information Security Policies**
- **Jurisdiction and Regulation**



Iaas refs

- http://ritesh.samanpure.com/cloud-computing-models/
- http://searchcio.techtarget.in/tutorial/IaaS-cloud-computing-platform-guide-for-managers
- http://ritesh.samanpure.com/category/learning/



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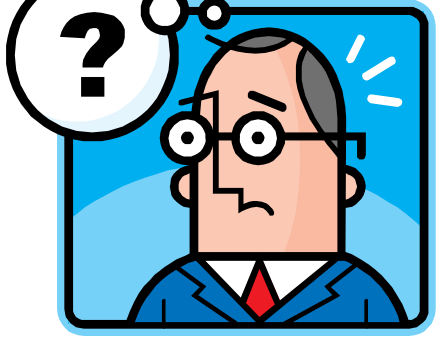
Part C. More on PaaS



- **1. Review on basic infos**

defines, points of view, flatform vs softs, identifications

- **2. PaaS Benefits**

developers, users

- **3. History and Development**

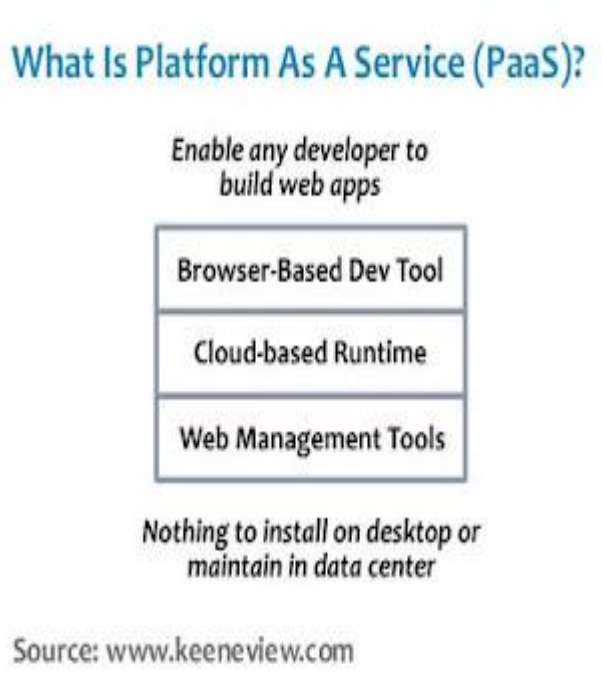
history, top ten companies

- **4. Why Saleforces?**

forces behind, Paas orientation, game theory

“P” in PaaS means “Platform” not “Process”

C.1. Review on basic infos



Definitions: KEENE

http://www.keeneview.com/2009/03/what-is-platform-as-service-paas.html

- PaaS solutions are development platforms for which the development tool itself is hosted in the cloud and accessed through a browser. With PaaS, developers can build web applications without installing any tools on their computer and then deploy those applications without any specialized systems administration skills.

McKinsey & Company, in their 2008 report "Emerging Platform Wars," defined Platform as a service as "cloud based IDEs that not only incorporate traditional programming languages but include tools for mashup-based development."

C.1. Review on basic infos

Definitions: SALESFORCE, IBM, …

http://www.salesforce.com/paas/

- for building and running custom applications, a concept known as "platform as a service" (or PaaS).
- PaaS applications are also referred to as on-demand, Web-based, or software as a service (or SaaS) solutions.

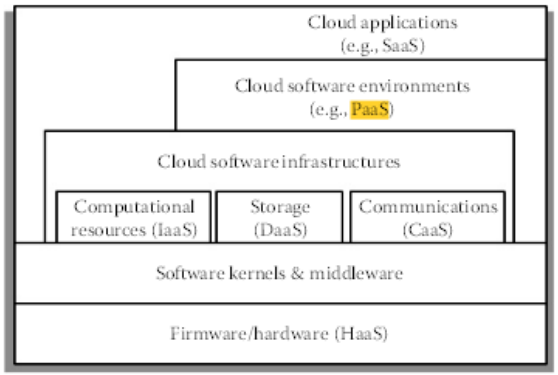


Figure 1.1 UCSB-IBM Cloud Computing Classification Model depicted as five layers, with three constituents to the cloud infrastructure layer.

http://searchcloudcomputing.techtarget.com/definition/Platform-as-a-Service-PaaS

DEFINITION

Platform as a Service (PaaS)

Platform as a Service (PaaS) is a way to rent hardware, operating systems, storage and network capacity over the Internet. The service delivery model allows the customer to rent virtualized servers and associated services for running existing applications or developing and testing new ones.

C.1. Review on basic infos

Definitions: WIKI

Platform as a service

From Wikipedia, the free encyclopedia

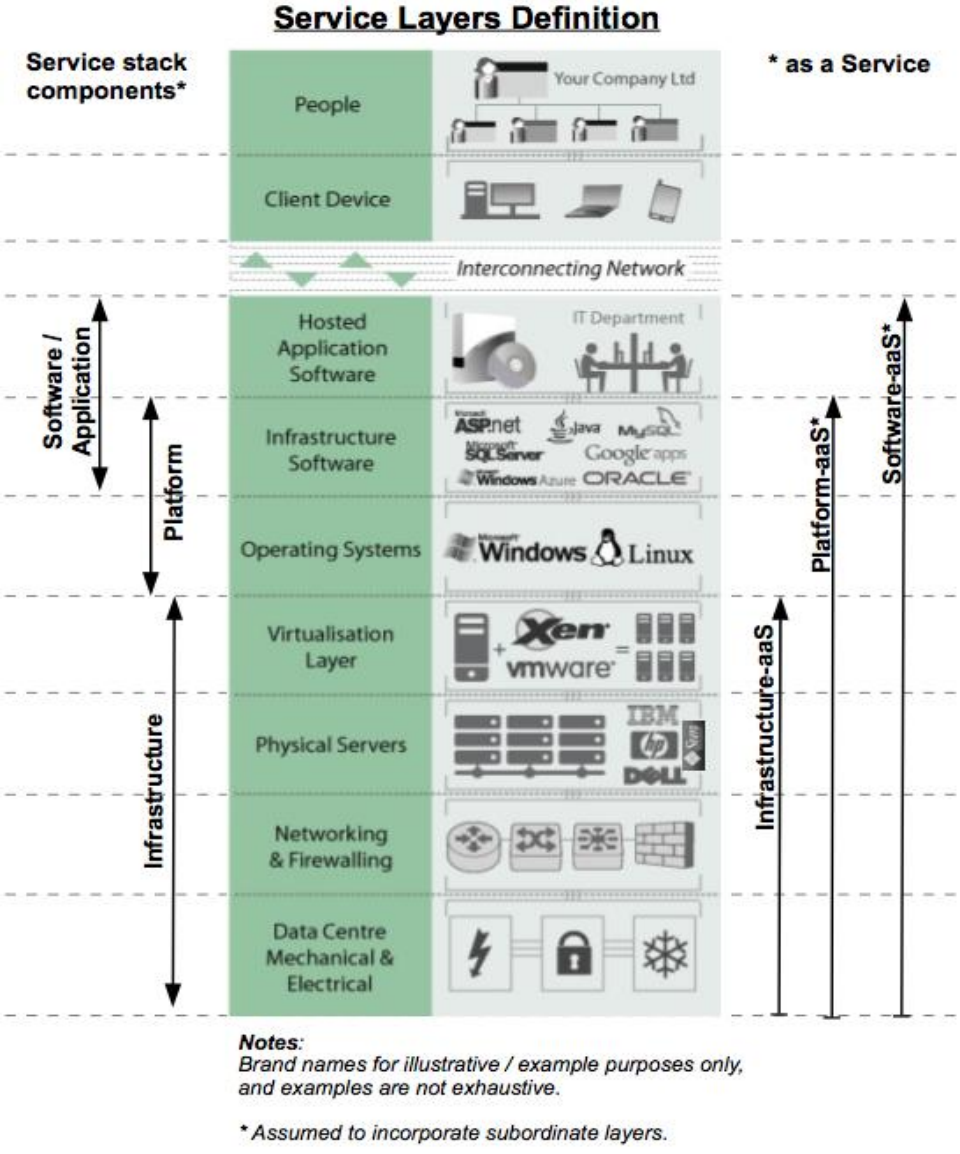
- **Platform as a service** (**PaaS**) is a category of cloud computing services that provide a computing platform and a solution stack as a service. In the classic layered model of cloud computing,[1] the PaaS layer lies between the SaaS and the IaaS layers.
- PaaS offerings facilitate the deployment of applications without the cost and complexity of buying and managing the underlying hardware and software and provisioning hosting capabilities,[2] providing all of the facilities required to support the complete life cycle of building and delivering web applications and services entirely available from the Internet.[3]
- Various types of PaaS vendor offerings could be extensive and will include a total application hosting, development, testing, and deployment environment, along with extensive integrated services that consist of scalability, maintenance, and versioning.[4]
- PaaS offerings may include facilities for application design, application development, testing, deployment and hosting as well as application services such as team collaboration, web service integration and marshalling, database integration, security, scalability, storage, persistence, state management, application versioning, application instrumentation and developer community facilitation. These services may be provisioned as an integrated solution over the web

C.1. Review on basic infos

http://www.katescomment.com/iaas-paas-saas-definition/

- …The key differentiator between ‘platform’ and ‘software’ is that a platform is standardised and to an extent commoditised, with the software being the bespoke / custom element. A *platform* would also often, but not always, be *highly scalable across multiple servers* …

- …PaaS software that can sit on top of an IaaS provider of your choice (to some extent)…
- …They each have their own merits and disadvantages…
- …an important difference between the old concept of “hardware” and ours of “infrastructure”: virtualisation…



C.1. Review on basic infos

(Theo Keene) PaaS platforms also have functional differences from traditional development platforms. These include:

- **Multi-tenant development tool**: traditional development tools are single user – a cloud-based studio must support multiple users, each with multiple active projects.
- **Multi-tenant deployment architecture**: scalability is often not a concern of the initial development effort and is left instead for the sys admins to deal with when the project deploys. In PaaS, scalability of the application and data tiers must be built-in (e.g., load balancing, failover need to be basic elements of the dev platform itself).
- **Integrated management**: traditional development solution usually do not concern themselves with runtime monitoring , but in PaaS, the monitoring ability needs to be baked into the development platform.
- **Integrated billing**: PaaS offerings require mechanisms for billing based on usage that are unique to the SaaS world.

http://...

C.1. Review on basic infos

(Theo Keene) **4 Ways To Tell If It's *Really* PaaS**

- **1. Browser-based development studio** – if you have to install something on your computer to develop applications, that's not PaaS!
- **2. Seamless deployment to hosted runtime environment** – ideally, a developer should be able to deploy a PaaS application with one click. If you have to talk to a person to get your app deployed, that's not PaaS!
- **3. Management and monitoring tools** – while cloud-based solutions are very cost effective, they can be tricky to manage and scale without good tools. If you have to bolt on DIY monitoring to scale your cloud app, that's not PaaS!
- **4. Pay as you go billing** – avoiding upfront costs has made PaaS popular. If you can't pay with your credit card based on usage, that's not PaaS!

C.1. Review on basic infos

(Theo Keene) **Expert developer with three, highly specialized skill sets**

- 1. Back end server development (e.g., Java/J2EE)
- 2. Front end client development (e.g., Javascript/Dojo)
- 3. Web site administration.

C.1. Review on basic infos

Different PaaS solutions available in the market are:

+ Social Application Development Platforms

Hot TOPICS →

+ Web Based Application Add-On Platforms (eg. Google provides API)

+ Open Computing Platforms

+ Stand Alone Business Application platforms

http://www.ibm.com/developerworks/opensource/library/os-eclipse-facebook/index.html

Develop a Facebook application with Eclipse Galileo

Create, debug, and deploy a restaurant search application

Suresh Krishna, Software Developer, Freelance Developer

Compare Packages

Check out this table to find out what is included in each package.

	Java	Java EE	C/C++	RCP/Plugin	Modeling	Reporting	PHP	Pulsar	Classic
RCP/Platform	✓	✓	✓	✓	✓	✓	✓	✓	✓
CVS	✓	✓	✓	✓	✓	✓	✓	✓	✓
EMF	✓	✓		✓	✓	✓			
GEF	✓	✓		✓	✓	✓			
JDT	✓	✓		✓	✓	✓		✓	✓
Mylyn	✓	✓	✓	✓	✓	✓	✓	✓	
UDC	✓	✓	✓	✓	✓	✓	✓	✓	
Web Tools		✓				✓	✓		
Java EE Tools		✓				✓			
XML Tools	✓	✓		✓		✓	✓	✓	
RSE		✓				✓			
EclipseLink		✓				✓			
PDE		✓		✓	✓	✓			✓
Datatools		✓				✓			
CDT			✓						
BIRT						✓			
ECF				✓					
GMF					✓				
PDT							✓		
MDT					✓				
MTJ								✓	

C.2. PaaS benifits

A1. The NIST Definition of Cloud Computing

3 service models

4 deployment models

5 essential characteristics

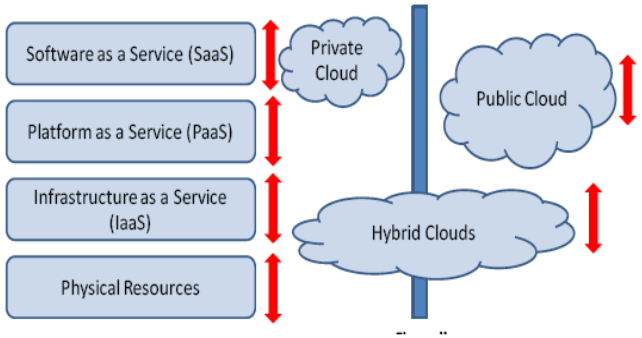


Figure 2. Managing Clouds and Cloud Services.

Deployment Models:

Private cloud. The cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on premise or off premise.

Community cloud. The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise.

Public cloud. The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services.

Hybrid cloud. The cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load-balancing between clouds).

On-demand self-service.

Measured Service. **Essential Characteristics:** *Broad network access.*

Rapid elasticity. *Resource pooling.*

The Korean Economic Review
Volume 27, Number 2, Winter 2011, 203-230.

C.2. PaaS benifits

- Type of users

A.2.1. Classification of Cloud Computing Applications via Fichman's Framework

		Locus of Adoption	
		Individual	Organizational
Class of Technology	Type 1 (low user interdependencies and knowledge barriers)	Personal adoption of simple SaaS applications such as email, word processing, data management	Organizational adoption of SaaS applications such as CRM or enterprise email.
	Type 2 (high user interdependencies and knowledge barriers)	Personal adoption of PaaS for web development and IaaS for hosting	Organizational adoption of PaaS for application development, and IaaS for high volume computing

The Korean Economic Review
Volume 27, Number 2, Winter 2011, 203-230.

Ergin Bayrak** · John P. Conley*** · Simon Wilkie****

C.2. PaaS benifits

- Type of Users

A.2.2. Determinants of Adoption via Fichman's Framework

		Locus of Adoption	
		Individual	Organizational
Class of Technology	Type 1 (low user interdependencies and knowledge barriers)	Classical diffusion variables: Perceived Innovation Characteristics; Adopter Characteristics; Information Sources and Communication Channels; Change Agents and Opinion Leaders	Classical diffusion variables: Organizational characteristics; Organizational decision processes; Stage of implementation; Competitive effects (adopter industry); Supply side factors; Economic factors (price); IT group characteristics
	Type 2 (high user interdependencies and knowledge barriers)	Classical diffusion variables; Managerial influences; Critical mass; Absorptive capacity; Implementation characteristics; Institutions lowering knowledge barriers	Combination of variables

The Korean Economic Review
Volume 27, Number 2, Winter 2011, 203-230.

Ergin Bayrak** · John P. Conley*** · Simon Wilkie****

C.2. PaaS benifits

- For users:

Values from Optimization

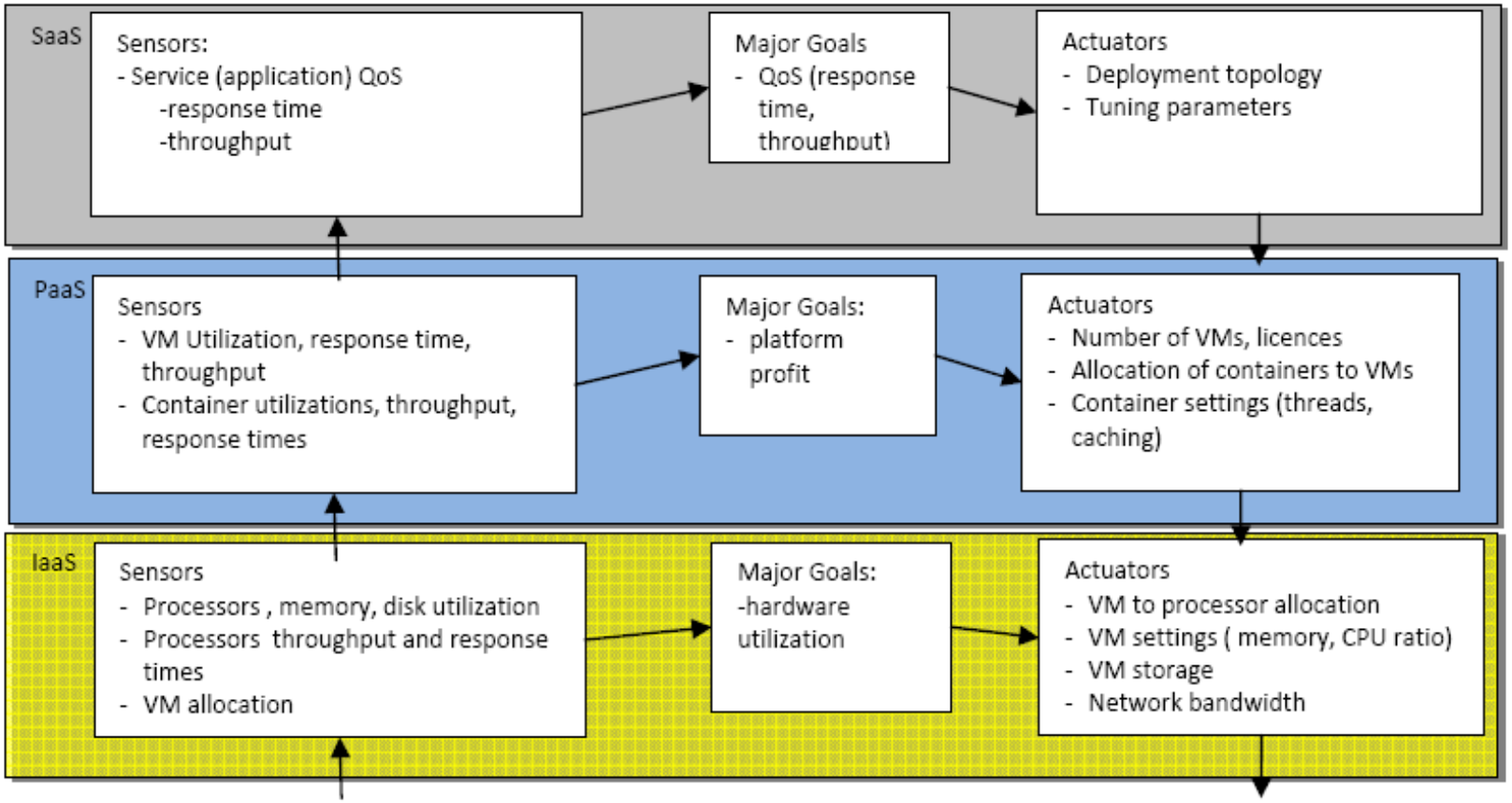


Figure 2 Conceptual optimization in cloud

http://blogs.computerworld.com/18863/take_the_paas

C.2. PaaS benifits

FOR DEVELOPERS

When passionate software developers get to work in the morning (or in the middle of night) what do you think they look forward to doing?

- A) Looking for updates to runtimes, installing them, testing to make sure they work correctly, and then calling the operations staff to get that stuff deployed everywhere; or,
- B) Firing up their IDE of choice and cranking out code.

http://blogs.computerworld.com/18863/take_the_paas

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C.2. PaaS benifits

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← The obvious (shorter) answer to this question points to the advantage of platform as a service (PaaS) -- one that is often taken for granted.

http://blogs.computerworld.com/18863/take_the_paas

C.2. PaaS benifits

For developers:

- The best PaaS not only does a great job of providing the most optimal deployment environment (good for the developer) but also manages the environment on behalf of the operations staff (autoscale, build, monitor, patch, alert, report). The expertly-written PaaS allows developers to simply drop their code into something like a folder, and it's off to the races. The code is built and running in the cloud in seconds. The results are compelling and are why PaaS is a hot technology right now.
- Software developers have a saying, **"The best line of code is the line of code I don't have to write".** PaaS takes that saying to the next level by doing the same application operations: **"The best config, deploy, patch is the one I don't have to do".**

C.2. PaaS benifits

For all

- *Up Front Cost* – Platform as a Service provides significant cost reduction in the development, deployment and hosting of business applications. There is hardly any cost involved in hosting the application on rented platform, and you pay only for what you use. Businesses don't need to worry about the large capital cost incurred to host a large scale application, saving investment on computing, storage, middleware and internetworking devices.
- *Operational Cost* – The development platform being provided, hosted and managed by the provider not only brings in zero infrastructure cost but also removes the maintenance cost associated in controlling such a large computing resource. The platform provider manages all hardware, software patching and update, physical & software security and day to day routine operational tasks.
- *Reliability*– Platform as a Service provides enhanced reliability of development stack, where in the case of a faulty server or any hardware device, the transition is quick and easy, mostly without interruption. Also these solutions are built upon the best industry standards and managed under a signed Service Level Agreement that ensures constant availability of the underlying platform.

http://...

C.2. PaaS benifits

For all ..

- *Management* – PaaS provides enhanced monitoring capabilities by centralizing all resources utilized for the solution deployed, automating their management & provisioning. PaaS eliminates the need for maintaining the data centre/production environment as back-end engineering & constraints are always resolved & maintained by the provider, freeing customer from updating and maintaining the development platform.
- *Strategic Advantage*– The ever increasing and limitless computing resources give a competitive edge over competitors where procurement time for new computing resources is virtually zero. Organizations can take advantage of the scalable and on-demand Cloud infrastructure, whenever they need it, reducing the provisioning time required at traditional in-house data centre. PaaS provides strategic advantage, by shifting businesses towards their primary goals rather than to worry about the platform required for their key applications to execute.
- *Lower Risk*– PaaS adoption gives virtually zero risk by eliminating the hefty capital investment required to build & operate infrastructure for facilitating thousands of users. An organization simply needs an internet browser to tap in the massive computing resource, and paying only for the portion utilized

http://...

C.2. PaaS benifits

For all (IBM)

Decreased development time

Increased quality and control

Reduced risk in a cloud environment

An environment that fosters innovation

Deferral or avoidance of hardware purchases

Test environments that closely mirror the delivery environment

C.3. History and Development

PhD Dessertation 2012: fei teng.pdf, page 32.

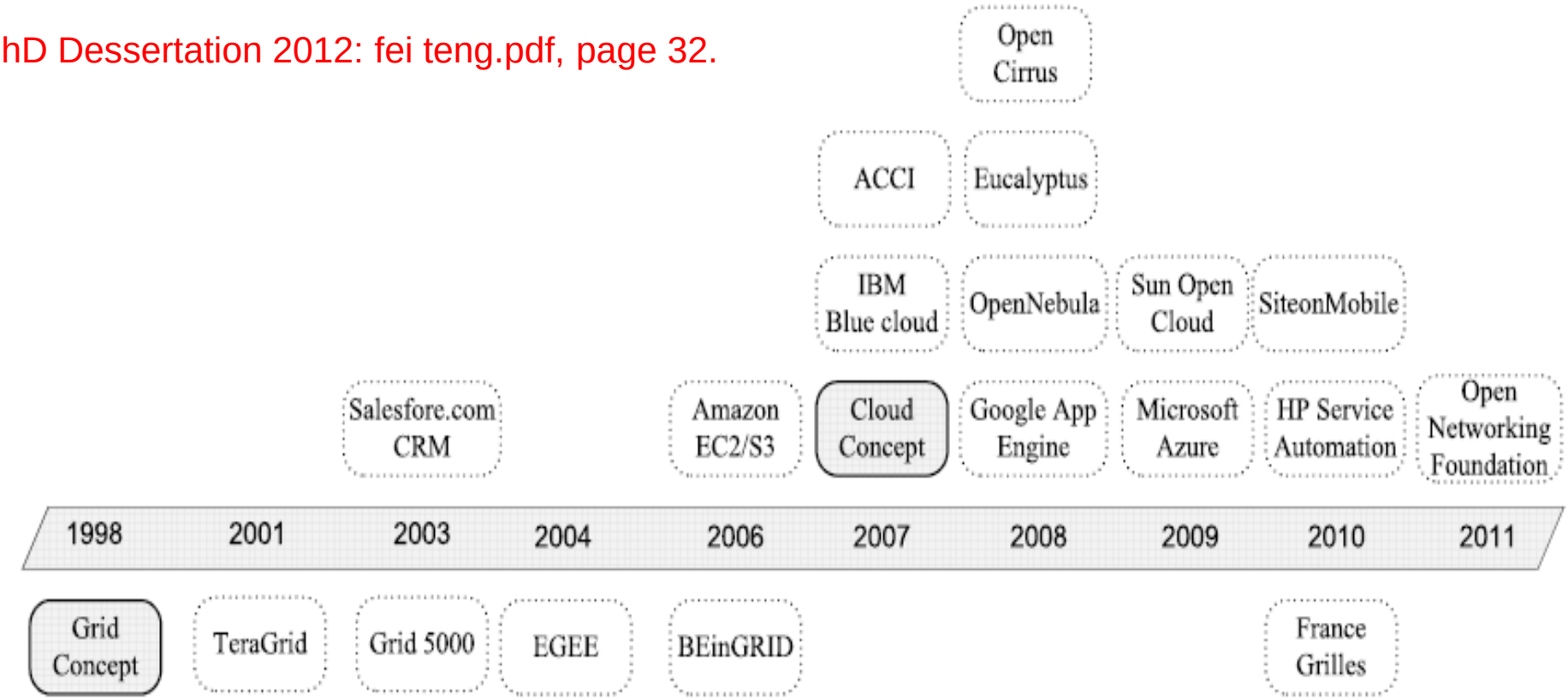


Figure 2.2: Cloud development history

C.3. History and Development

* Solutions and Factors

Cloud PaaS Solutions:

Vendor	Solution(s) Evaluated
VMware (VMW)	vFabric suite, Cloud Foundry (beta)
Microsoft (MSFT)	Windows Azure
Red Hat (RHT)	OpenShift (beta)
Amazon (AMZN)	AWS Elastic Beanstalk (beta)
Oracle (ORCL)	Exalogic Elastic Cloud

Cloud PaaS Factors:

Factor	Solution Features Evaluated
Runtime Language Support	Breadth of languages and frameworks supported (Java, Ruby, Microsoft, others).
Developer Tools	Support for popular IDEs, dynamic languages (PHP, Python, etc.), code generation tools, drag-and-drop development, and command line interfaces.
Application Services	Web server. Application (code execution) server. Messaging services. Support for load balancing, high availability and dynamic scale-up and scale-down.
Data Management	Support for relational database, database as a service, in-memory data, New-SQL and No-SQL (key value store, document store, blob store).
Application Performance Management	Code execution monitoring, application services monitoring, performance issue alerting and resolution, and policy-based auto-remediation.
Application Portability (Hybrid)	Integration with hybrid cloud infrastructure and management to enable apps to be deployed across on-premise and off-premise (private/public) clouds.

C.3. History and Development

* comparison

CLOUD APPLICATION PLATFORM COMPETITIVE LANDSCAPE

PaaS Factors	VMW	MSFT	AMZN	RHT	ORCL
Runtime Language Support	◕	◑	●	◑	◑
Developer Tools	●	●	◑	◑	◑
Application Services	◕	◕	◕	◕	◑
Data Management	●	◕	◕	◑	◑
Application Performance Mgmt.	●	●	◔	◑	◔
Application Portability	●	◑	◔	◑	◔
OVERALL SCORES:	◕ 3.7	◕ 3.1	◑ 2.4	◑ 2.2	◔ 1.7

TANEJA GROUP

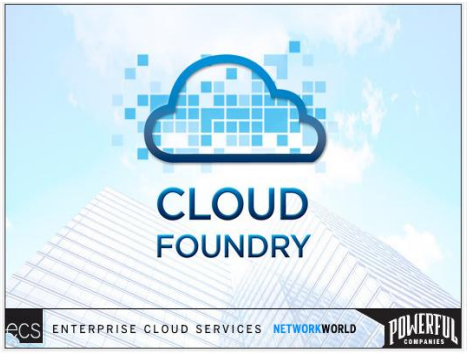
The Cloud Market: Ranking the Solutions (4 = Highest Score)

Roll-Up Scores	VMW	MSFT	AMZN	IBM	HP	CA	RAX	BMC	RHT	ORCL
IaaS + Mgmt.	◕ 3.6	◑ 2.6	◑ 2.4	◑ 2.4	◑ 2.4	◑ 2.4	◑ 2.3	◑ 2.2	◔ 1.8	◔ 1.0
PaaS	◕ 3.7	◕ 3.1	◑ 2.4						◑ 2.2	◔ 1.7

C.3. History and Development

http://www.networkworld.com/slideshow/32927?source=NWWNLE_nlt_daily_pm_2012-02-27#slide5

* top ten companies



C.3. History and Development

http://www.networkworld.com/slideshow/32927?source=NWWNLE_nlt_daily_pm_2012-02-27#slide5

- Amazon web services

Just like Jack planting his magic beans in solid ground, Amazon has built its application runtime PaaS, Amazon Web Service (AWS) Elastic Beanstalk (now in beta), on the solid footing of the very popular Infrastructure as a Service platform, EC2. And while the retailer turned cloud provider doesn't necessary have a loyal developer following, it's continually rolling out new tools to entice them. So far the portfolio includes AWS Toolkit for Eclipse (a plug-in for the Eclipse Java Integrated Development Environment), AWS CloudFormation (a service that lets developers create and provision Amazon resources), several cloud-based database options and SDKs for Android and Apple mobile machines, ERuby, Java, PH and .Net.

C.3. History and Development

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- Salesforce

The original SaaS giant has successfully parlayed its prowess down the cloud stack with its double one-two PaaS punch of Force.com's AppExchange and Heruko platform. Right now, the company enjoys the status of market share leader, according to IDC. Salesforce.com touted some impressive numbers to its base at last fall's DreamForce conference, including the claims that in 2011 3,000 apps were built or installed every 24 hours and that the Force.com platform executes more than 650 million transactions per day.

Heroku is part of salesforce.com. It was acquired in 2010.

C.3. History and Development

http://www.networkworld.com/slideshow/32927?source=NWWNLE_nlt_daily_pm_2012-02-27#slide5

- LongJump

LongJump landed in the PaaS fray very early on in 2008. It has steadily added new features and developer-centric support to attract a customer following that the company says is 600 strong at this point. Long Jump's biggest coup came in the form of an AT&T partnership announced last November in which the telco rolled out a simplified PaaS service geared toward tech savvy business folks that has the LongJump PaaS stack at its core. Forrester analyst Stefan Reid said this deal could pave the way for more licensing deals for the company.

C.3. History and Development

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- Windows Azure

There have been rumblings that Microsoft's 2-year-old Azure PaaS play is not getting the traction the company had hoped. Microsoft's PaaS portfolio includes the Windows Azure computing environment for applications and persistent storage for both structured and unstructured data; Windows Azure AppFabric a range of services that connects users and on-premises applications to cloud-hosted applications, manages authentication, and implements data management, and SQL Azure, a cloud database service. All Windows centric, of course, but analysts say that Microsoft is making noises about opening that up a bit. And they say you can't discount the power Microsoft has in its army of .Net developers waiting in the wings to see what the cloud means for them.

C.3. History and Development

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- IBMSmartCloud

IBM is a relatively late entry into the PaaS market as it only rolled out SmartCloud Application Services PaaS last October (2011). But the company has long-standing ties to the corporate enterprise and this platform – based on the long-trusted WebSphere middleware -- allows enterprises to build Java-based apps that can run in the public cloud, called IBM Smart Cloud Enterprise, or on premise. IBM is looking to keep their customers in a comfort zone while pushing them out to the cloud.

C.3. History and Development

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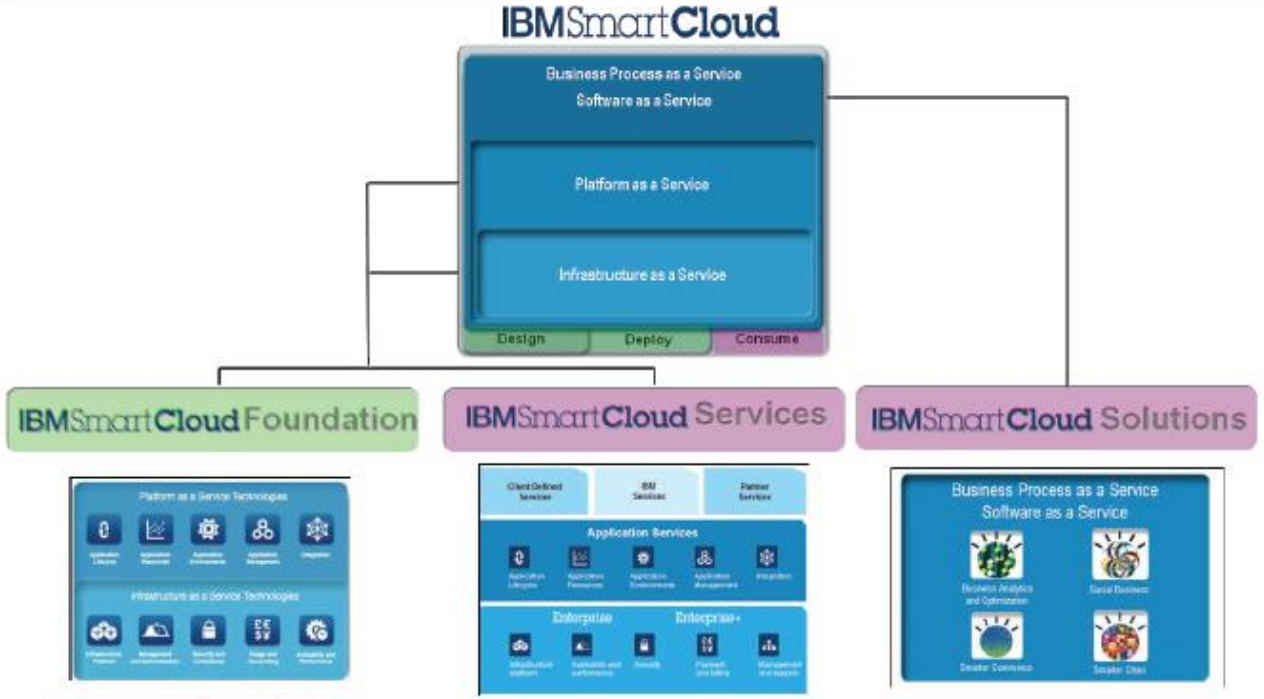
Figure 2: IBM SmartCloud



An integrated set of private cloud enablement technologies

An infrastructure and platform as a service designed for enterprise-class service delivery

New business and industry software as a service solutions

Source: IBM

C.3. History and Development

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- OpenShift

(RED HAT) Linux lovers are uniting behind the thought of an open source PaaS like RedHat's OpenShift. And industry watchers are intrigued by the prospect of portable applications that can be pulled from one infrastructure platform whose fees or contingencies become arduous and easily placed on another one without breakage. It simply remains to be seen how big an ecosystem RedHat can build around OpenShift and how useful it will be corporate developers.

C.3. History and Development

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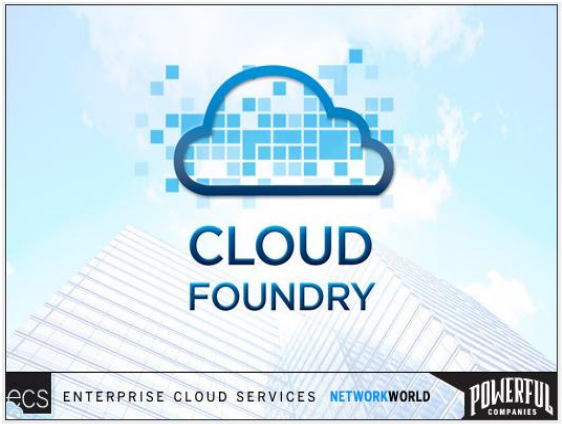


- Cloud Foundry

Cloud Foundry is the open source PaaS that was spearheaded in early 2011 by VMware and around which the company plans to build a future commercial product. As with Red Hat's initiative, VMware is attracting developers who want an open platform that lets them build in the language they want and run on the IaaS they like. According to company officials, the project is gaining significant traction because over 2,100 developers are actively following the changes in the open source code. Analysts have speculated that AppFog, a start-up already offering a comprehensive PaaS based on the Cloud Foundry code, is ripe for the picking should the commercial side of CloudFoundry need a boost.

C.3. History and Development

http://www.networkworld.com/slideshow/32927?source=NWWNLE_nlt_daily_pm_2012-02-27#slide5

- Google App Engine

Google claims it's got 200,000 developers building applications on top of its App Engine PaaS. That's in spite of a rate hike that really got their base riled up back in the September, giving all kinds of fodder to competing products that claim to be both more open and more affordable. But Google doesn't seem to be bothered and is forging ahead with an upgrade that supports a premium level of service in which customers will receive a 99.95 uptime service-level agreement.

C.3. History and Development

http://www.networkworld.com/slideshow/32927?source=NWWNLE_nlt_daily_pm_2012-02-27#slide5

- CloudBee

CloudBees was first out of the gate with a Java-based PaaS that gave enterprises an easy way to move existing Java applications into the cloud. RUN@cloud is the application runtime side of the CloudBees' PaaS story, providing traditional application server functionality for web, Java and Spring applications. CloudBees customers choose their underlying IaaS or private cloud. Applications running on RUN@cloud can be built using traditional Java EE development tools or using CloudBees' second PaaS offering called, DEV@cloud. DEV@cloud is a cloud-based development, build and test environment. CloudBees' power lies in its understanding that there are lots of sunk costs in existing Java applications from which enterprises are loath to walk away.

C.3. History and Development

http://www.networkworld.com/slideshow/32927?source=NWWNLE_nlt_daily_pm_2012-02-27#slide5

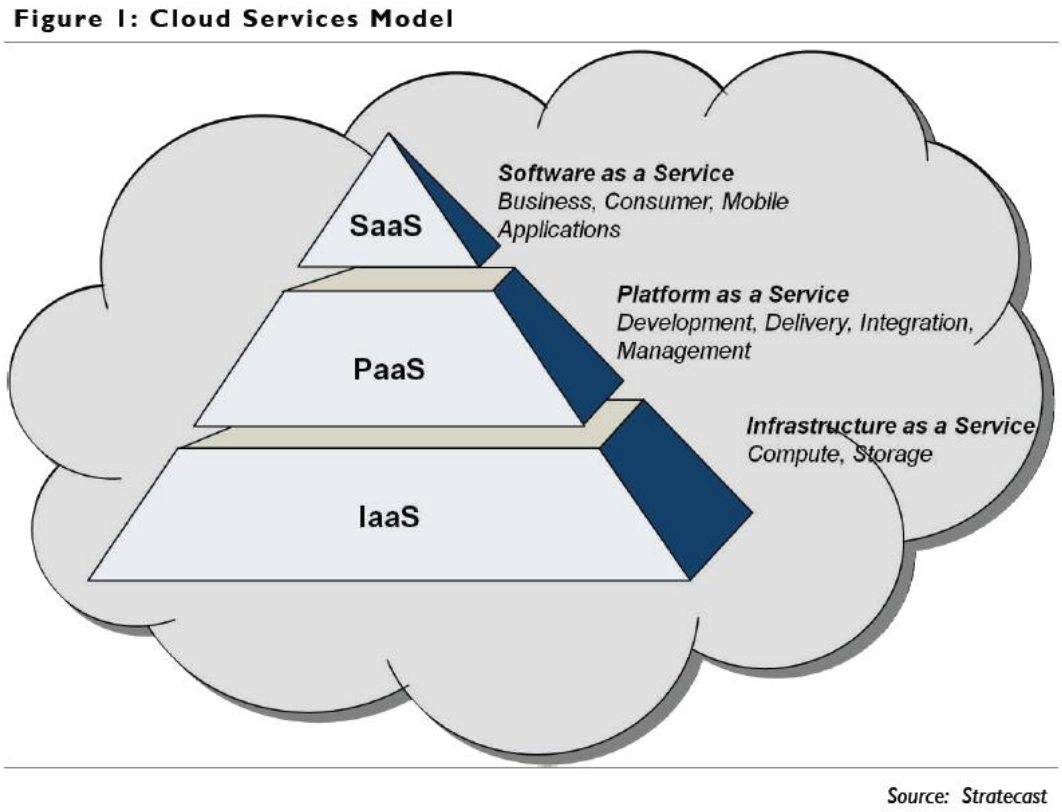
- Engine Yard

Engine Yard is one of the leading PaaS players for Ruby on Rails and PHP developers. These two development languages are most often associated with cool, new greenfield applications running in the cloud. Engine yard, founded in 2006 and still privately held, has a client list that includes Nike, AOL, Apple, Disney, and MTV.

C.4. Why Salesforce

- From Application to Platform:
+ A Strategic Assessment of Salesforce

IBM



C.4. Why Salesforce

Five Forces Behind Cloud-Based CRM

- Industrial Rivalry: High
- Buyer Power: Low-Moderate
- Substitutes: Medium-High
- Threat of Entry: High
- Supplier Power: Moderate-Low

Strategic Challenges, Trends & Implementation

- Continuing to Combat Substitutes and Rivals.
- Deterring the Thread of New Entrants and Mitigating Buyer Power

C.4. Why Salesforce

- *Five Forces Behind Cloud-Based CRM*

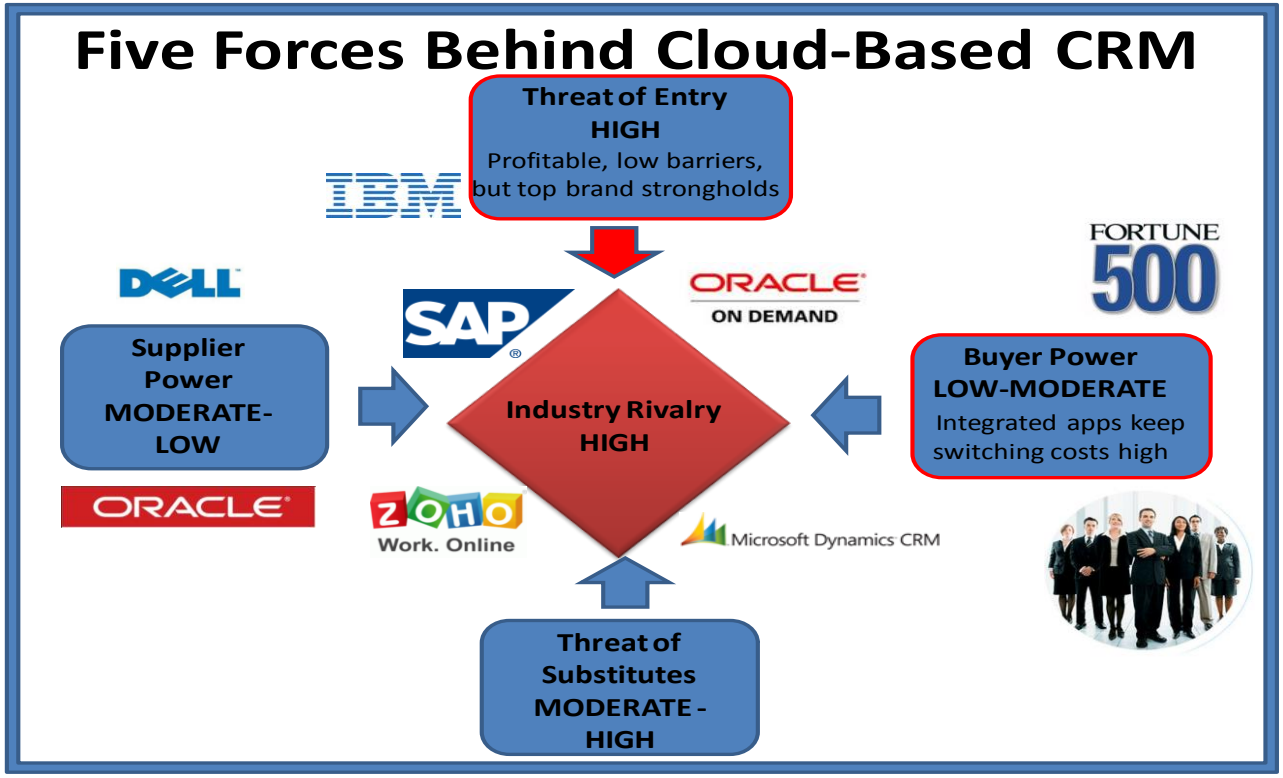
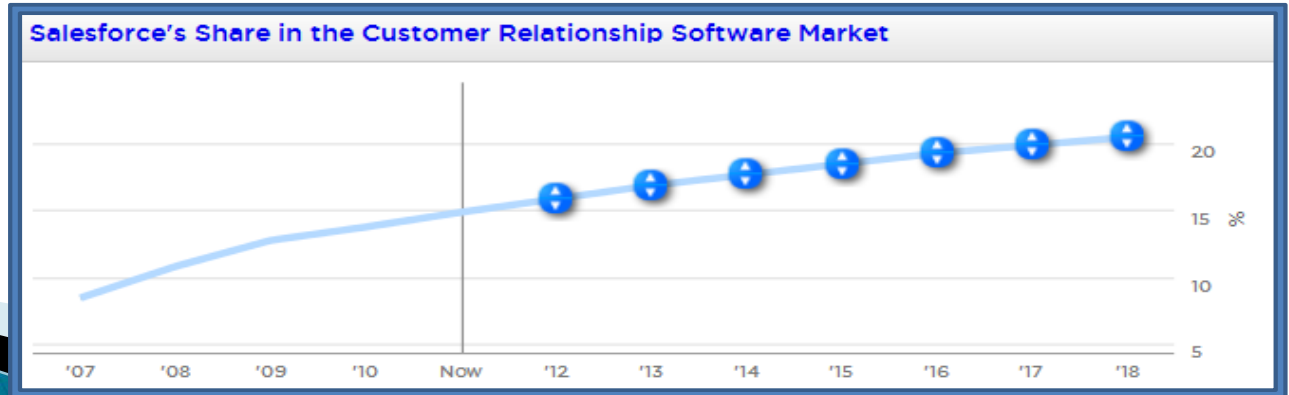


Exhibit 2: Market Share Data
Data source: Trefis.com



C.4. Why Salesforce

- *Threat of Low-Priced Solutions*

C.4. Why Salesforce

- *Game Theoretical Price vs. Perceived Quality Shift*

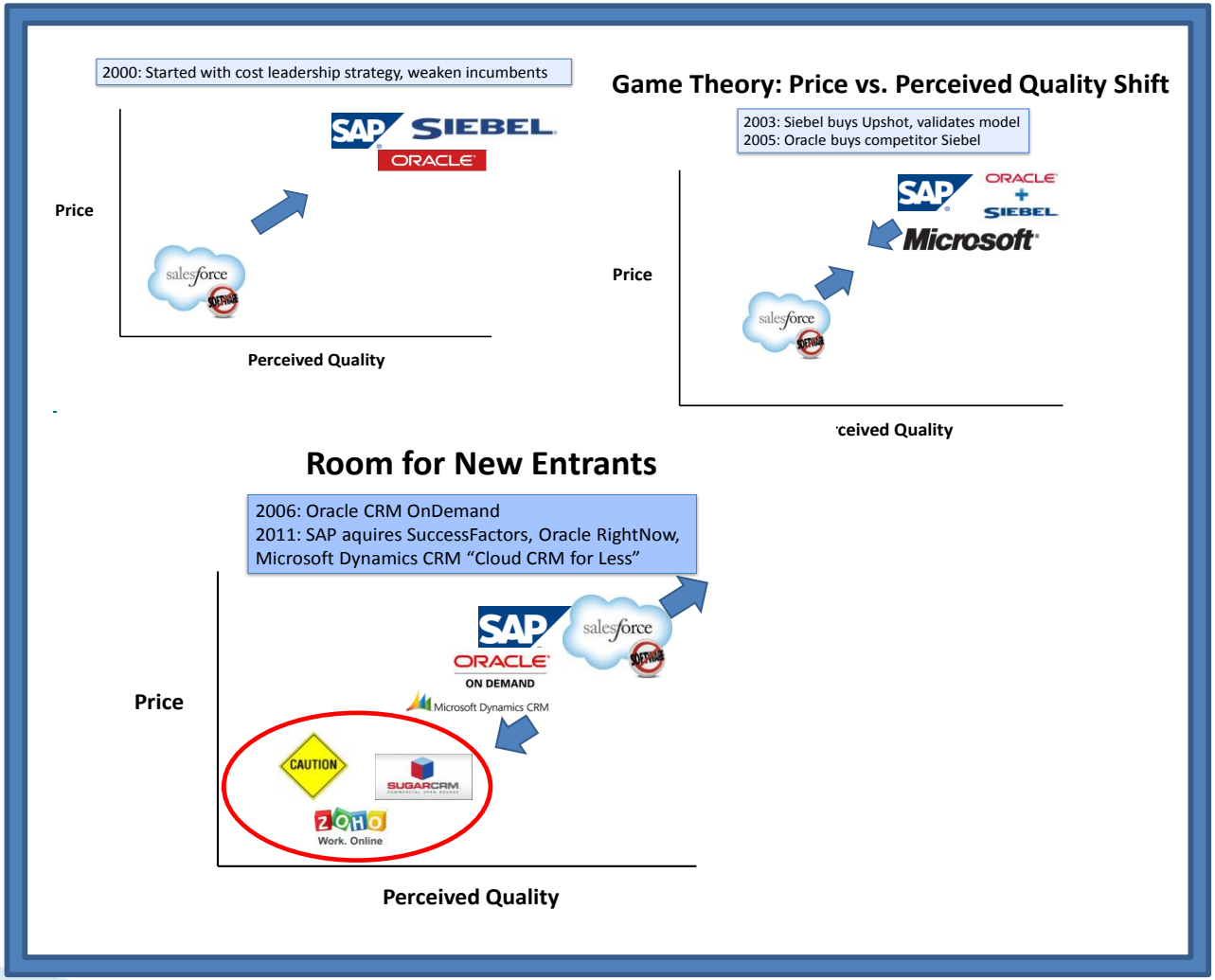
Cost and Quality

Cost Leadership; Segmentation of the Marketplace; Differentiation and Attacking Competitors' Strongholds; Price vs. Perceived Quality Shift; Strategic Challenges

Year 2000

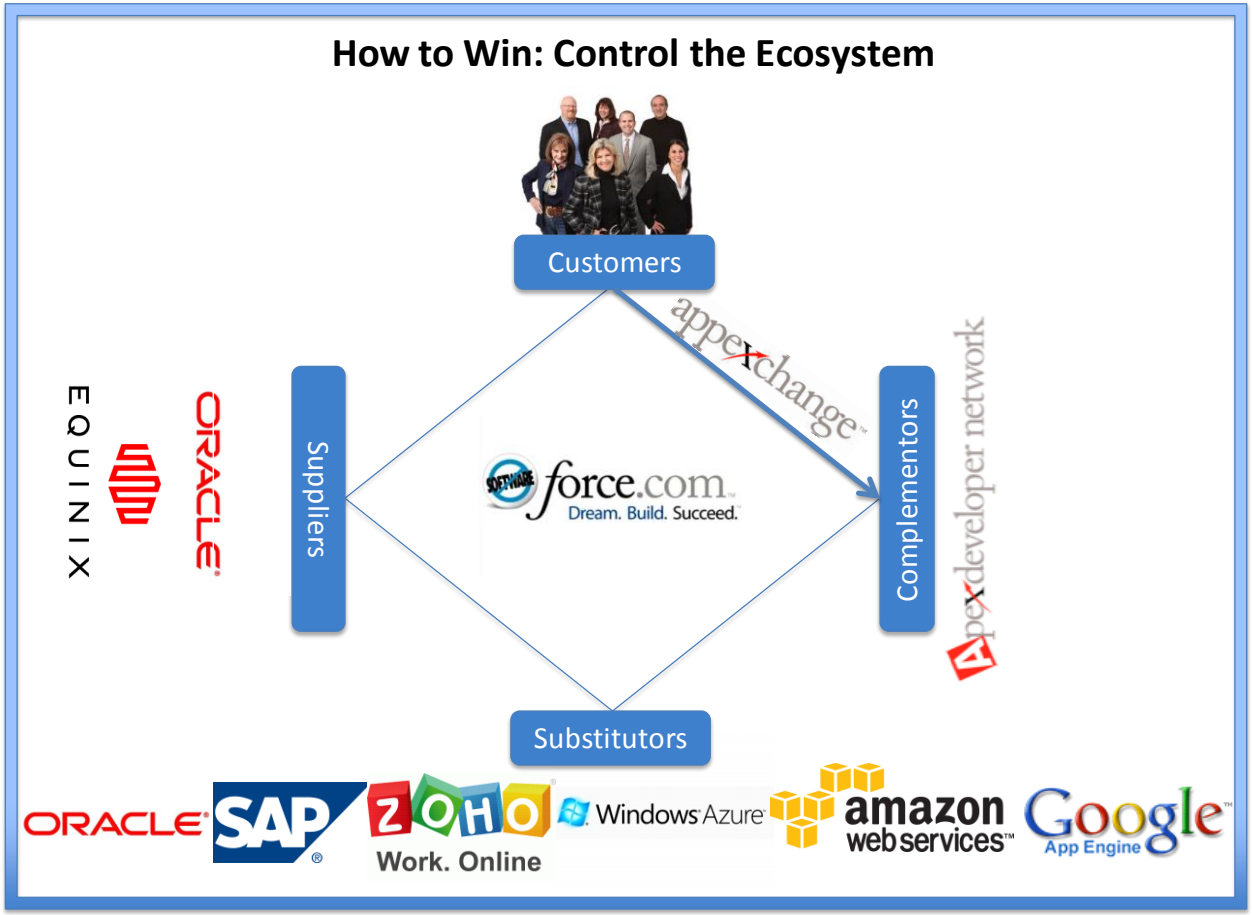
Year 2003-05

Year 2011 →



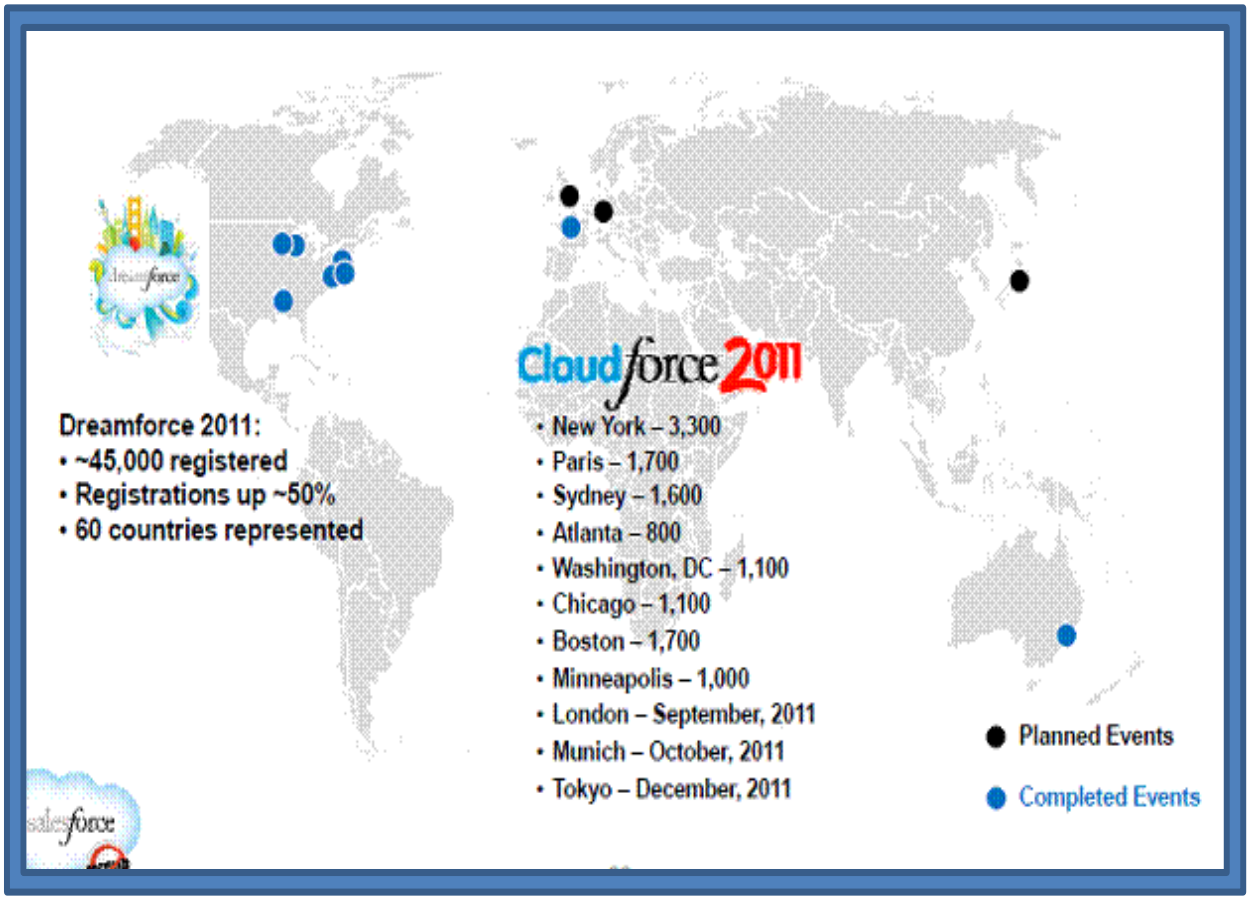
C.4. Why Salesforce

- *Value Net*



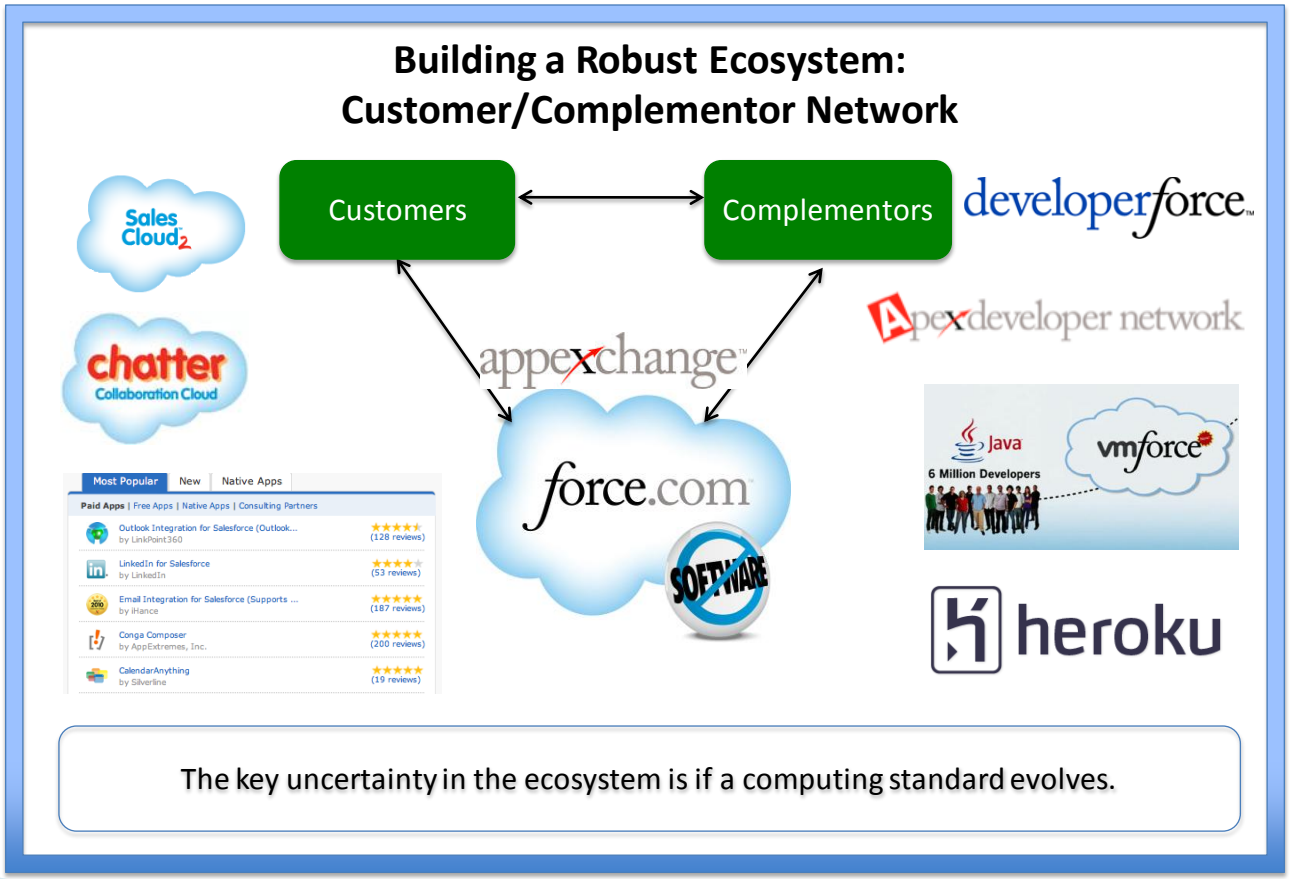
C.4. Why Salesforce

- *Dreamforce Conventions*



C.4. Why Salesforce

- *Customer Complementor Network*



C.4. Why Salesforce

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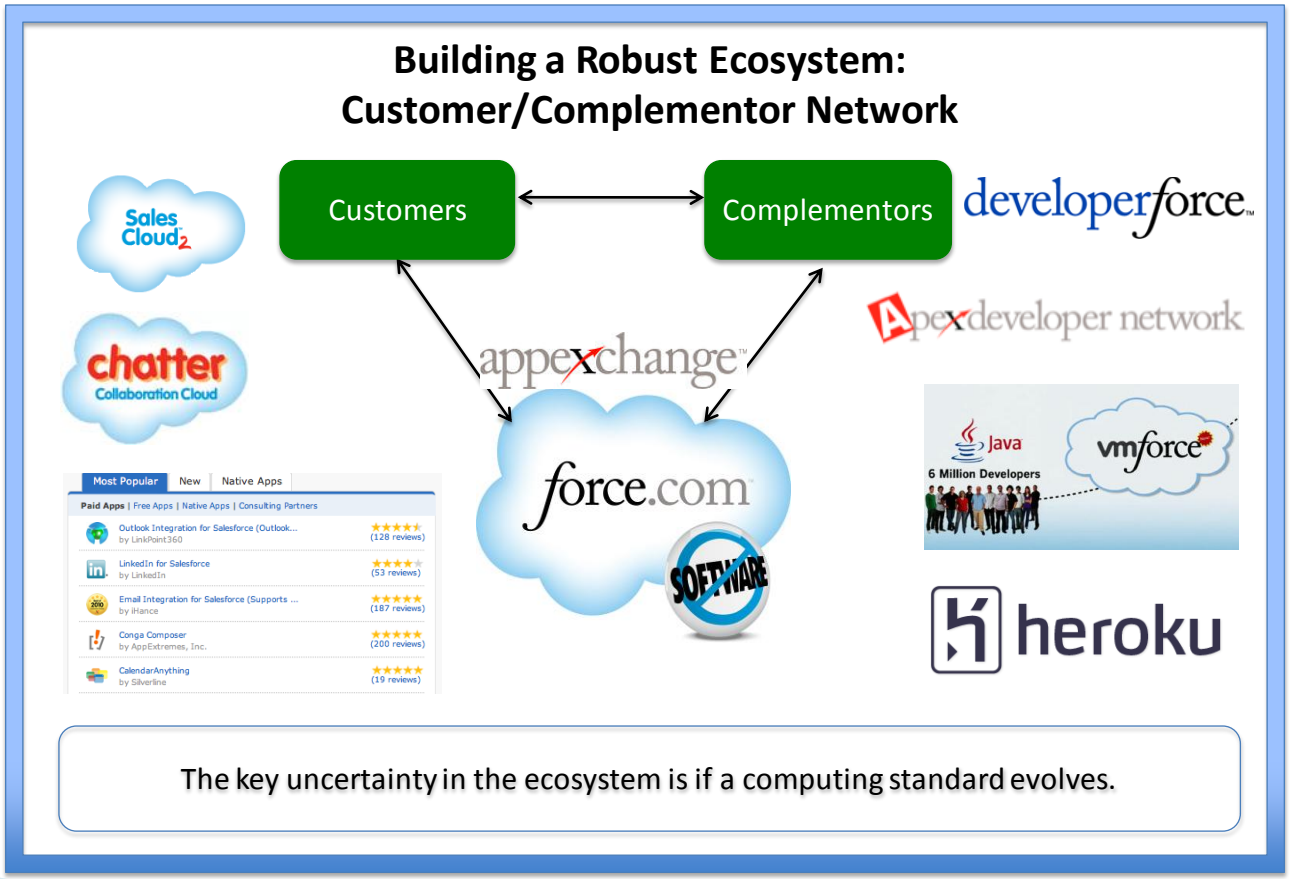

Thanks for attending!