Cloud Computing

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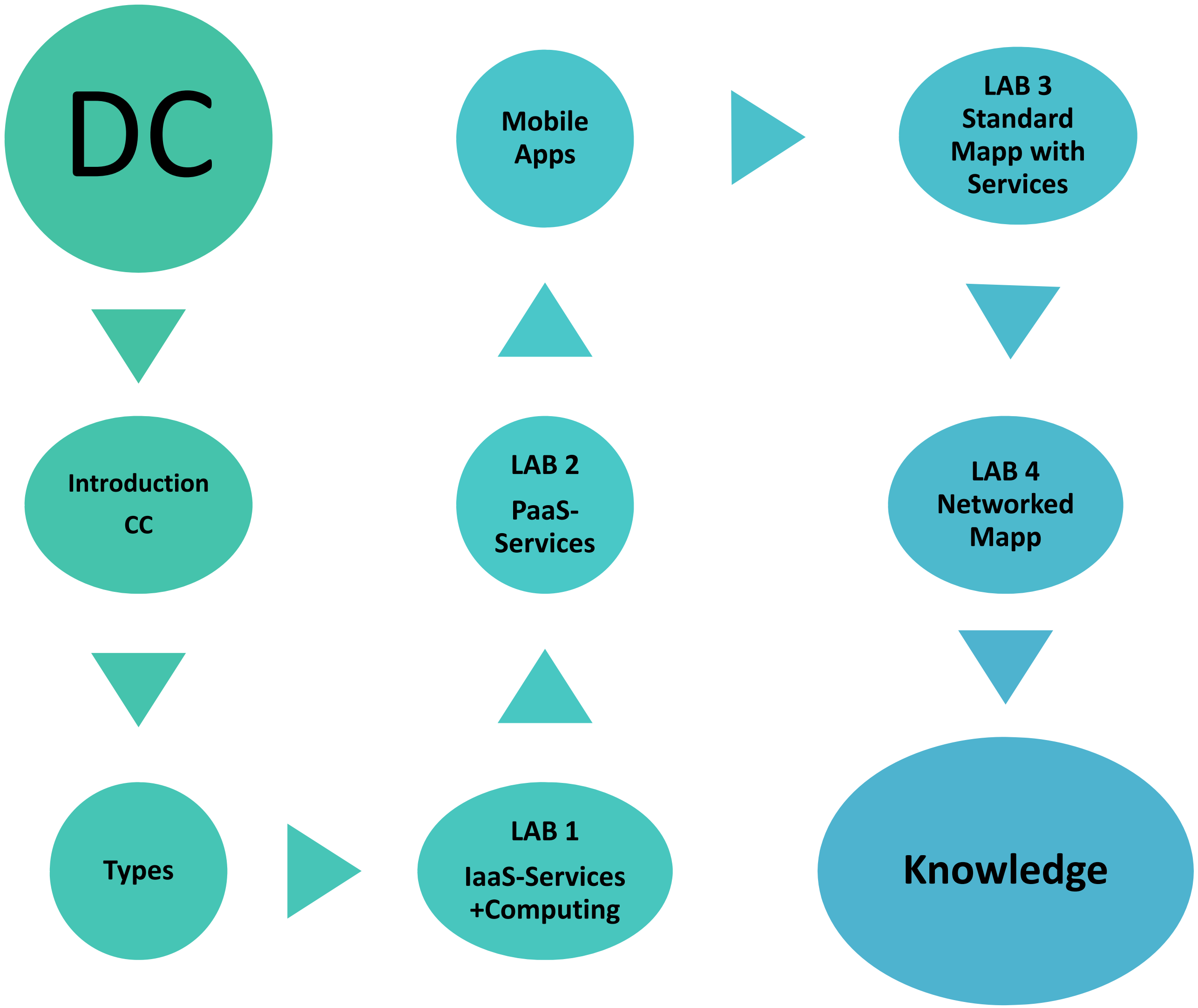
Conceptual map

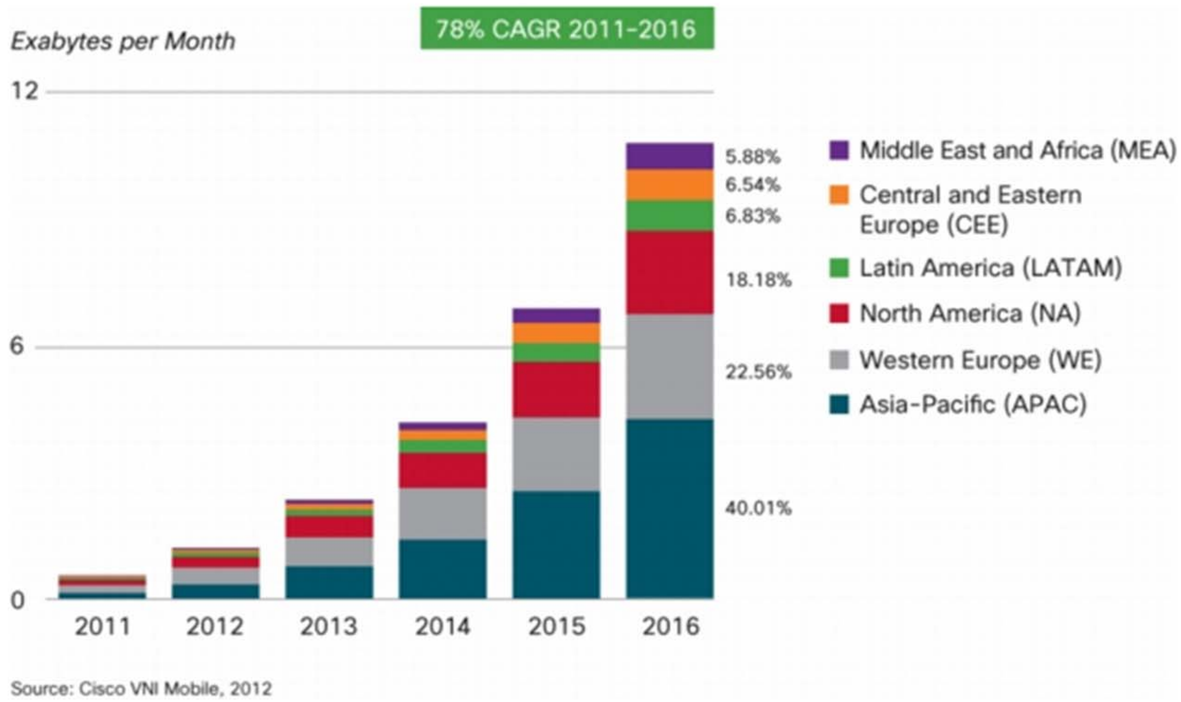


Context

Global mobile data traffic: 597 petabytes per month

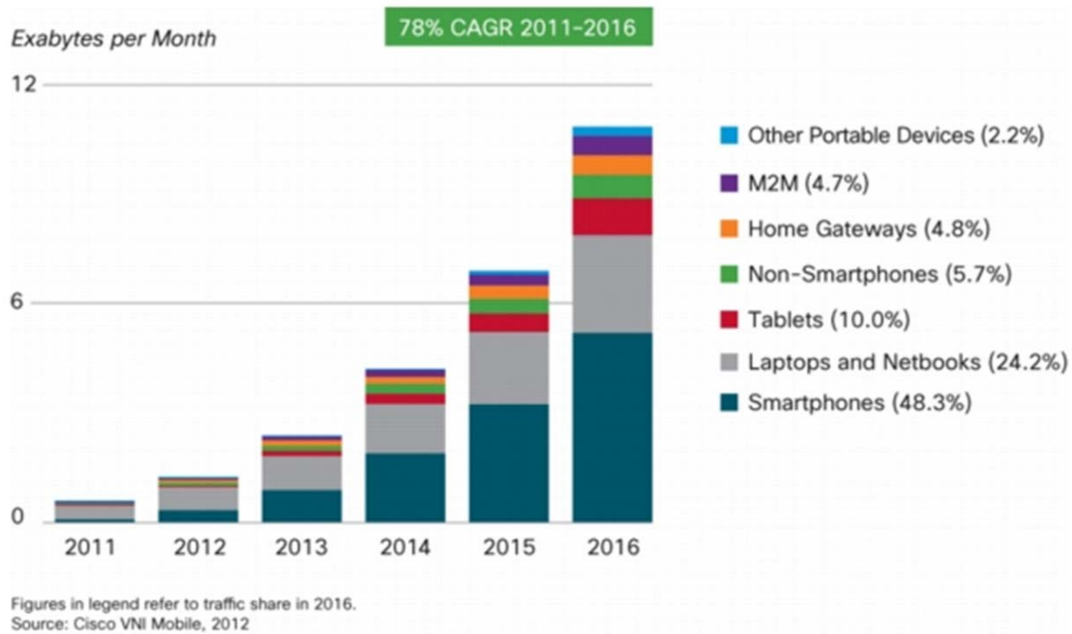
The number of mobile-connected devices exceeded the world's population (2012). 10 billion mobile-connected devices in 2017;

The average mobile network connection speed 2.9 megabits per second (Mbps) in 2015.



Context

The vast majority of computers – 98% - do not have traditional keyboard, mouse, screen.
They are in cars, planes, washing machines, mobile phones…
The number of computers will vastly out-number humans on the planet very soon.



Context

This is the 'Internet of Things' or 'future internet' (IoT)

We need to :

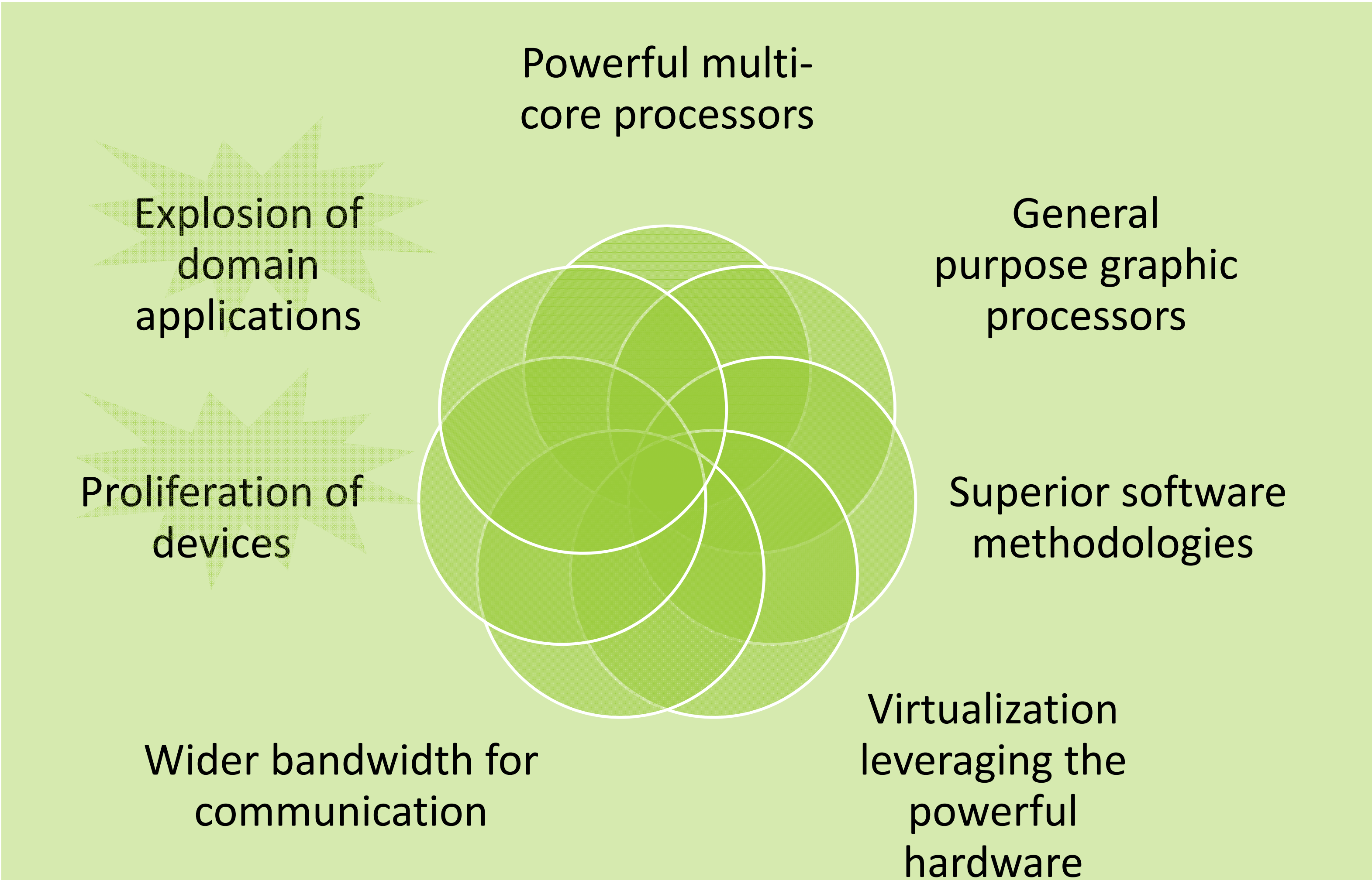
Manage the huge numbers, sizes, data (big data)
Integrate the different kinds of systems
Into one environment leading to human decision-making
whether managing a business, shopping, media choice, social interaction

But there is a problem…in last 20 years

Data storage density increased ~10^{18}
Processor power increased ~10^{15}
BUT broadband capacity increased ~10^{4}

This has implications for Information Systems Engineering!
In fact the requirement and limitations challenge the very basis of traditional computer science / ICT

Today: a golden era in computer science



Short History

Time 0

User request, programmer, punched cards, low-level program, mainframe

Time 1

User interacts with in-house-written software in high level language on mainframe or mini. Network proprietary.

Time 2

User interacts with off-the-shelf software on PC which interacts with in-house-written or purchased software on mainframe. Client-server to 3-tier. Network is (becoming) internet

Time 3

User interacts with pre-written software on mobile device which interacts with pre-written software on mainframe. Network is internet WiFi, 3G, 4G… and using WWW

Short History

Having virtualised the way the user interconnects to the application on the mainframe (Client-Server or 3-tier)

The next logical step is to virtualise the mainframe

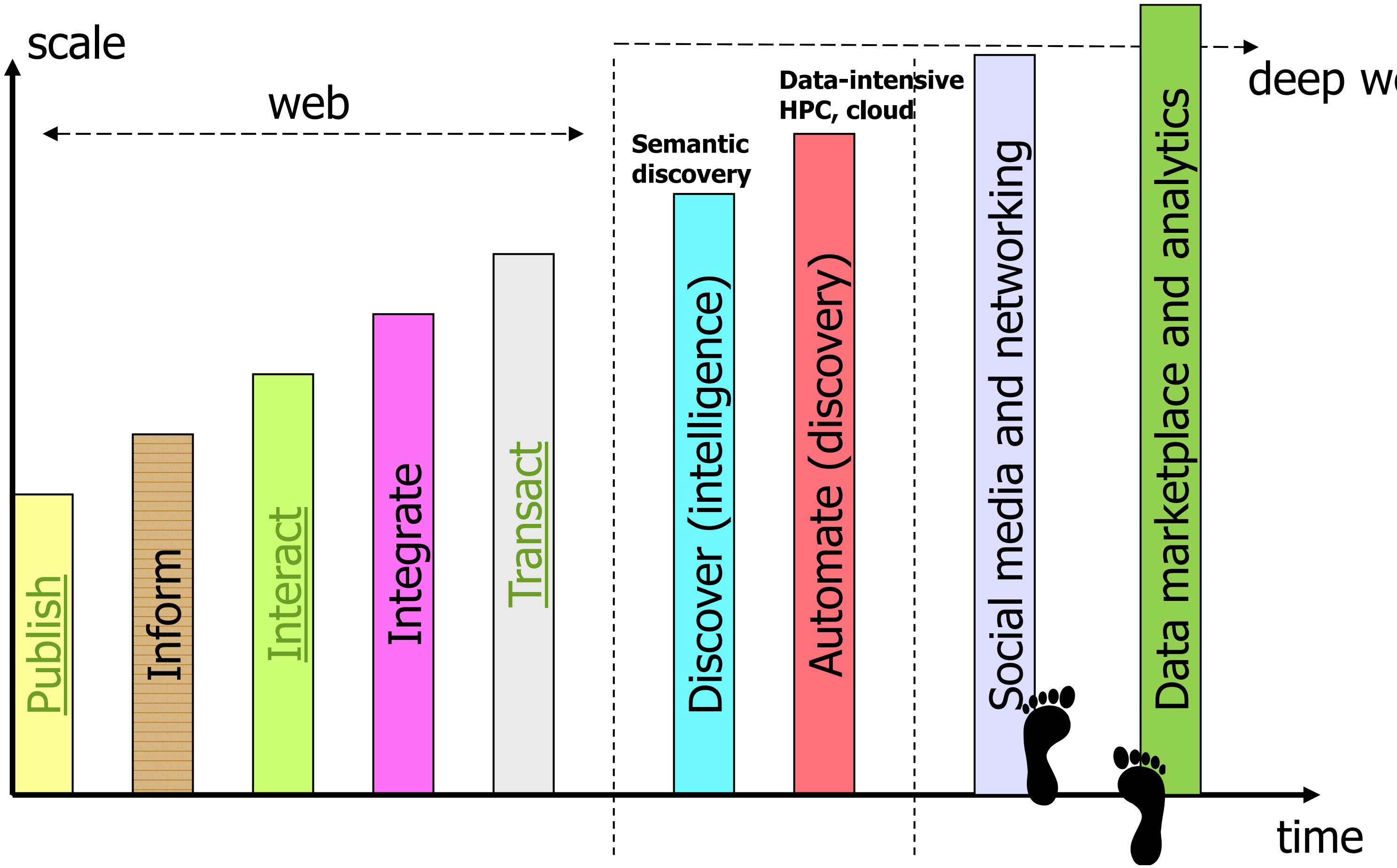
CLUSTER
Racked mainframe in-house
Homogeneity
Dynamically reassigned resources

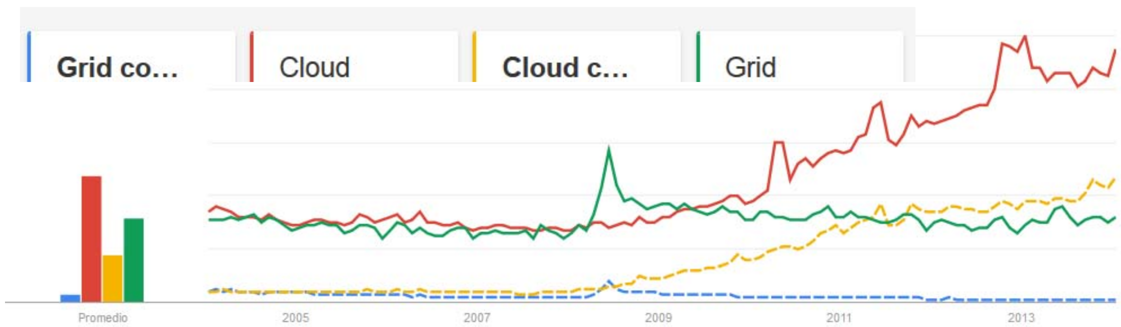
GRID
Distributed racked mainframes
Heterogeneity
Dynamically reassigned resources
Mobile Code

Which leads us towards CLOUD Computing

Just to mention there has been a parallel evolution in software:
Programming languages, Data modelling and management, Software and systems design, Systems development methods (CASE to IDE)

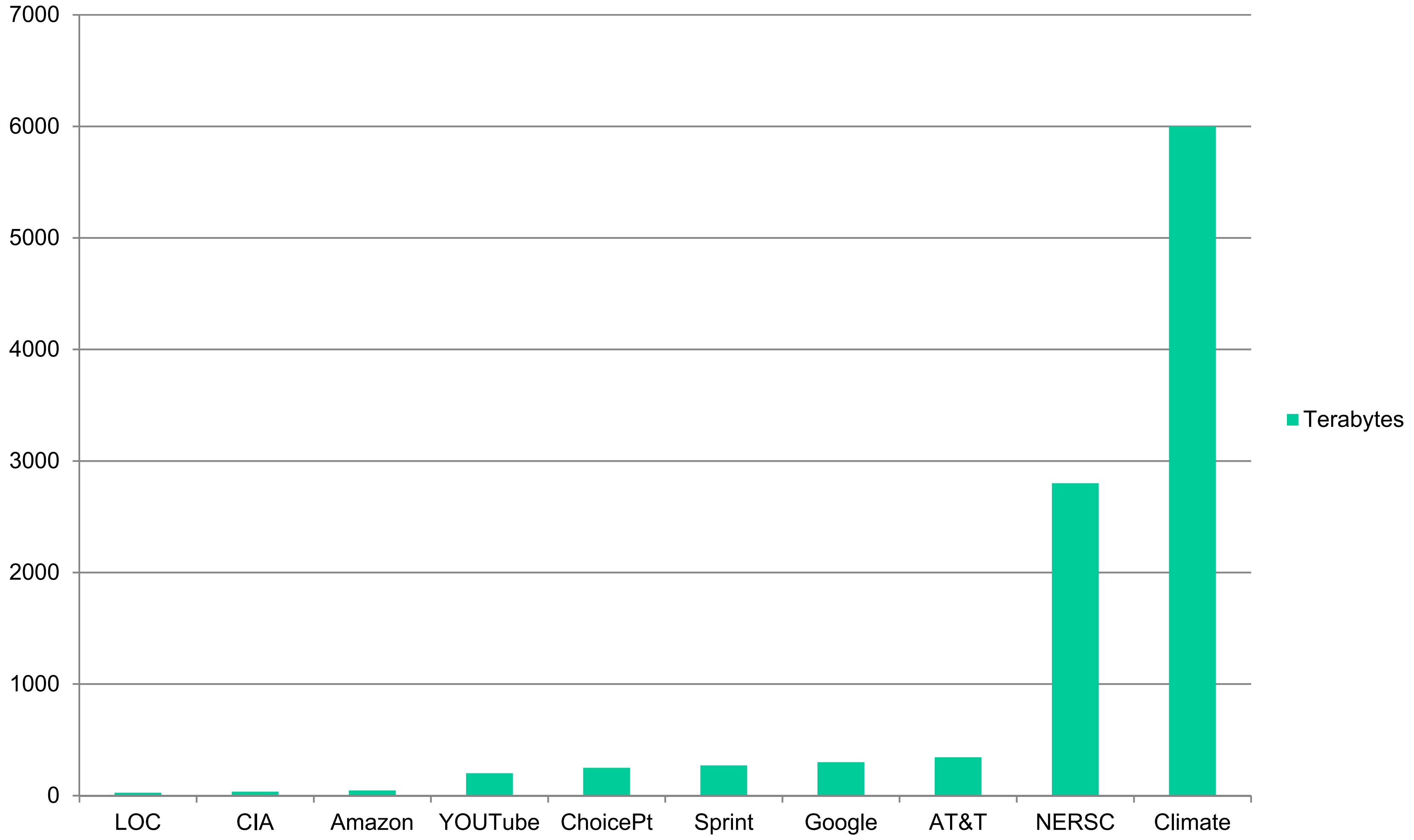
Evolution of Internet Computing





Trends

Top Ten Data Bases



Ref: http://www.comparebusinessproducts.com/fyi/10-largest-databases-in-the-world

Challenges

- Alignment with the needs of the business / user / non-computer specialists / community and society
- Need to address the scalability issue: large scale data, high performance computing, automation, response time, rapid prototyping, and rapid time to production
- Need to effectively address (i) ever shortening cycle of obsolescence, (ii) heterogeneity and (iii) rapid changes in requirements
- Transform data from diverse sources into intelligence and deliver intelligence to right people/user/systems
- What about providing all this in a cost-effective manner?

It's a changed world now

- Explosive growth in applications: biomedical informatics, space exploration, business analytics, web 2.0 social networking: YouTube, Facebook
- Extreme scale content generation: e-science and e-business data deluge
- Extraordinary rate of digital content consumption: digital gluttony: Apple iPhone, iPad, Amazon Kindle, Android, …
- Exponential growth in compute capabilities: multi-core, storage, bandwidth, virtual machines (virtualization)
- Very short cycle of obsolescence in technologies: Vista-> W7->W8->W10; Java versions; C->C#; Python
- Newer architectures: web services, persistence models, distributed file systems/repositories (Google, Hadoop), multi-core, wireless and mobile
- Diverse knowledge and skill levels of the workforce
- You simply cannot manage this complex situation with your traditional IT infrastructure!!

What is Cloud Computing?

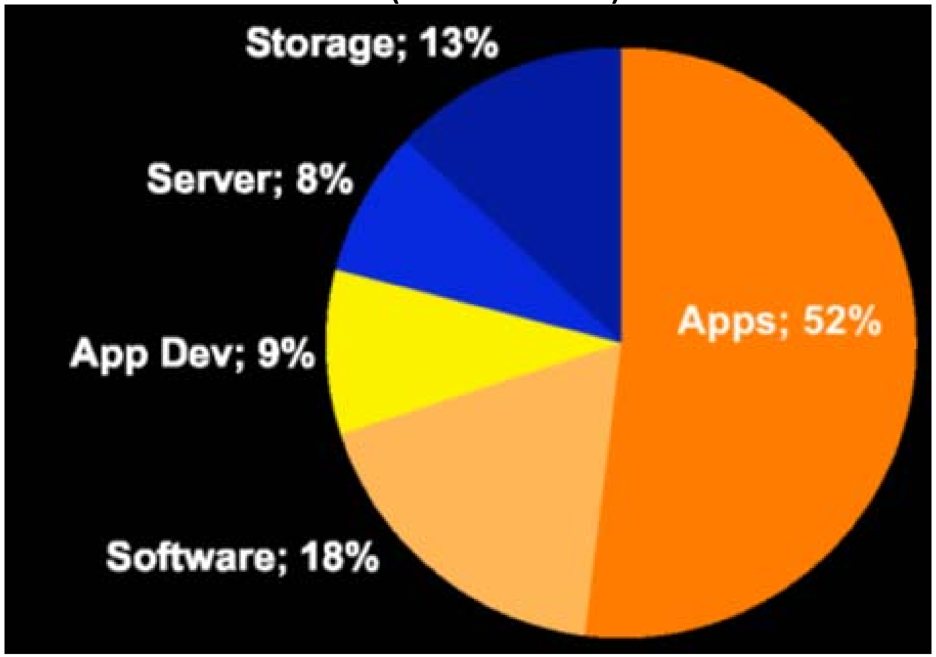
the Fifth Generation of Computing
(after Mainframe, Personal Computer, Client-Server Computing, & Web)

The **biggest thing** since the web?

Forrester Research, October 13, 2009 :

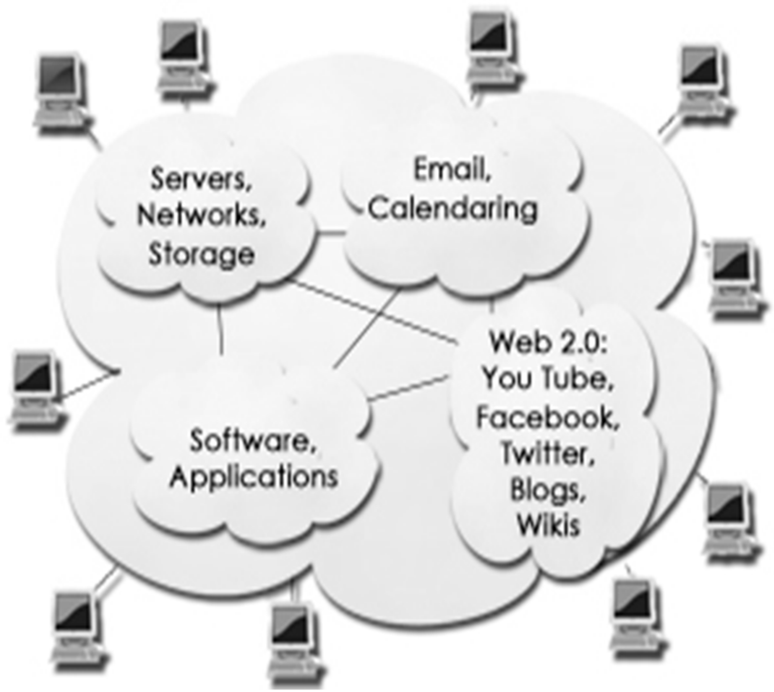
"……that cloud computing is one of the **Top 15 Technology Trends** and that it warrants investment now so you can gain the experience necessary to take advantage of it in its many forms to transform your **<u>organization into a more efficient and responsive service provider</u>** to the business."

Worldwide IT Cloud Spending 2012
(source IDC)



What is Cloud Computing?

Cloud Computing, means **Internet Computing**. The Internet is commonly visualized as clouds; hence the term *cloud computing* for computation done through the Internet. With Cloud Computing users can access database resources via the Internet from anywhere, for as long as they need, without worrying about any maintenance or management of actual resources.



"… means using Web services for our computing needs which could include using software applications, storing data, accessing computing power, or using a platform to build applications. " (E. Kroski, LJ, 2009)

What is Cloud Computing?

Very old idea
Use of cloud to depict a computing service or network
  virtualisation
Now used for a new concept
Confused with
  - GRIDs
  - Autonomic computing
  - Utility Computing
  - Service-Oriented Architecture

The premise:
Most compute centres utilise only 10% of capacity but need 100% for rare peaks of demand

Hardware:
A very large number of processors
  - Clustered in racks as blades

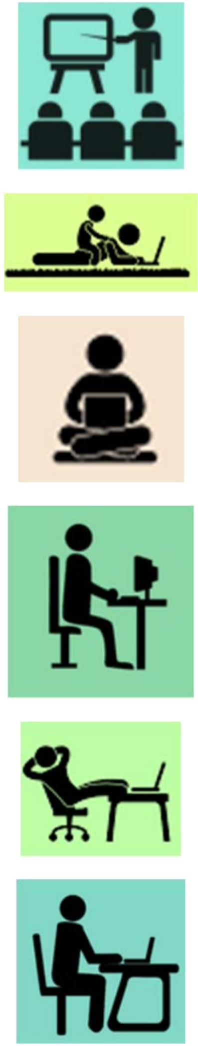
In one major computer centre
  - May be replicated for business continuity

With massive online storage
  - RAID for resilience

And excellent communications links
  - For access

Economies of scale – both purchasing and operation
Energy economies in location
Staffing economies in location

Cloud Computing: Why we use CC?



Case 1:

Write a file

Computer down, file is lost

Files are always stored in cloud, never lost (probability → 0)

Case 2:

Use CS6 --- download, install, use

Use Off2013 --- download, install, use

Use C++ --- download, install, use

……

Get the serve from the cloud

Cloud Computing: Customer View

Low cost of entry for customers

Device and location **independence**

Capacity at reasonable cost (performance, space)

Cloud Operator manages resource **sharing balancing** different peak loads

Elastically scalable as demand rises (or falls) from user

Security due to data centralisation and software centralisation

Sustainable and environmentally friendly – concentrated power

it is a service and the user does not know or care from where, by whom, and how it is provided

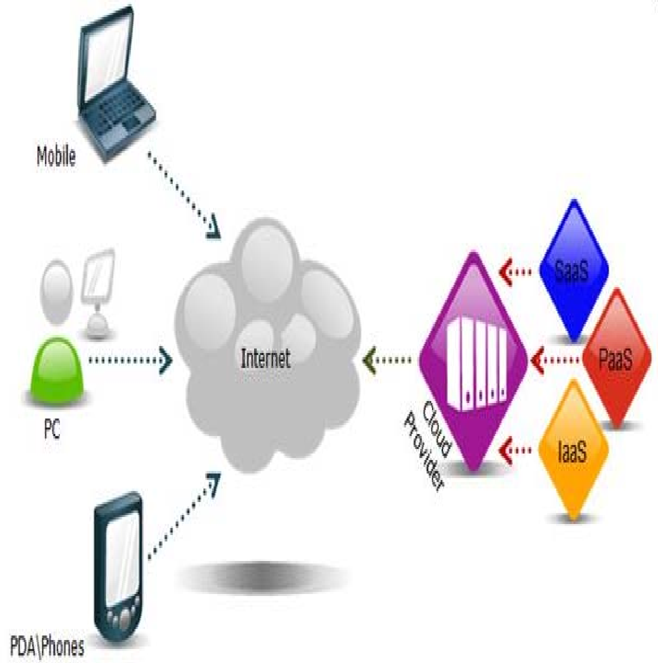
as long as the **SLA** (service level agreement) **QoS** (quality of service) is satisfied

it is a **computing utility** (IaaS, PaaS, SaaS….'XaaS')

What is Cloud & Cloud Computing?

Cloud

Demand resources or services over Internet
scale and reliability of a data center.



Cloud computing is a style of computing in which dynamically scalable and often virtualized resources are provided as a serve over the Internet.

Users need not have knowledge of, expertise in, or control over the technology infrastructure in the *cloud* that supports them.

We consider:

"…is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (for ex., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."**(*National Institute of Standards and Technology* - NIST)**

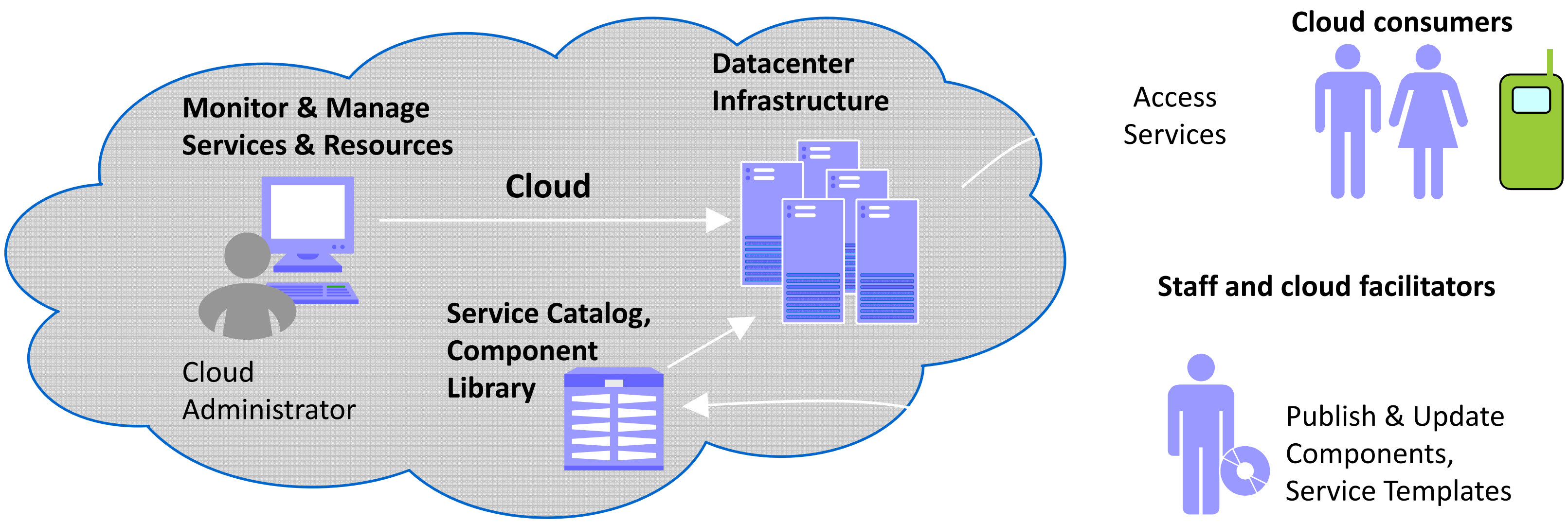
What is Cloud & Cloud Computing?

A user experience and a business model

Cloud computing is an emerging style of IT delivery in which applications, data, and IT resources are **rapidly provisioned** and provided as **standardized offerings** to users over the web in a **flexible pricing model.**

An infrastructure management and services delivery methodology

Cloud computing is a way of **managing** large numbers of highly **virtualized resources** such that, from a management perspective, they resemble a single large resource.
This can then be used to deliver services with **elastic scaling**.



Cloud-onomics?

CLOUD COMPUTING

VIRTUALIZATION + ENERGY EFFICIENCY + STANDARDIZATION + AUTOMATION = Reduced Cost

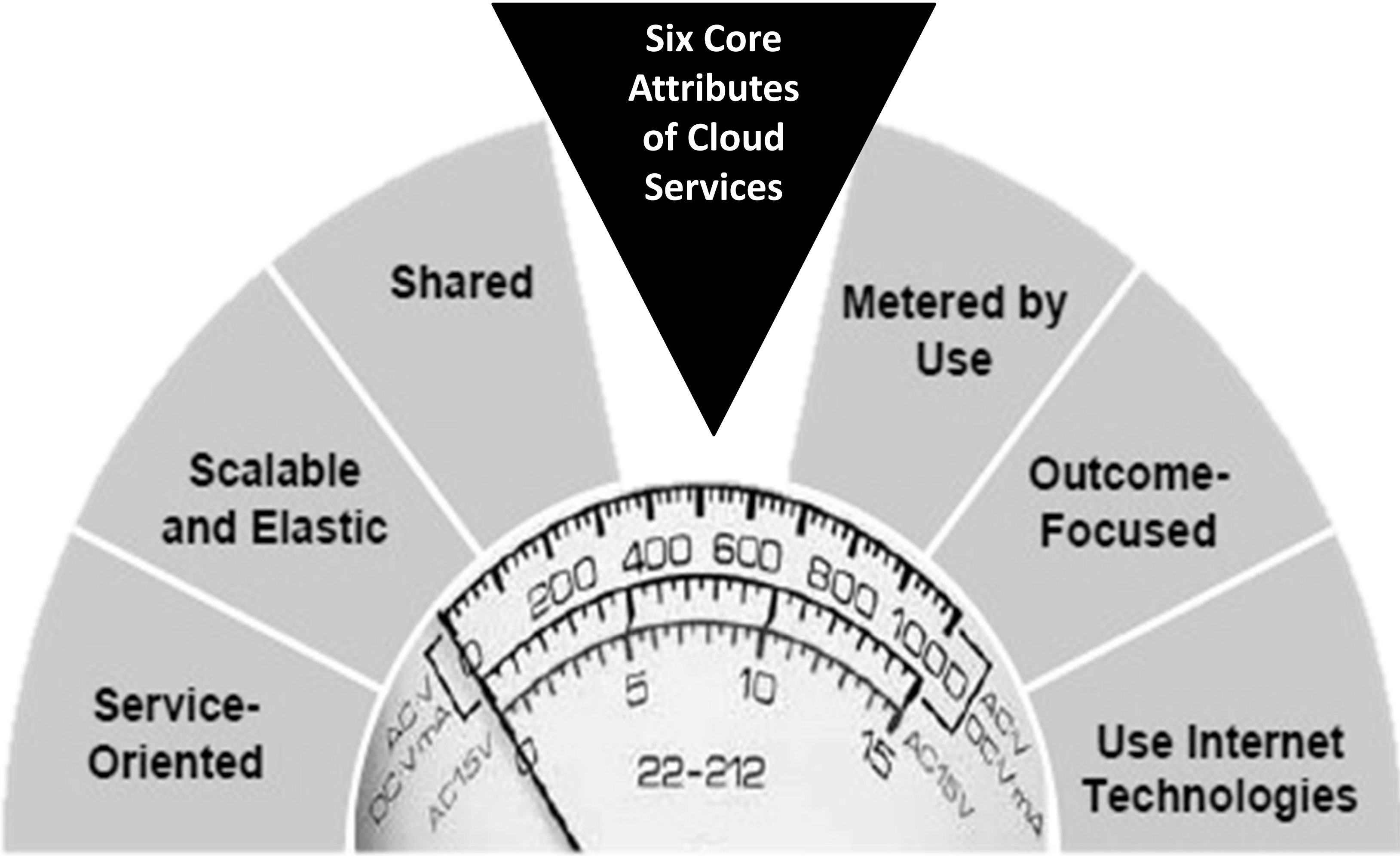
….leverages virtualization, standardization and automation to free up operational budget for new investment

AGILITY + BUSINESS & IT ALIGNMENT + SERVICE FLEXIBILITY + STANDARDS = OPTIMIZED BUSINESS

Why the crazy interest in Cloud Computing today?

- IT needs to deliver service, to meet the needs of the business you are supporting
- IT has not been doing a good job of this. Users are not satisfied
- A private cloud is a model for IT to do a better job of delivering services to end users
- IT needs to operate as a value center. When IT is a cost center, the only thing they ask you to do is cut costs!

Attributes of Cloud Service (Gartner)?



Cloud Computing Architecture

Is the systems architecture of the software systems involved in the delivery of cloud computing, typically involves **multiple cloud components** communicating with each other over *application programming interfaces*, usually .

Components:

- the front end - is the part seen by the client, i.e. the computer user. This includes the client's network (or computer) and the applications used to access the cloud via user interface such as a web browser.
- the back end - is the *cloud* itself, comprising various computers, servers and data storage devices.

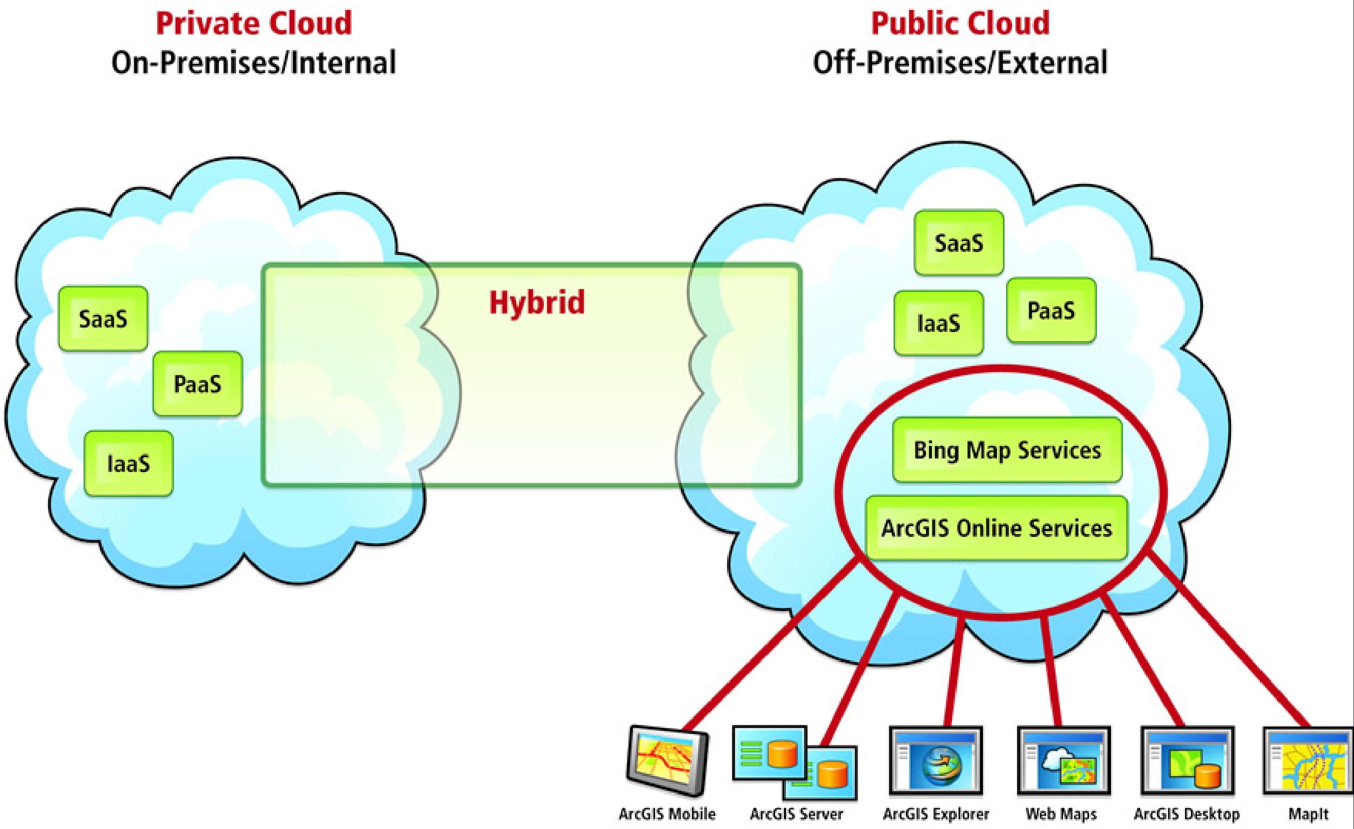
Cloud Computing Types (business model)

Public clouds computing environment are open for use to anyone who wants to sign up and use them. These are run by vendors and applications from different customers are likely to be mixed together on the cloud's servers, storage systems, and networks.

Examples of a public cloud: Amazon Web Services and Google's AppEngine

sells services to anyone on the Internet. In the traditional mainstream sense, resources are dynamically provisioned on a fine-grained, self-service basis over the Internet, via web applications/web services, from an off-site third-party provider who bills on a fine-grained utility computing basis.

Cloud Computing Types (business model)

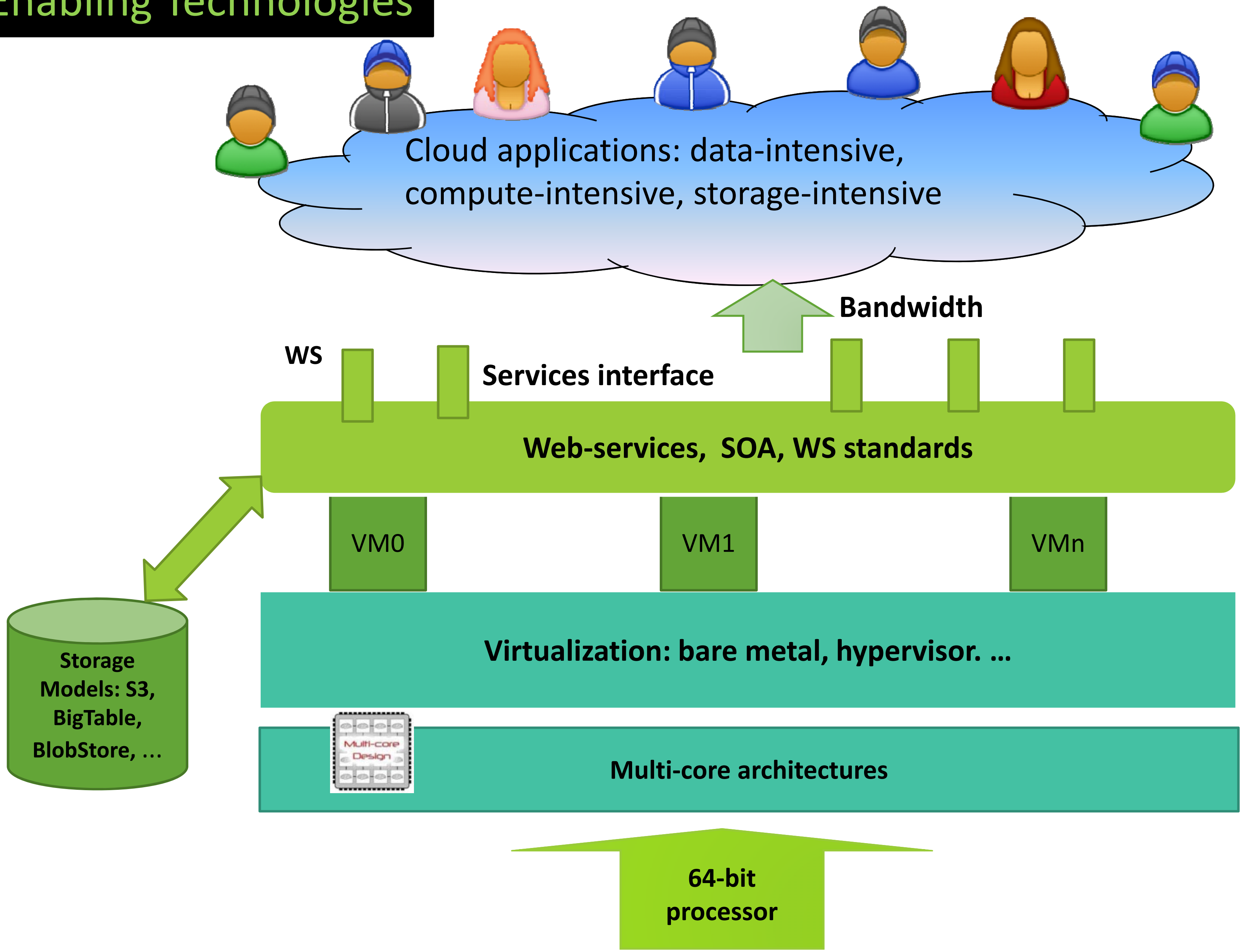


A **private cloud** is basically an organization that needs more control over their data than they can get by using a vendor hosted service.

A **hybrid cloud** combine both public and private cloud models

These are built for the exclusive use of one organization, providing the utmost control over data, security, and quality of service.

Enabling Technologies



Cloud Implementation

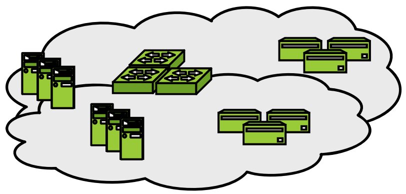
End Users ❯ Service Portal ❯ Service Request Catalog ❯

- Easy to access, easy to use Service Request Catalog
- Hides underlying complex infrastructure from user and shifts focus to services provided
- Enables the ability to provide standardized and lower cost services
- Facilitates a granular level of services metering and billing
- Workload standardization eases complexity

Provisioning Engine
- Workflows
- Expert Systems
- Scripts

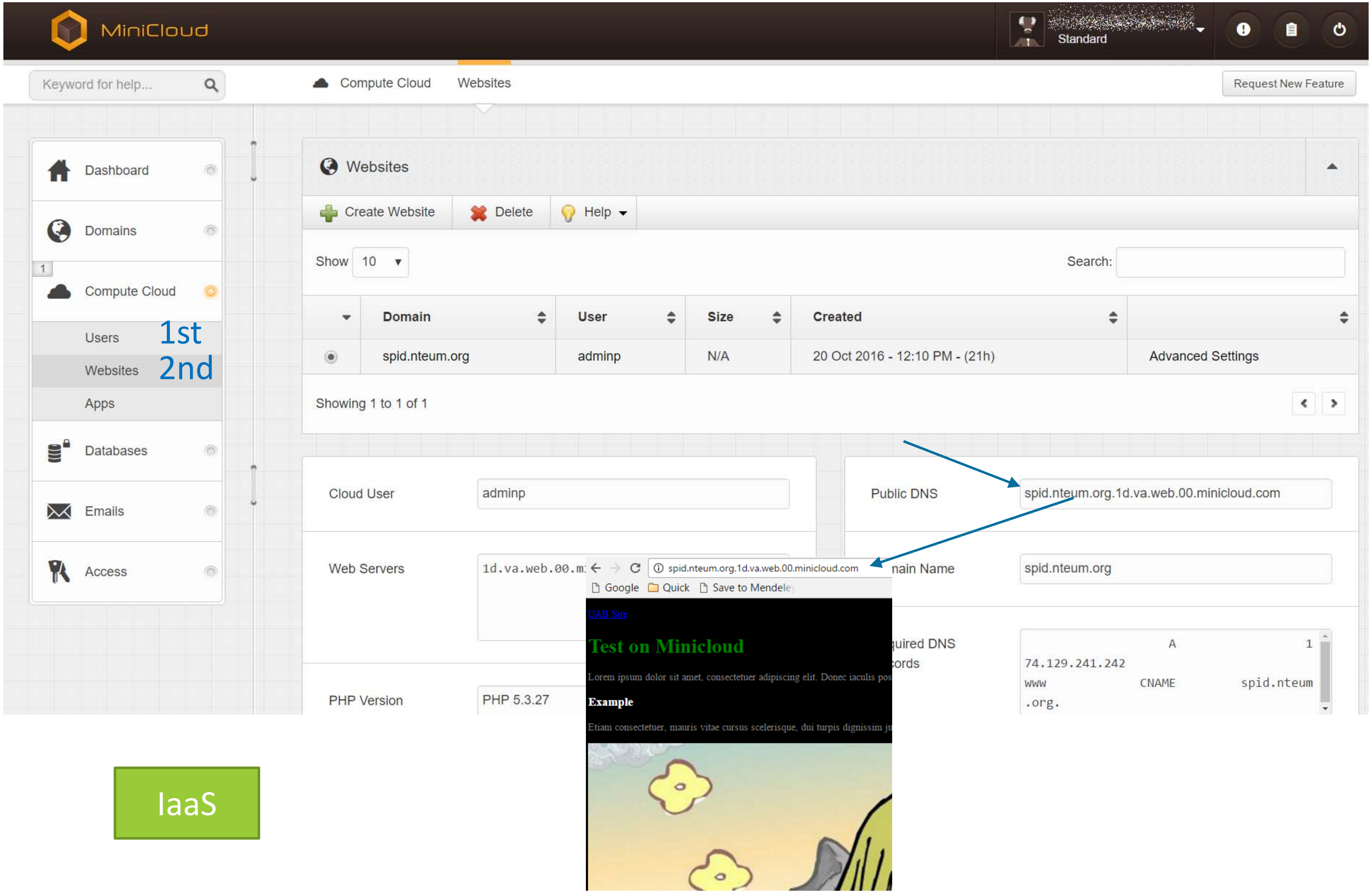
Optional Service Modules
- e.g. Metering/ Usage Billing, Monitoring, etc.

Virtualized Cloud Infrastructure



Cloud Implementation: MiniCloud (.c

End Users → Service Portal → Service Request Catalog

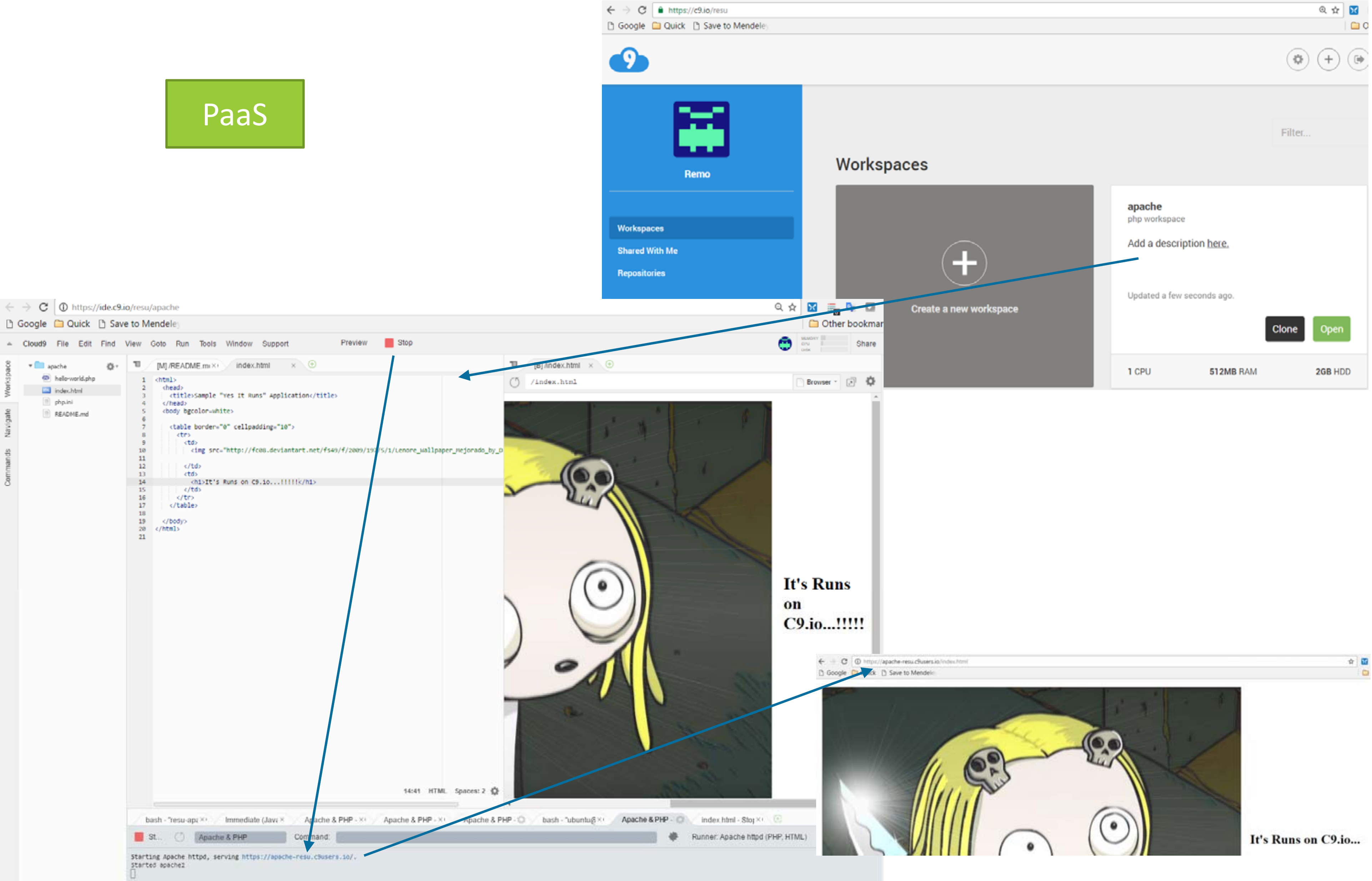


IaaS

Cloud Implementation: Cloud9 (c9.io)

End Users → Service Portal → Service Request Catalog

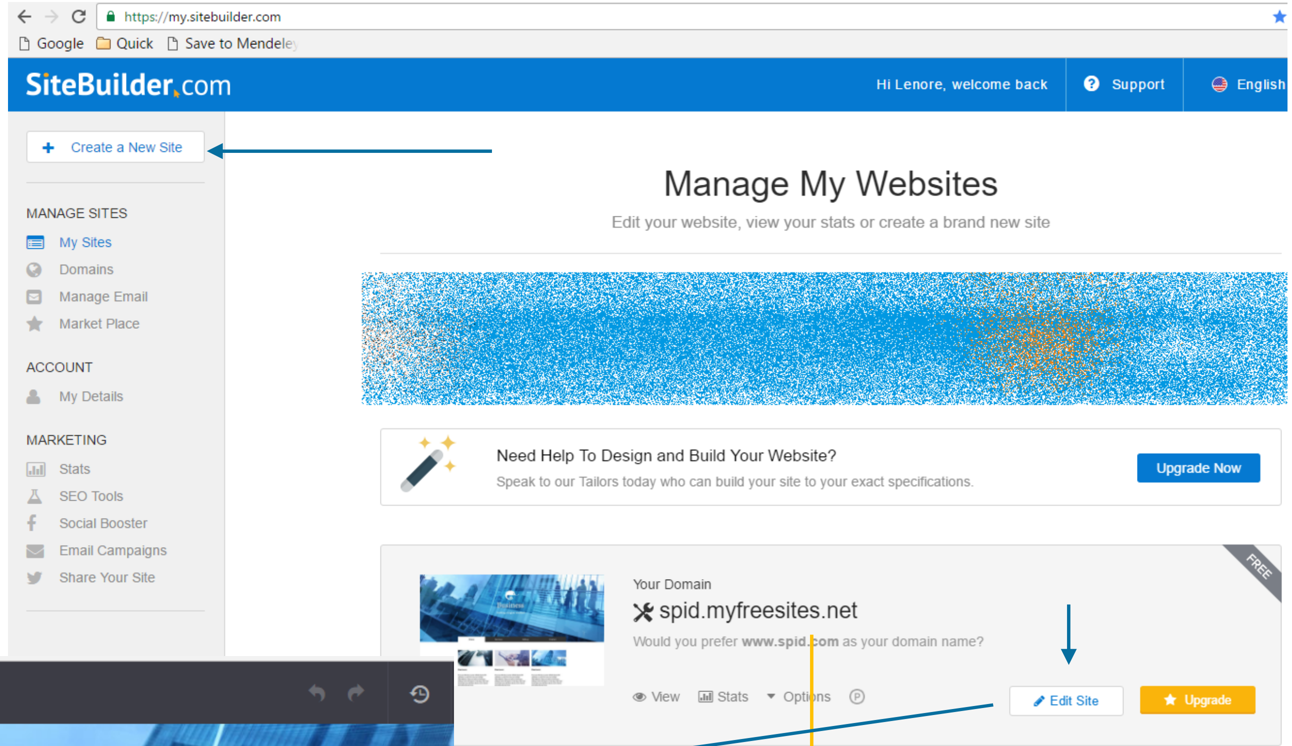
PaaS

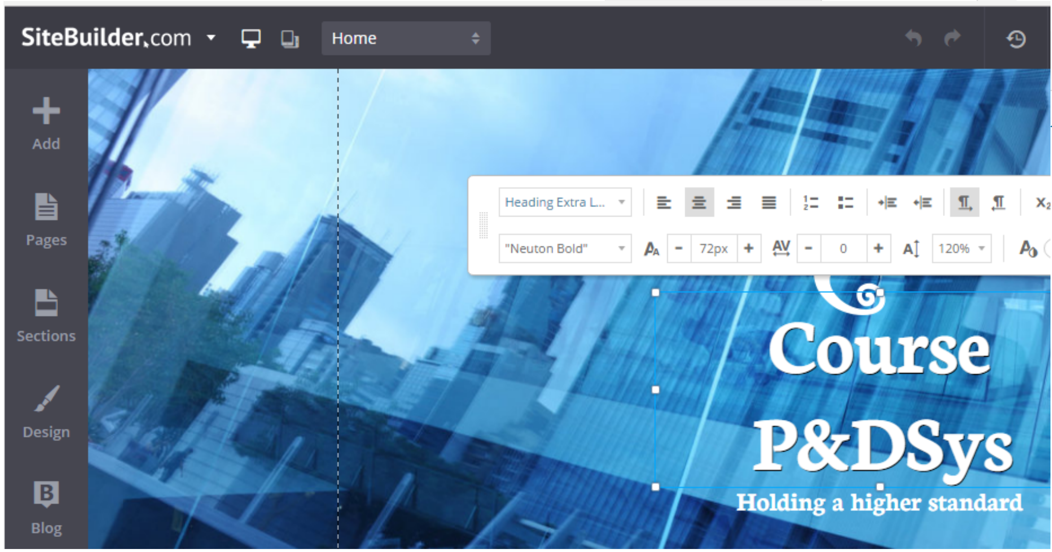


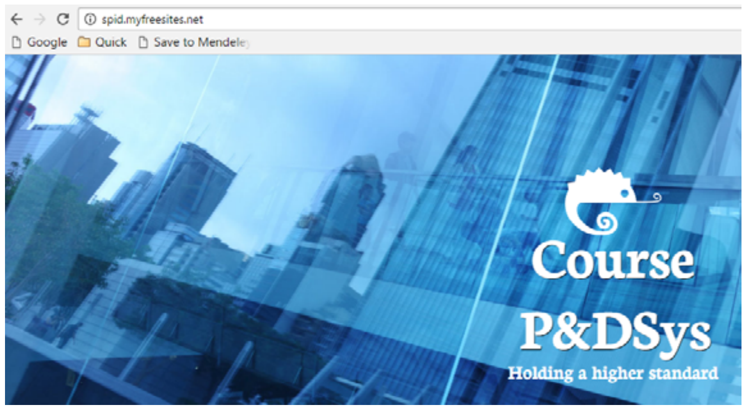
Cloud Implementation: sitebuilder (.com)

End Users → Service Portal → Service Request Catalog

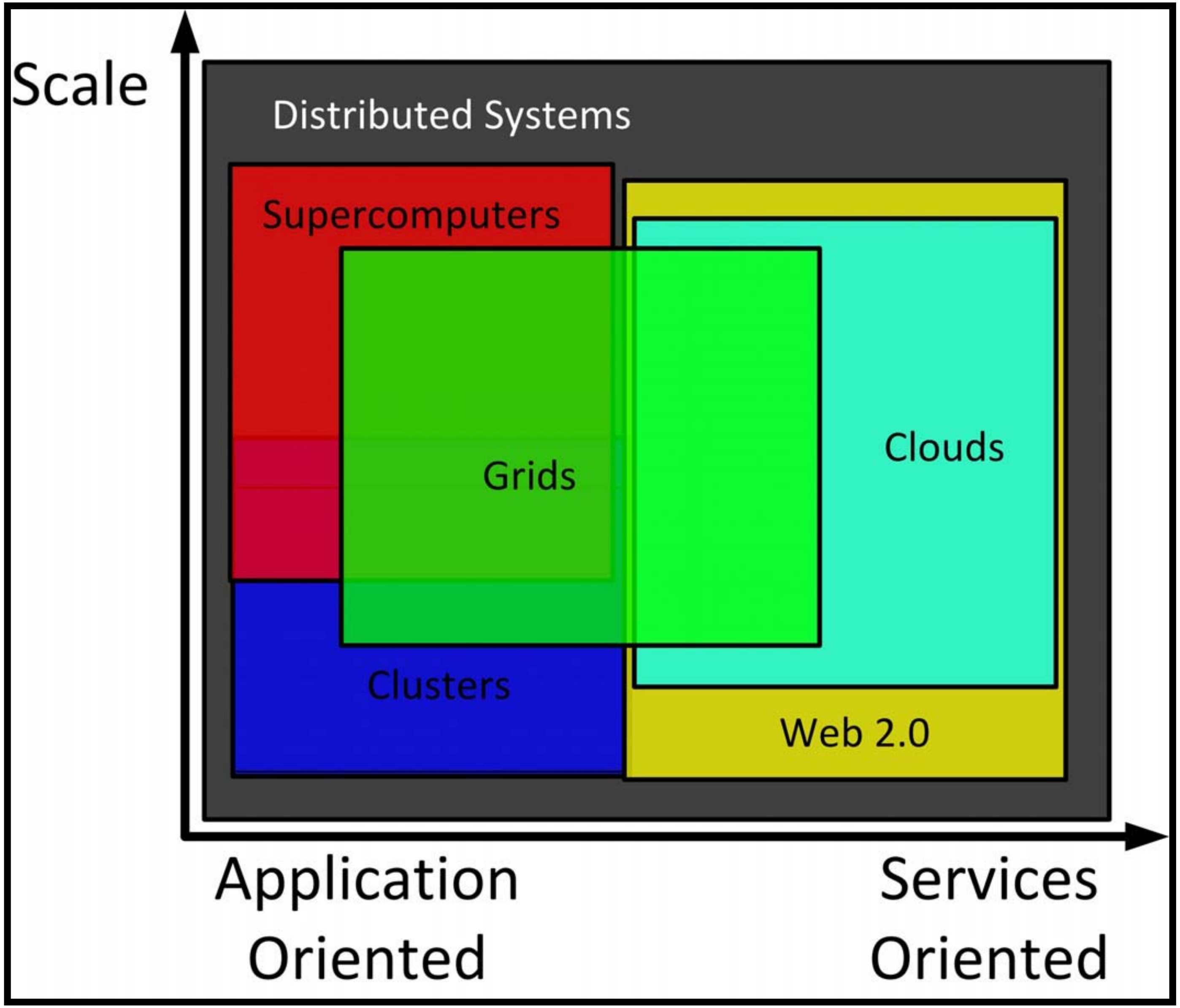
SaaS







Relation with other Paradigms of Distributed Computing



Major Players' Cloud Computing Services

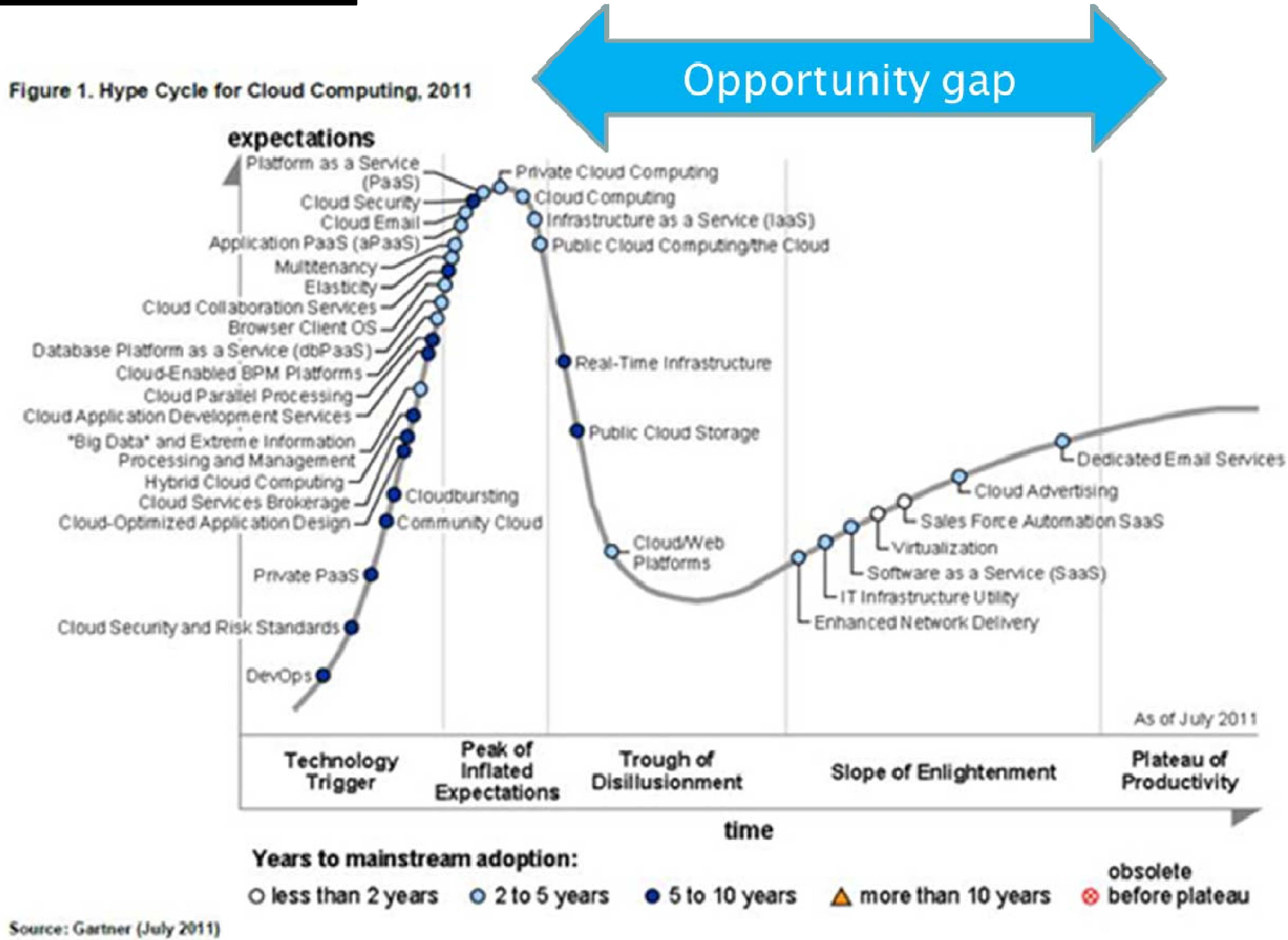
The Best Cloud Computing Companies And CEOs To Work For In 2014

Forbes February 2014.

Company Name	(%) of employees who would recommend this company to a friend	(%) of employees who approve of the CEO as of February 23, 2014 on Glassdoor	CRN Survey Classification
FinancialForce.com	98%	100%	Cloud Software
Intacct	96%	100%	Cloud Software
MuleSoft	91%	85%	Cloud Platforms and Development
Zoho	91%	98%	Cloud Software
Google	90%	95%	Cloud Software
Tableau Software	85%	95%	Cloud Software
Red Hat	84%	96%	Cloud Platforms and Development
SAP	83%	93%	Cloud Software
RackSpace	80%	88%	IaaS
Workday	78%	94%	Cloud Software
Microsoft	77%	83%	IaaS
Cisco Systems	76%	75%	IaaS
Salesforce.com	76%	93%	Cloud Software
Nebula	75%	83%	IaaS
EMC	72%	88%	IaaS
LogMeIn	71%	86%	Cloud Platforms and Development
Avalara	71%	76%	Cloud Software
Veracode	68%	69%	Cloud Security
Cloudscaling	67%	100%	IaaS
Amazon Web Services	66%	82%	IaaS
Parallels	66%	89%	Cloud Platforms and Development
Marketo	66%	83%	Cloud Software
NetSuite	66%	76%	Cloud Software
Oracle	65%	78%	Cloud Software
Zscaler	65%	89%	Cloud Security
IBM	59%	68%	IaaS

http://www.forbes.com/sites/louiscolumbus/2014/02/24/the-best-cloud-computing-companies-and-ceos-to-work-for-in-2014/

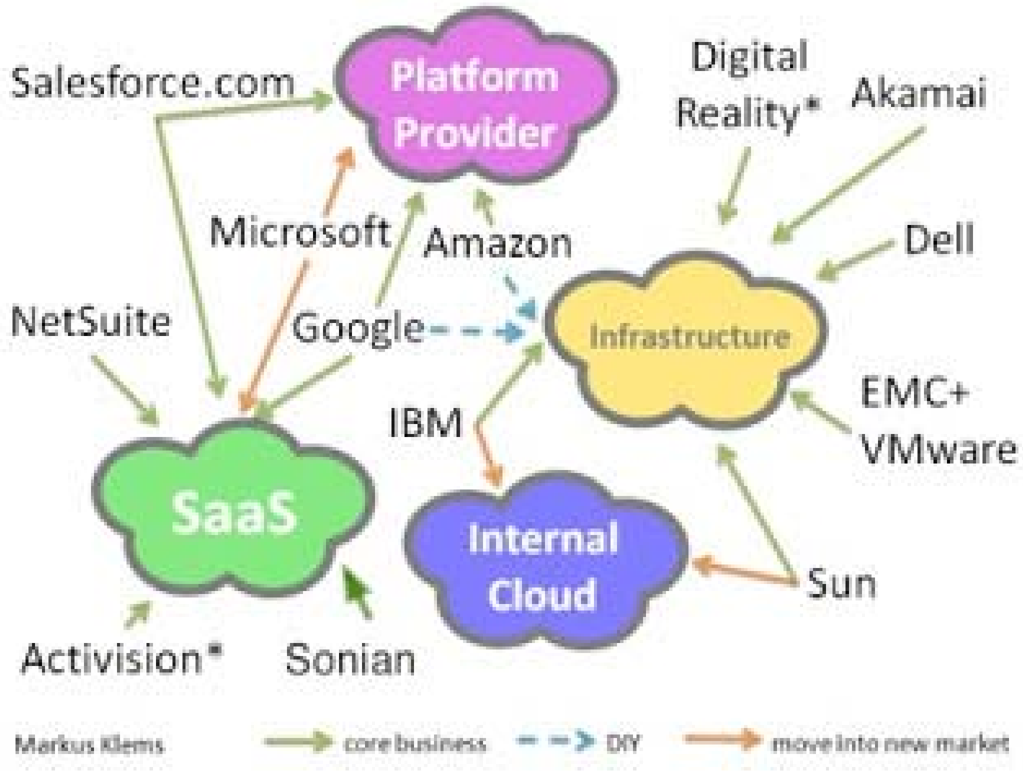
Gartner Hyper-cycle



Types of Cloud Services

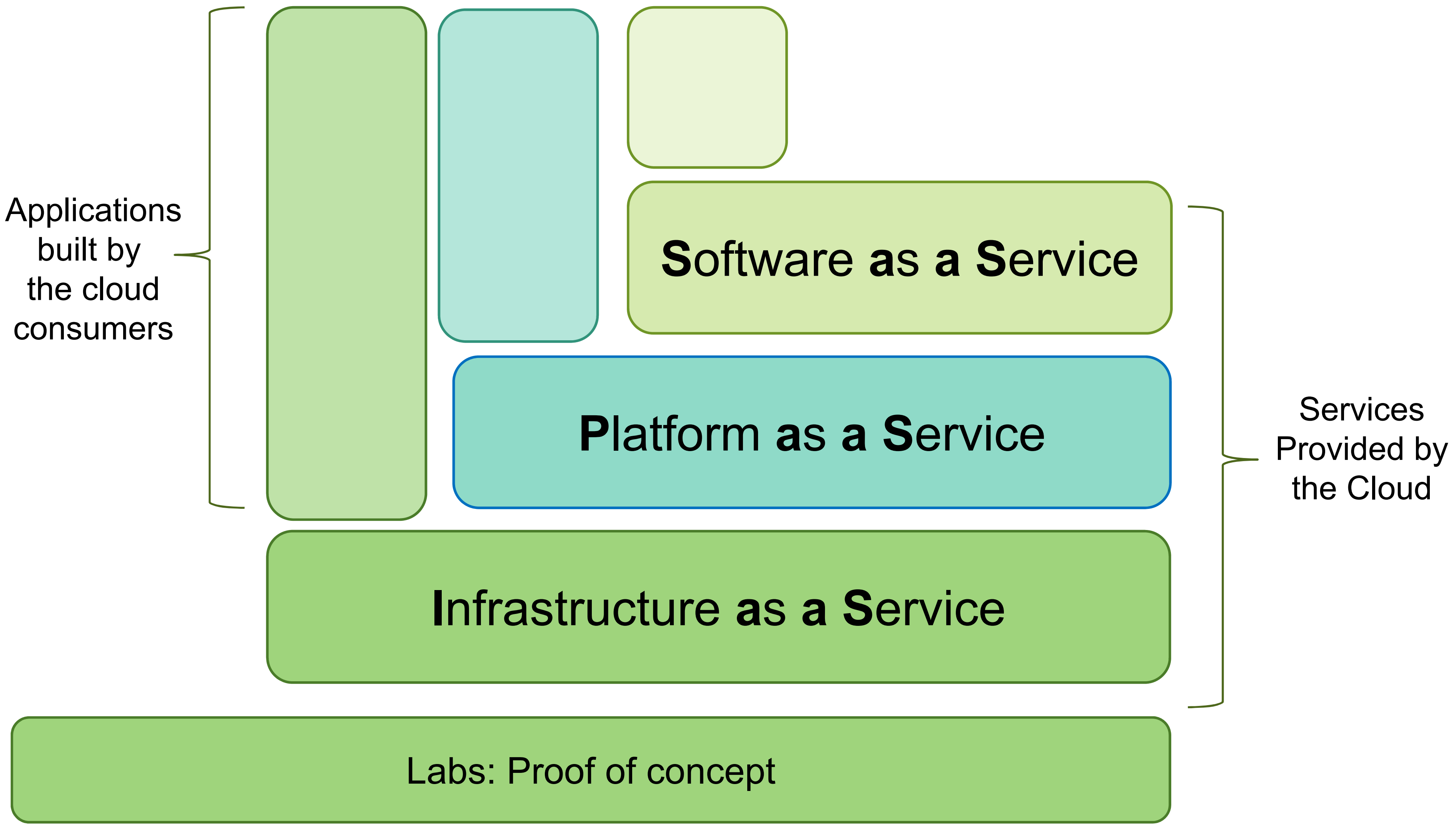
Everything-as-a-Service

1. **IaaS**
2. **PaaS**
3. **SaaS**
4. Business-as-a-service
5. Storage-as-a-service,
5. Desktop-as-a-service,
6. Disaster recovery-as-a-service,
7. Marketing-as-a-service
8. Healthcare-as-a-service.
9. …



Merrill Lynch Report

Types of Cloud Services



Source: http://itechthoughts.wordpress.com/2010/02/23/cloud-computing-the-new-it-paradigm/

Characteristics & Types of cloud computing

Virtual.
Software, Databases, Web servers, Operating systems, Storage and Networking as virtual servers.

On demand.
Add and remove processors, memory, network bandwidth, storage.

Types

SaaS
Software as a Service

PaaS
Platform as a Service

IaaS
Infrastructure as a Service

Characteristics & Types of cloud computing

Just run it for me!
Key Technology:
Everybody has their own secret sauces, but
Ajax is de-facto front-end

SaaS
Software as a Service

Software delivery model

- No hardware or software to manage,
- Service delivered through a browser (are fully managed and hosted) & don't require installation of specialized software,
- Customers use the service on demand,
- Instant Scalability & allow for anytime, anywhere access (usually 24/7 services),
- have regular recurring payments (Pay-As-They-Go and Pay-As-They-Grow),
- Have multiple tenants on servers.

Examples:
1. Your current CRM package is not managing the load or you simply don't want to host it in-house. Use a SaaS provider such as Salesforce.com

2. Your email is hosted on an local server in your office and it is very slow. Outsource this using *Hosted Service* or buy a *Full Service* to provide it.

Some Web-based applications such as Hotmail, Google Apps, Skype, and many 2.0 applications, while most business-oriented SaaS, such as Sales Force, is leased on a subscription basis

Characteristics & Types of cloud computing

PaaS
Platform as a Service

Give me nice API and take care of the implementation
Key Technology: New cloud programming paradigm, i.e. MapReduce, PIG, HIVE,…

Platform delivery model

Platforms are built upon Infrastructure, which is expensive
Estimating demand is not a science!
Platform management is not fun!

Examples:
1. You need to host a large file (5Mb) on your website and make it available for 35,000 users for only two months duration. Use Cloud Front from Amazon.

2. You want to start storage services on your network for a large number of files and you do not have the storage capacity…use Amazon S3.

Bundles all stack components (hardware, infrastructure, storage) together with database, security, workflow, user interface, and other tools that allow users to create and host powerful business applications, web sites, and mobile apps.

Examples
Sales force http://www.force.com
800APP http://www.800app.com

Characteristics & Types of cloud computing

Why buy machines when you can rent cycles?
Key Technology: Virtualization

IaaS
Infrastructure as a Service

Computer infrastructure delivery model

A platform virtualization environment

Computing resources, such as storing and processing capacity.

Virtualization taken a step further

Examples:

1. You want to run a program in 100 cores but you don't have the infrastructure necessary to run it in a timely manner. Use Amazon EC2.

2. You want to host a website, but only for a few days. Use Flexiscale.

Provides user computing resources and storage comprised with many servers as an on-demand and "pay per use" service: Data Center, Bandwidth, Private Line Access, Servers and Server Room, Firewall, Storage space .....

Examples:

Amazon : EC2 (ElasticComputeCloud)

Rackspace: cheaper than EC2

Characteristics & Types of cloud computing

IaaS
Infrastructure as a Service

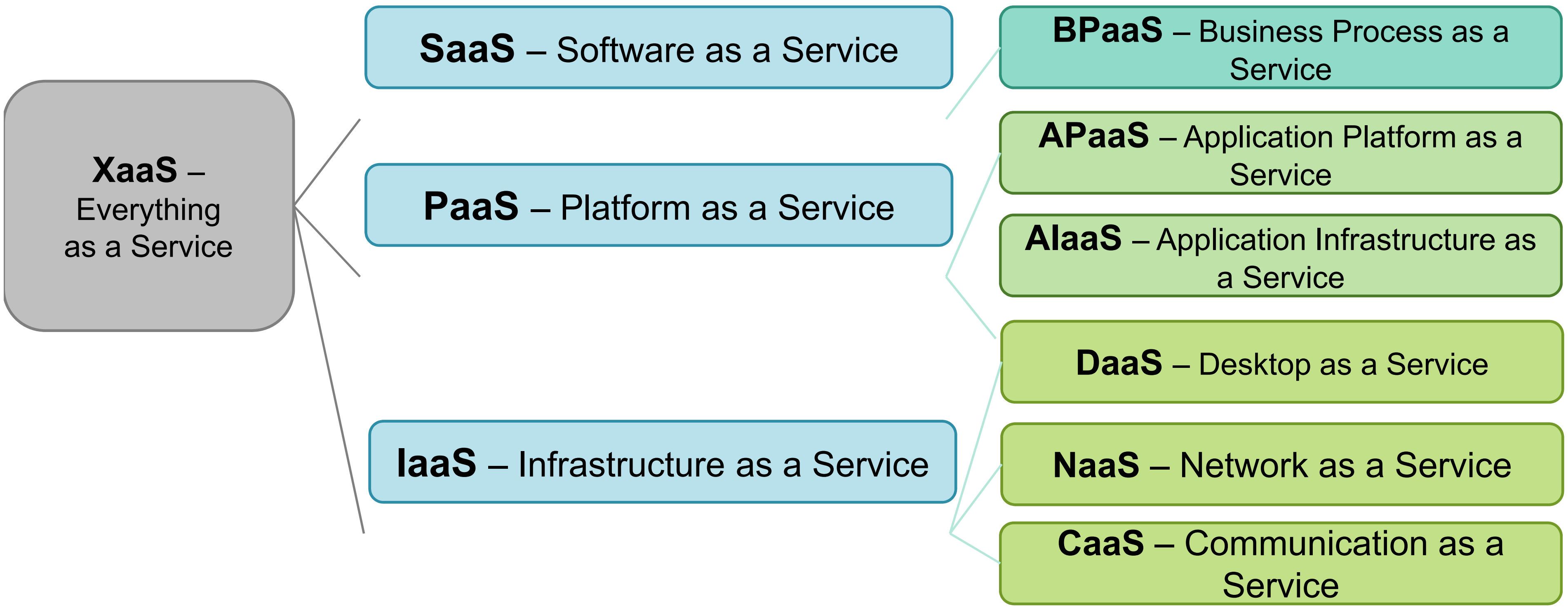
Infrastructure includes **servers, software, network equipment, data storage media, and data center space**.
Platforms consist of operating systems and product development tools.
Applications include the software that has been developed to attend to specific tasks such as accounting or production scheduling.

Rather than purchasing servers, software, data-center space or network equipment, clients instead buy those resources as a fully outsourced service.
Suppliers typically bill such services on a utility computing basis and amount of resources consumed (and therefore the cost) will typically reflect the level of activity.

In a cloud computing environment, users can buy Infrastructure-as-a-Service (IaaS), availing the memory, CPU, IP addresses, and data storage space that they require. Using the APIs made available by the service provider, users can access these resources over the Internet through their local workstations.

Characteristics & Types of cloud computing

There are a number of other models emerging that for some analysts will have a classification of their own, not falling within the models just described. Some examples of these are:



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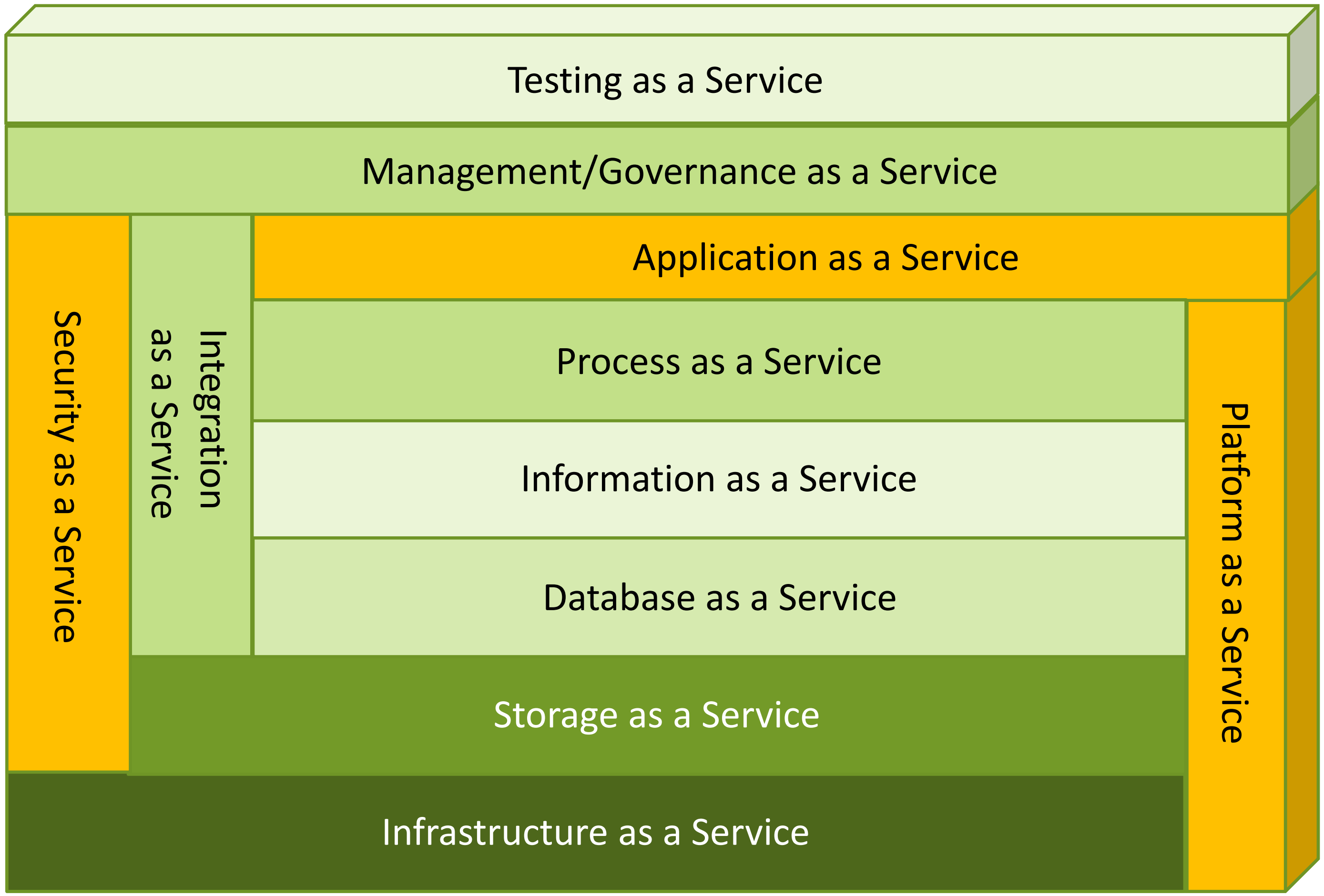
Characteristics & Types of cloud computing



Source : Cloud Computing Deep Dive, Inforworld, Sep. 2009

How much data?

20TB/month: WaybackMachine:435 billion web pages saved over time. Photo uploaded to FB/month

120 TB: all data collected from Hubble.

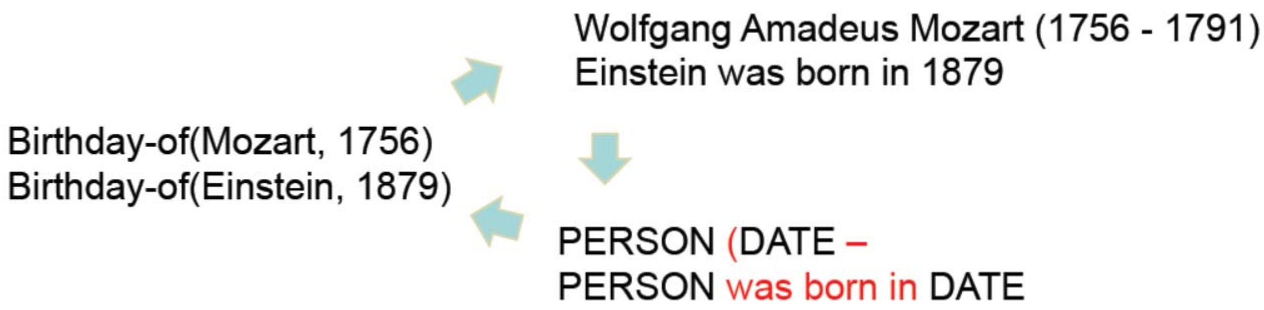
330 TB: data of LHC produce every week

530 TB: all videos in YouTube

1 PB: data processed by Google every 72 minutes

5 EB (1k PB) “all words ever spoken by human beings”

What to do with more data?
Answering factoid questions: Pattern matching on the Web, Works amazingly well (Who shot Abraham Lincoln? → X shot Abraham Lincoln), Learning relations (Start with seed instances, Search for patterns on the Web, Using patterns to find more instances)



How much data?

There are huge volumes of data in the world:

- From the beginning of recorded time until 2003, we created 5 billion gigabytes (exabytes) of data.
- In 2011, the same amount was created every two days
- In 2013, the same amount of data is created every 10 minutes.

But having data bigger it requires different approaches:

Techniques, tools, architecture

… with an aim to solve new problems

Or old problems in a better way

Volume: growing data of all types, easily amassing terabytes—even petabytes—of information.

- Turn 12 terabytes of Tweets created each day into improved product sentiment analysis
- Convert 350 billion annual meter readings to better predict power consumption

Velocity: Sometimes 2 minutes is too late. For time-sensitive processes such as catching fraud, big data must be used as it streams into your enterprise in order to maximize its value.

- Scrutinize 5 million trade events created each day to identify potential fraud
- Analyze 500 million daily call detail records in real-time to predict customer churn faster
- The latest I have heard is 10 nano seconds delay is too much.

Variety: Big data is any type of data - structured and unstructured data such as text, sensor data, audio, video, click streams, log files and more. New insights are found when analyzing these data types together.

- Monitor 100’s of live video feeds from surveillance cameras to target points of interest
- Exploit the 80% data growth in images, video and documents to improve customer

Cloud Computing: A delicate balance of risk and benefit

Cloud Computing @ Daily Life

Cloud Computing Activities by Different Age Cohorts

Internet users in each age group who do the following online activities (%)

	18-29	30-49	50-64	65+
Use webmail services such as Hotmail, Gmail, or Yahoo! mail	77%	58%	44%	27%
Store personal photos	50	34	26	19
Use online applications such as Google Documents or Adobe Photoshop Express	39	28	25	19
Store personal videos	14	6	5	2
Pay to store computer files online	9	4	5	3
Back up hard drive to an online site	7	5	5	4
Have done at least one activity	87%	71%	59%	46%
Have done at least two activities	59	39	31	21

Source: Pew Internet & American Life Project April-May 2008 Survey. N=1,553 Internet users. Margin of error is ±3%.

69% of Americans used cloud computing services

Why Cloud Computing is significant?

Cloud computing reduce energy consumption significantly. The 1000 plus US government data centers, for example, were consuming 6 billion kWh of energy in 2006, and this value is duplicated is doubled every 5 years.

Cloud computing involves centralizing the computing resources on the Internet (the cloud) and making these available to those who need it, when needed. Because the resources are shared by many, capacity utilization goes up. And modern developments like virtualization can make the same resources available to multiple users "simultaneously," thus reducing the need for physical resources even further.

Why Cloud Computing is significant?

At the micro level, enterprises that used cloud computing services are freed of worrying about the technological issues related to IT installations. They can replace their complex installations of servers, workstations, networking and numerous applications with simple workstation computers and fast Internet connectivity. The cloud service providers will attend to the infrastructure, platforms and even applications needed by the enterprises.

Cloud computing resources are available immediately as soon as the agreement with the service provider is executed. Under the utility model of service provision, users are charged only for what they use, for the memory, CPU, data transfer, I/O requests, storage space and so on. As the business expands, the enterprises can seamlessly expand their computing capacities.

Downsides of Cloud Computing

Service level agreements – What assurances do we have for uptime, legal protection, and **security**? **Data lock-in**

Uptime and reliability – How does this provider compare to being able to locally host and manage our resources?

Cost and affordability – What personnel and technology resources are involved with a hosted versus local solution? How does this cost model look over time?

Legal and organizational issues – What organizational and legal issues do we need to consider? Are we dealing with patron data? Are we sure that the platform and our connection to it are secure?

Staff knowledge – How would migrating to this platform impact staff knowledge and competency? Do we know everything that we need to know?

How does it work?

Multitenancy: Cloud resources (hardware) shared dynamically between customers;

Each customer application in its **own virtual machine**

Isolation for security, privacy

Allows **scheduling** with respect to shared resources

Application in one **VM multithreaded** with user data/profiles/… in other VMs

Novelty: **Pay-As-You-Go** (only for what you need)

Platforms – most famous & popular- (GPL, BSD, Apache…)

AppScale: is a platform that allows users to develop and run/store your own applications based on Google AppEngine and can run as a service or locally.

Cloud Foundry: is an open source plataform developed by VMware as PaaS basically written in Ruby and Go. It can run as a service and also locally.

Apache CloudStack: designed to manage large networks of virtual machines as IaaS and includes all the features necessary for the deployment of an IaaS.

Eucalyptus: compatible platform for building private cloud with AWS. This software allows you to leverage the resources of compute, network and storage to offer self-service deployment of private cloud resources. It is characterized by the simplicity of installation and stability in the environment with high efficiency in the utilization of resources.

Nimbus: is a platform that once installed on a cluster provides IaaS for building private clouds or community and can be configured to support different virtualisation, queuing systems, or Amazon EC2.

Platforms – most famous & popular- (GPL, BSD, Apache…)

OpenNebula: is a platform to manage all the resources of a data center allowing the construction of private, public and hybrid IASS. It provides a lot of services, benefits and adaptations that have allowed it to be one of the most widespread platforms today.

openQRM: is a platform for deploying clouds on a heterogeneous data center. Allows the construction of private, public and hybrid clouds with IaaS.

OpenShift: important commitment of the company and is a platform RH (Origin version) that allows cloud serve in PaaS mode.

OpenStack: is a software architecture that allows the deployment of cloud in the form of IaaS. It is managed through a web control console that allows for the provision and control of all subsystems and provisioning of resources. It is another of the most referenced platforms.

Commercial examples of Public Clouds: Amazon (EC2 Elastic Compute Cloud), Google (Engine for Apps), Microsoft (Azure), IBM (SmartCLOUD), …

Example AWS

Amazon EC2

Elastic Cloud Computing
Virtual servers for rent,
called Amazon Machine Images (AMIs)
Based on Xen
Priced on per hour from $0.013 to $0.56

Amazon S3

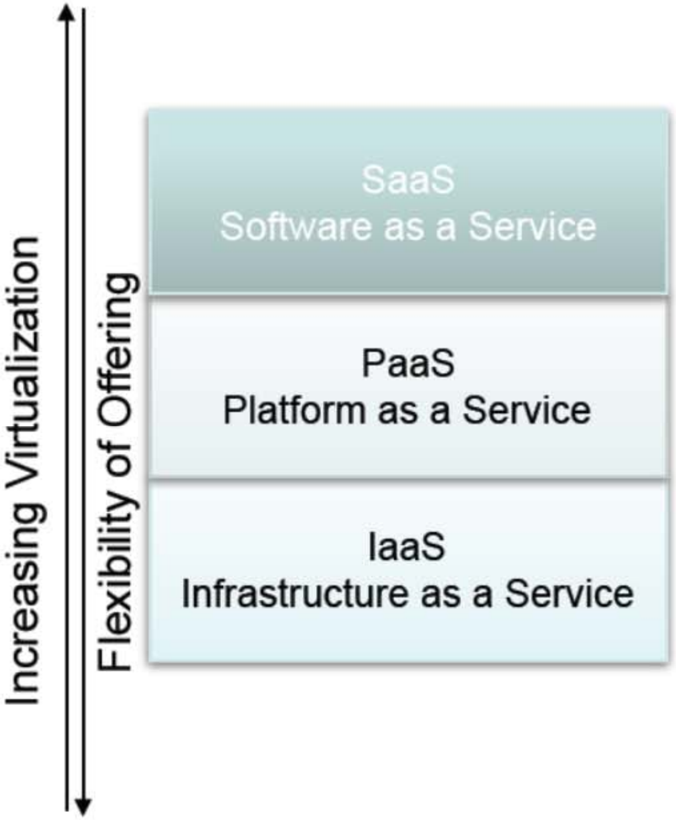
Simple Storage Service
$0.03/GB first 1TB/month ($0.0295 next 49TB/month)
from $0.10 per GB transfer
Via: REST, SOAP, BitTorrent

Free Tier: As part of AWS's Free Usage Tier, new AWS customers can get started with Amazon EC2 for free (each month for one year):

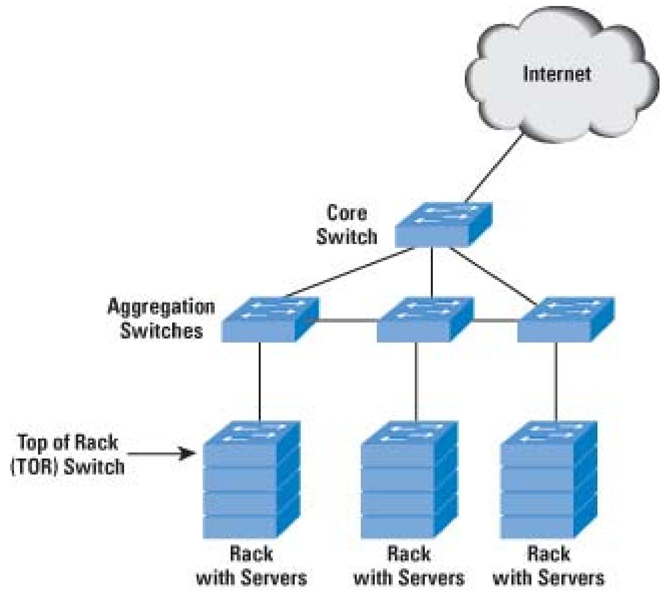
750 hours of EC2 running Linux, RHEL, or SLES t2.micro instance usage
750 hours of EC2 running Microsoft Windows Server t2.micro instance usage
750 hours of Elastic Load Balancing plus 15 GB data processing
30 GB of Amazon Elastic Block Storage in any combination of General Purpose (SSD) or Magnetic, plus 2 million I/Os (with Magnetic) and 1 GB of snapshot storage
15 GB of bandwidth out aggregated across all AWS services
1 GB of Regional Data Transfer

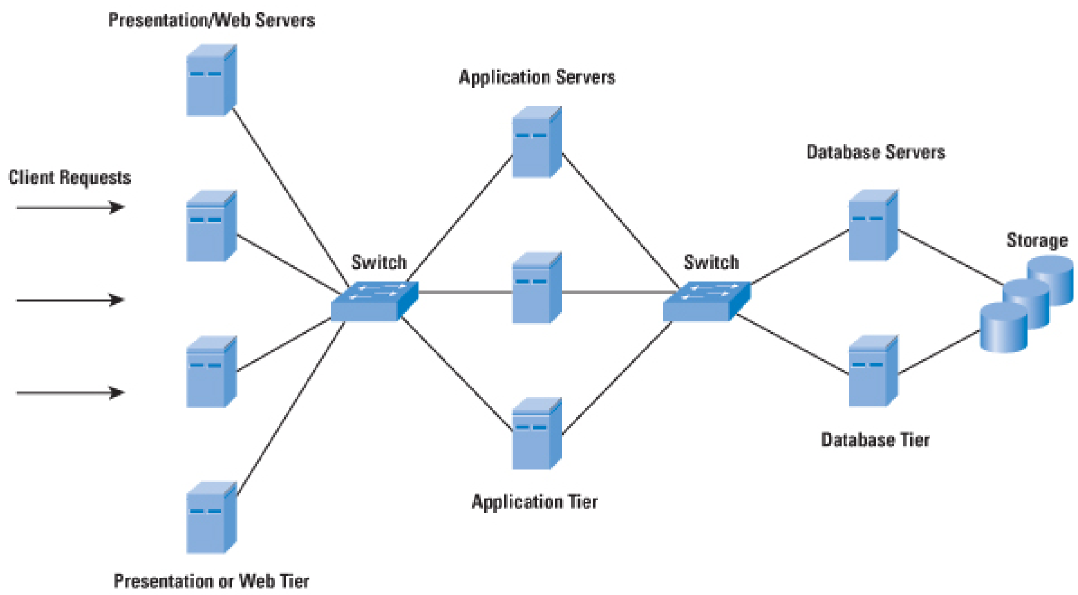
https://aws.amazon.com/ec2/pricing/

Example of Business



Example of Infrastructure





Data-center architecture often follows the common three-layer network topology of access, aggregation, and core networks with enabling networking elements (switches and routers).

The servers can be connected through a 1-Gbps link to a Top of Rack (TOR) switch, which in turn is connected through one or more 10-Gbps links to an aggregation End of Row (EOR) switch.

The EOR switch is used for interserver connectivity across racks. The aggregation switches themselves are connected to core switches for connectivity outside the data center.

From a functional perspective, data-center server organization has often adopted a three-tier architecture (a specific case of an N-tier architecture).

The three-tier functional architecture has a web or Presentation Tier on the front end, an Application Tier to perform the application and business-processing logic, and finally a Database Tier (to run the database management system), which is accessed by the Application Tier for its tasks.

Example of Cloud Infrastructure

IaaS Infrastructure

The cloud is seen as an extension of the existing data center. You would specify the number of servers in each tier, load the appropriate server image (web, business logic, or database manager), and "connect" them (through a menu or API provided by the IaaS provider) by specifying the links between them.

You can also specify the network connectivity at this time (more on this later). For an enterprise IT administrator, this model provides the greatest degree of control and, to an extent, a familiar operating topology

PaaS and SaaS Infrastructure

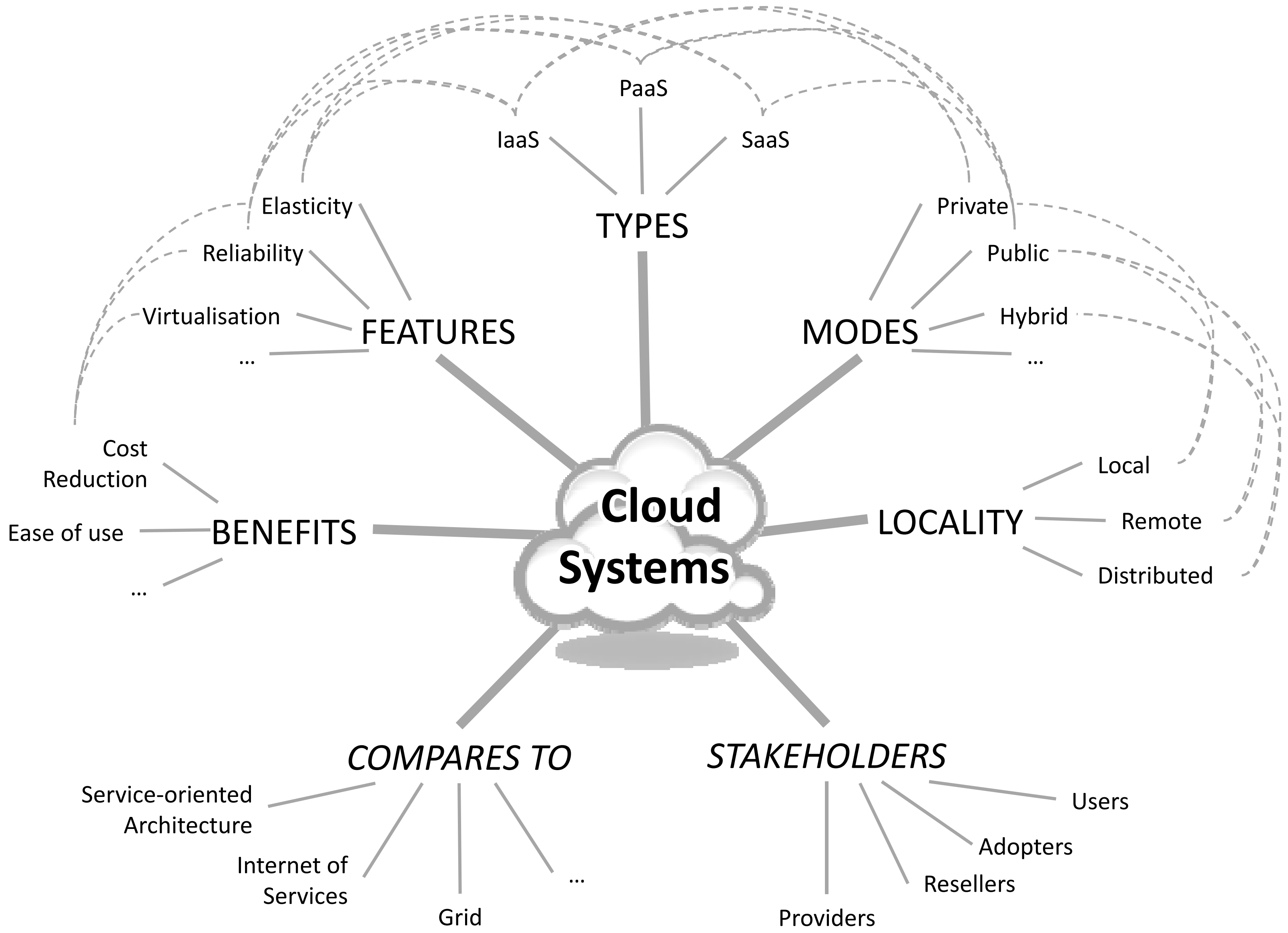
In the case of PaaS, you transfer more control to your cloud service provider. The platform used to build the service you require can scale transparently without any of your involvement other than at the time of configuration. You do not need to understand the tier connectivity, bandwidth requirements, or how it all functions under the hood (often with a three-tier topology similar to that for traditional data centers).

SaaS vendors have the highest degree of control among the three models. The realization of the network topology can be similar to existing data centers and scale up or down according to the number of users that are added. However, because they offer a specific set of applications to the cloud users, their server and network topology is quite straightforward.

Normally all discussions will use IaaS as the representative cloud service model, with a primary consideration being "cloud bursting"—how an existing IT infrastructure can take advantage of the power of the cloud when it needs additional resources.

In addition, we will assume a **virtualized server infrastructure** for the IaaS cloud because this infrastructure provides a greater degree of flexibility for cloud service providers (Amazon being a key example).

Resume


Cloud Systems
TYPES
IaaS
PaaS
SaaS
FEATURES
Elasticity
Reliability
Virtualisation
...
MODES
Private
Public
Hybrid
...
BENEFITS
Cost Reduction
Ease of use
...
LOCALITY
Local
Remote
Distributed
COMPARES TO
Service-oriented Architecture
Internet of Services
Grid
...
STAKEHOLDERS
Users
Adopters
Resellers
Providers

Other Computing Techniques

Cloud Computing
Next-Generation Internet Computing
Next-Generation Data Centers

Software as a Service
Networked-based subscriptions to applications
Gained momentum in 200

Utility Computing
Offering computing resources as a metered service
Introduced in late 1990s

Grid Computing
Solving large problems with Parallel Computing
Made Mainstream by Globus Aliance

Cluster (Linux)

Mainframe (supercomputer)

Industry = Transformed

Disney rendered its new animated film on a 55,000-core supercomputer

by Joseph Volpe | @jrvolpe | October 18th 2014 at 5:00 pm

During the film, more than 800 Vikings appeared in a single shot and more than 2,500 dragons appeared in another single shot! The entire film is comprised of 1,630 shots which is the highest shot count in a film produced by DreamWorks Animation to date. DreamWorks definitely needed a powerful machine to make this happen!

To create the thousands of fire-breathing flying dragons and hundreds of armored Vikings, DreamWorks Animation artists used our ultra powerful HP Z800 Workstations. The film used nearly 100 terabytes of data and more than 50 million render hours. Our HP Z800 Workstations were not only able to keep up, but they helped artists get the movie done fast. DreamWorks Animation's current render farm - which is a group of computers that work in concert to process animation sequences - is the largest and most powerful render farm ever used in the studio's production of a computer-generated animated film. Relying on a render farm that is comprised more than 25,000 computing cores, "How to Train Your Dragon" kept nearly 10,000 cores busy almost 100 percent of the time – 24 hours a day, 7 days a week for 28 weeks.

Industry = Transformed. Why?

DreamWorks Animation "Shrek the Third": Linux Feeds an Ogre

Jun 05, 2007 By Robin Rowe
in Audio/Video

DreamWorks Animation pushes the limits of CG filmmaking with Linux.

From Issue #159
July 2007

All the big film studios primarily use Linux for animation and visual effects. Perhaps no commercial Linux installation is larger than DreamWorks Animation, with more than 1,000 Linux desktops and more than 3,000 server CPUs.

"For *Shrek 3*, we will consume close to 20 million CPU render hours for the making of the film", says DreamWorks Animation CTO Ed Leonard. "Each of our films continues to push the edge of what's possible, requiring more and more compute power." Everyone knows Moore's Law predicts that compute power will double every one and a half years. A little known corollary is that feature cartoon animation CPU render hours will double every three years. In 2001, the original *Shrek* movie used about 5 million CPU render hours. In 2004, *Shrek 2* used more than 10 million CPU render hours. And in 2007, *Shrek 3* is using 20 million CPU render hours.

To create an animated film such as *Rise of the Guardians*, DreamWorks might render as much as 65 million hours of footage to come up with 90 minutes of worthwhile materials.

Movie files occupy as much as 250TB of storage. Each animator might have 96GB of RAM on their personal Z800 or Z820 at a time while the movie is being made.

Most films take 3-5 years to make, but the computer processing time has made a major dent in that timeframe, and has allowed DreamWorks to make more films per year.

Grid Vs. Cloud: Advantages? Downsides?

Share a lot of functionality (to reduce costs?): Architecture and Technology

Difference: programming model, <u>business model</u>, compute model, applications, and virtualization.

The problems are mostly the same: manage large facilities;

Define methods by which consumers discover, request and use resources provided by the central facilities

Implement the often highly parallel computations that execute on those resources.

Virtualization:

In Grid do not rely on virtualization as much as Clouds do, each individual organization maintain full control of their resources.

In Cloud an indispensable ingredient for almost every Cloud

Example: EGEEGRID Vs Amazon

	EGEE Grid	Amazon Cloud
Target Group	Scientific community	Business
Service	short-lived batch-style processing (job execution)	long-lived services based on hardware virtualization
SLA	Local (between the EGEE project and the resource providers)	Global (between Amazon and users)
User Interface	High-level interfaces	HTTP(S), REST, SOAP, Java API, BitTorrent
Resource-side middleware	Open Source (Apache 2.0)	Proprietary
Ease of Use	Heavy	Light
Ease of Deployment	Heavy	Unknown
Resource Management	probably similar	
Funding Model	Publicly funded	Commercial

Summary of „An EGEE Comparative Study: Grids and Clouds Evolution or Revolution" by Markus Klems

Grid Vs. Cloud

	Grid	Cloud
Underlying concept	Utility Computing	Utility Computing
Main benefit	Solve computationally complex problems	Provide a scalable standard environment for network-centric application development, testing and deployment
Resource distribution / allocation	Negotiate and manage resource sharing; schedulers	Simple user <-> provider model; pay-per-use
Domains	Multiple domains	Single domain
Character / history	Non-commercial, publicly funded	Commercial

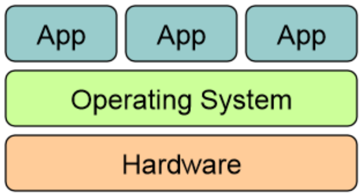
Today's Clouds

On-demand access: Pay-as-you-go, no upfront commitment.
➔Anyone can access it
Data-intensive Nature: What was MBs has now become TBs.
➔ Daily logs, forensics, Web data,…
New Cloud Programming Paradigms: MapReduce/Hadoop, Pig Latin, DryadLinq, Swift, and many others.
➔ High in accessibility and ease of programmability

Combination of one or more of these gives rise to novel and unsolved distributed computing problems in cloud computing.

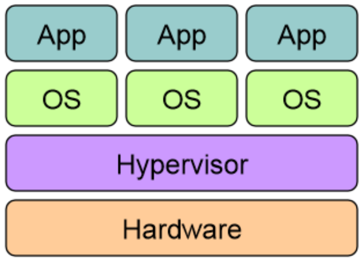
http://www.slideshare.net/DSPIP/cloud-computing-introduction-2978287

Key Technology = Virtualization



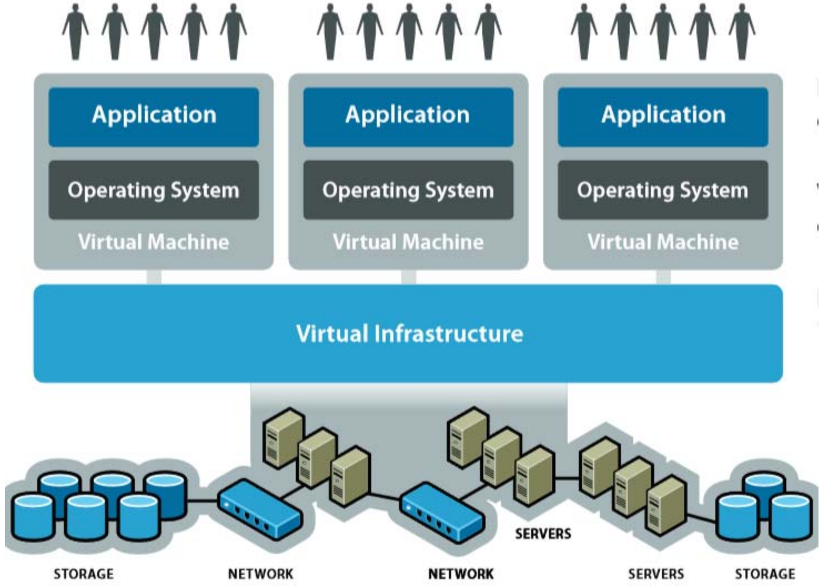
Traditional Stack

5 to 15 % utilization only



Virtualized Stack

High utilization and standardization

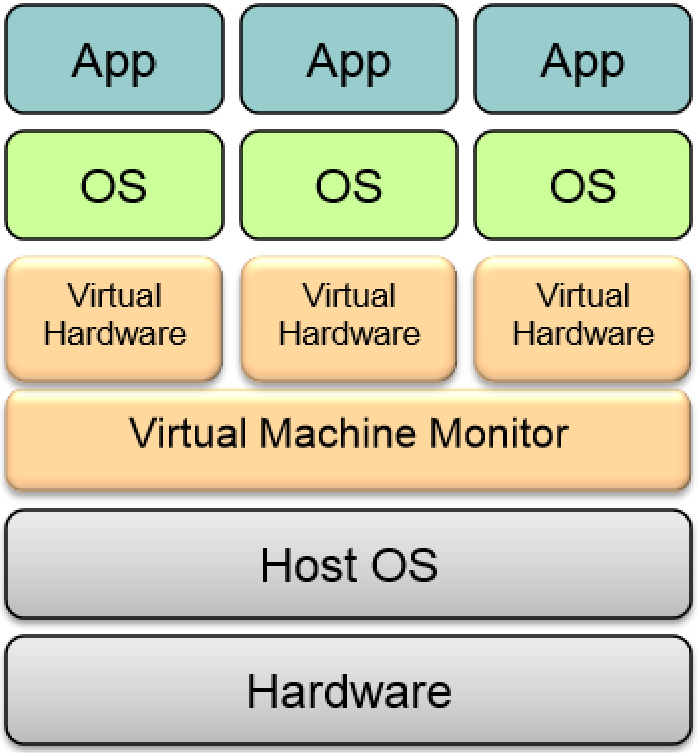


9-9-1 Principle for Hardware Usage = 90% servers, 90% time, 10% utilization
Enterprises that do not leverage virtualization: pay up to 40 percent more
in acquisition costs, and roughly 20 percent more in administrative costs

The x86 architecture is the most popular computer architecture in datacenters today, hence virtual infrastructure has tremendous benefits.
Two leading virtualization approaches to date have been **full virtualization** & **paravirtualization**. AMD & Intel have introduced processor instructions to assist virtualization software

Key Technology = Virtualization

The full virtualization approach allows datacenters to run an unmodified guest OS, thus maintaining the existing investments in OS & applications and providing a nondisruptive migration to virtualized environments.
Normally uses a combination of direct execution and binary translation techniques to achieve full virtualization of an x86 system
Pros: Different OS on a single node
Cons: High cost of hardware instruction translation, low efficiency.



KVM, VMWare (with AMD-V, VT-x)
VirtualBox, …

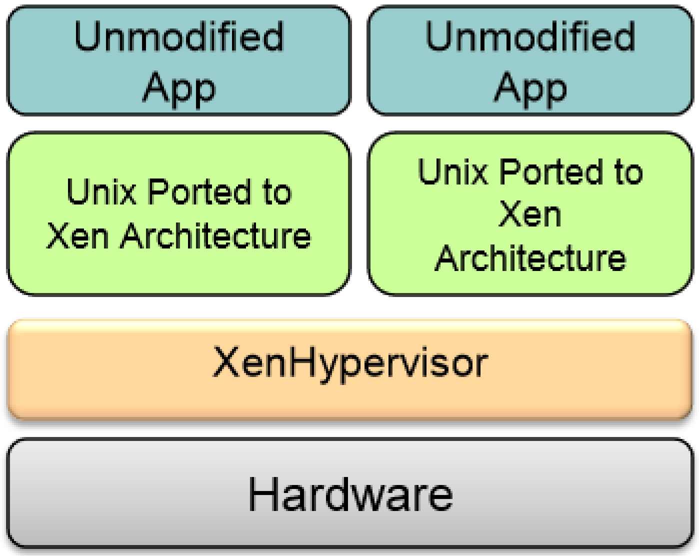
Virtual Machine Monitor (VMM)

VMM as an application on Host OS, no host OS kernel modification touched.
VMM adds an complete set of hardware simulation for guest OS

Key Technology = Virtualization

The paravirtualization approach modifies the guest OS to eliminate the need for binary translation. Therefore it offers potential performance advantages for certain workloads but requires using specially modified operating system kernels.

Xen open source project was designed initially to support paravirtualized operating systems. While it is possible to modify open source OS (Linux, BSD) it is not possible to modify *closed* source operating systems such as Windows. For such unmodified guest OS, a virtualization hypervisor must either adopt the full virtualization approach or rely on hardware virtualization in the processor architecture.



The hardware virtualization support enabled by AMD-V and Intel VT technologies introduces virtualization in the x86 processor architecture itself. The emergence of virtualization hardware assist reduces the need to paravirtualize guest operating systems. Some Xen vendors (Virtual Iron) have announced that they are supporting only full virtualization using AMD-V and Intel VT processors and are not supporting paravirtualization.

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