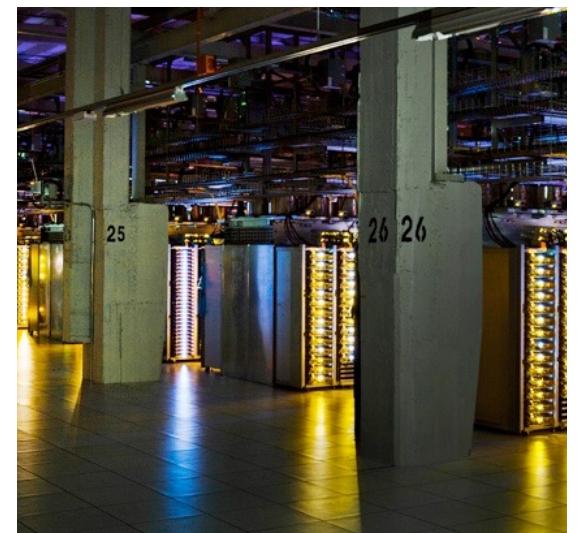


Cloud Computing – Introduction



Prerequisites for this class

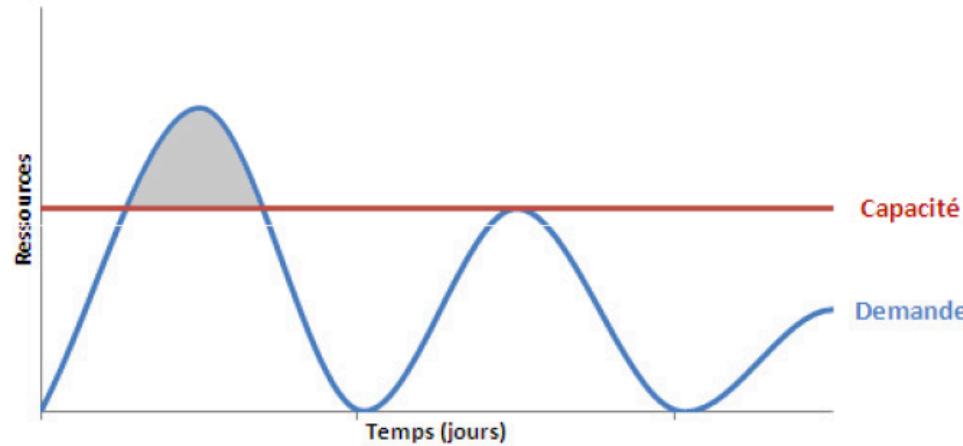
- Skills
 - Java
 - Python
 - Linux command line and shell
- Resources
 - Laptop
 - Mobile phone
 - Google account
 - Amazon Web Services account (requires credit card)

Content

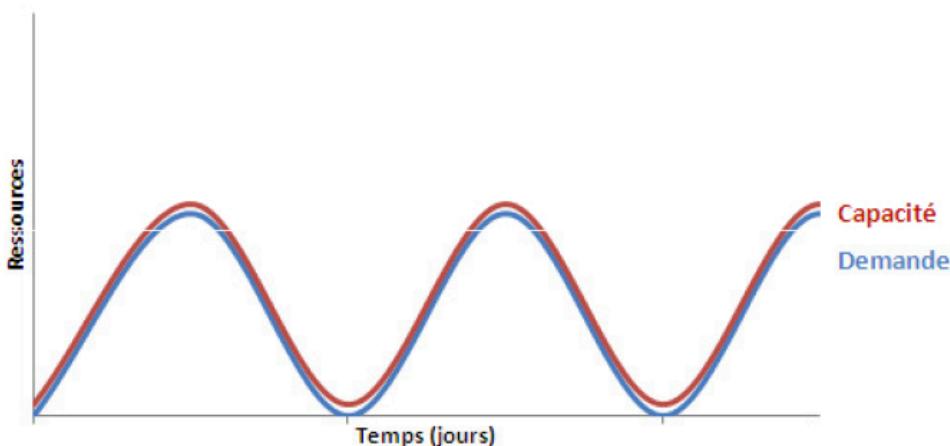
■ Context

- Definition of cloud computing
- Cloud computing service models
- Cloud computing deployment models
- Cloud computing market
- Key drivers for adoption
- Barriers
- Businesses' view of the cloud today

Context

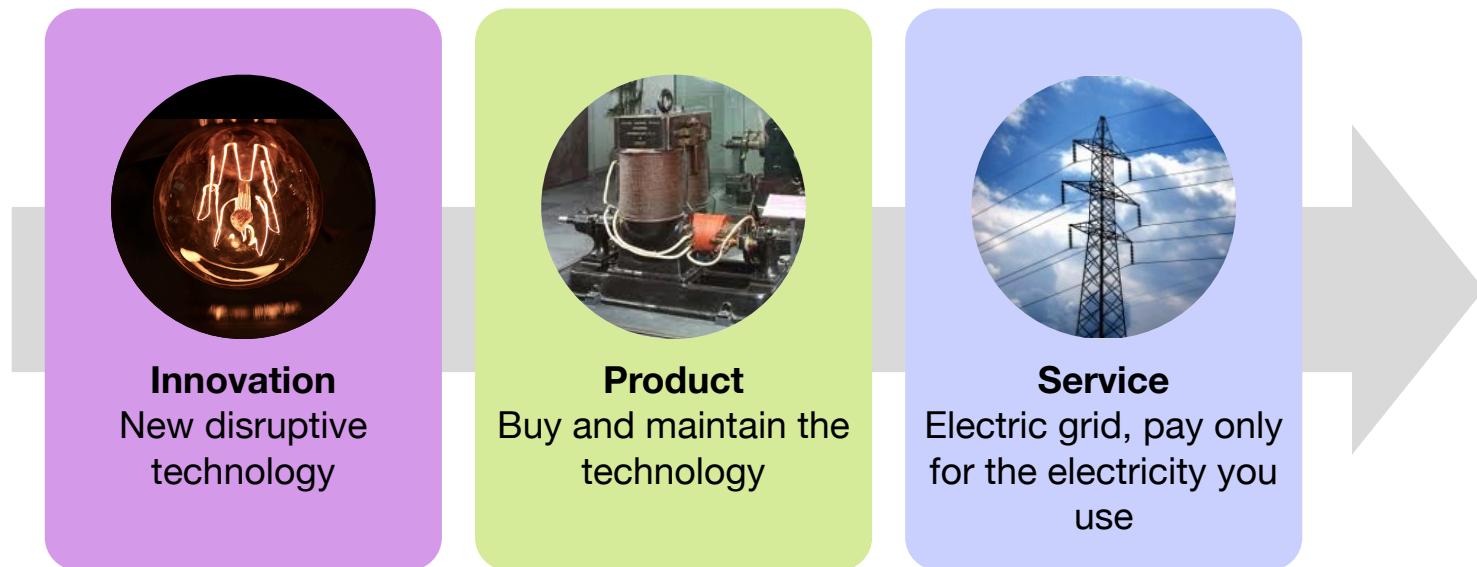


On-premise IT



Cloud computing

Context



Source: M. F. Sakr, Carnegie Mellon University

Context



- Cloud computing is for the information age what electrification is for industrial age
- “ ... in the end, the saving offered by utilities become too compelling to resist, even for the largest enterprises ... ”

The big switch, W.W. Norton et al, 2008

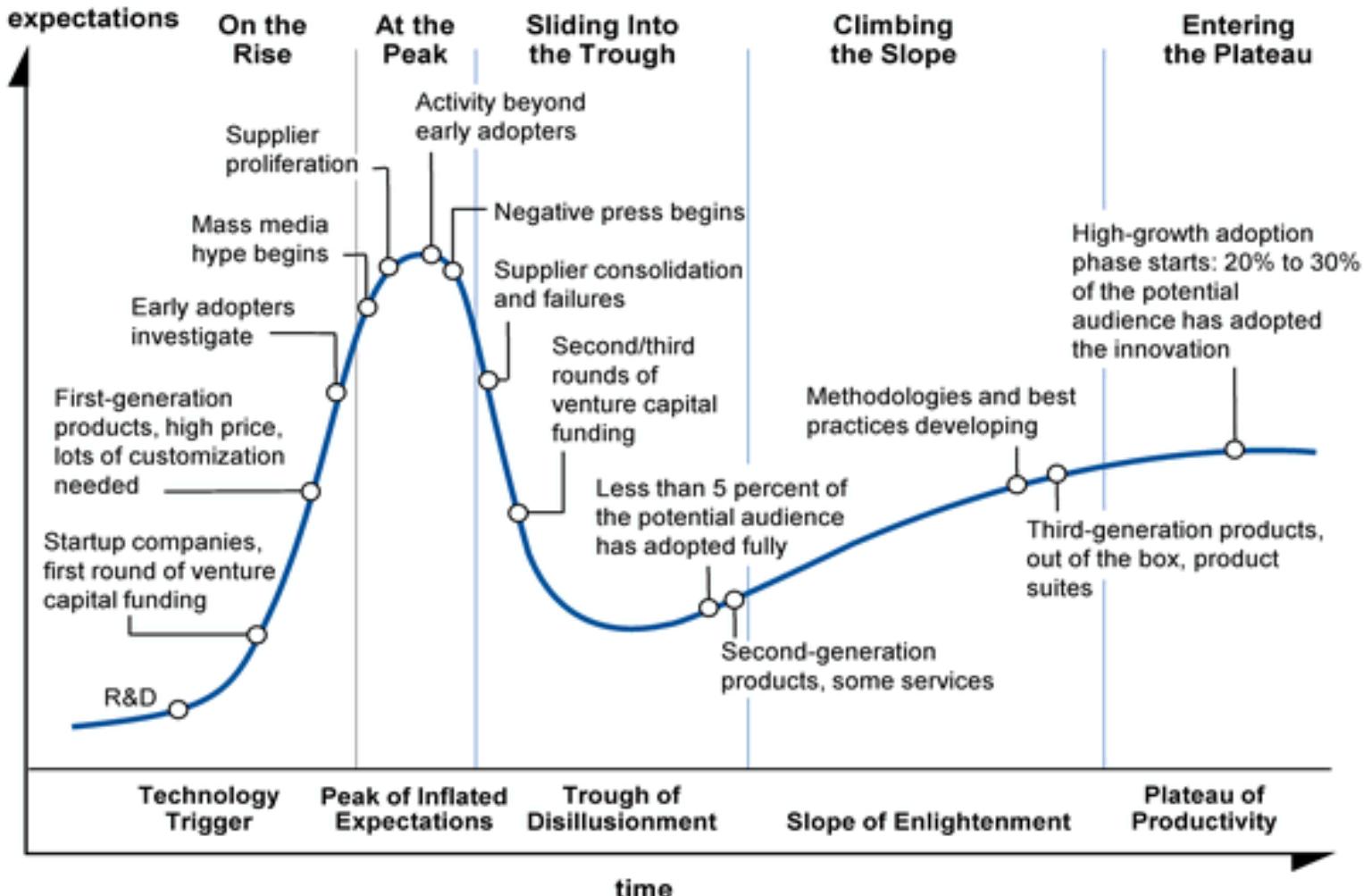
Context



Source: M. F. Sakr, Carnegie Mellon University

Context

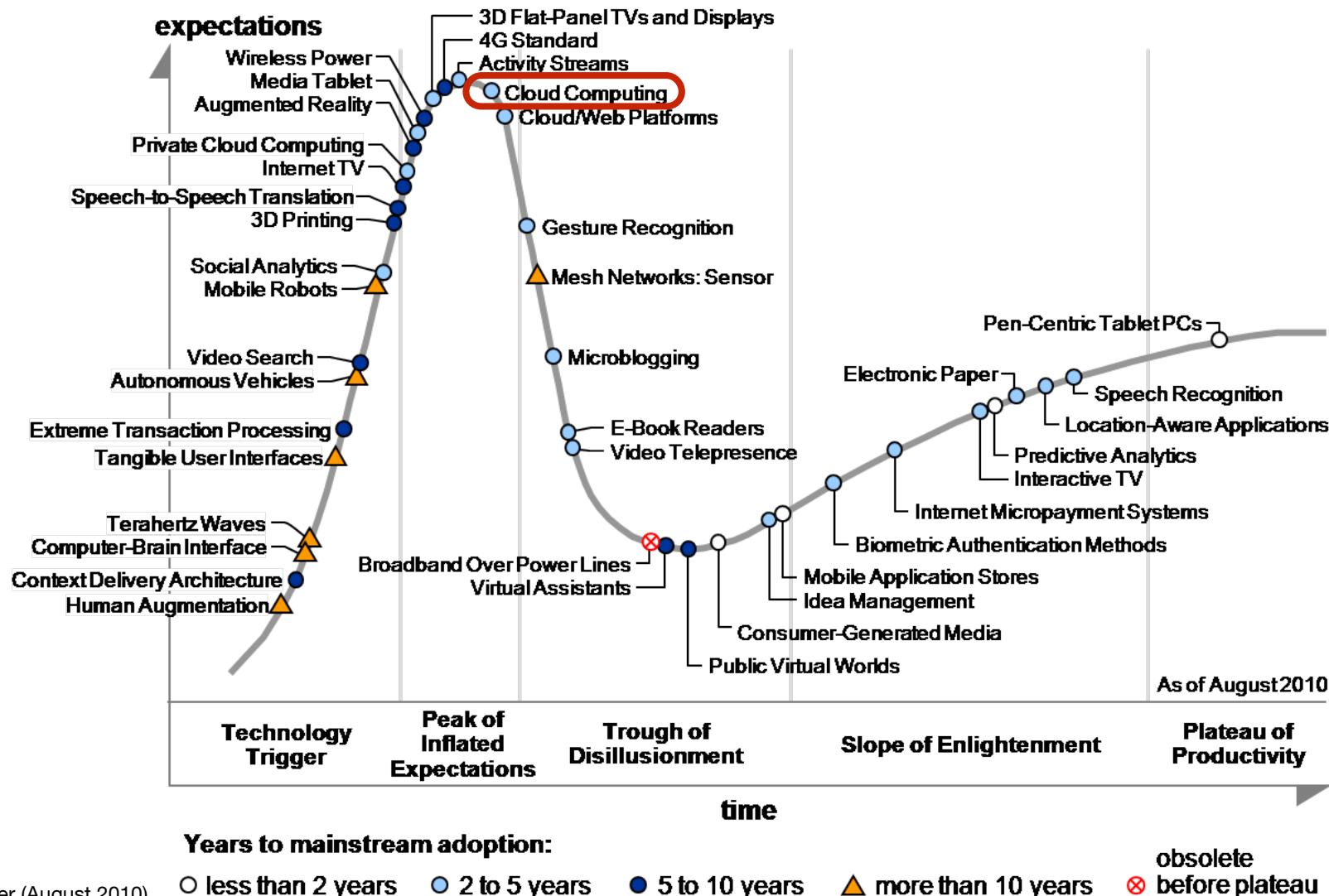
Gartner's model of technological innovation: Hype Cycle



Source: Gartner

Context

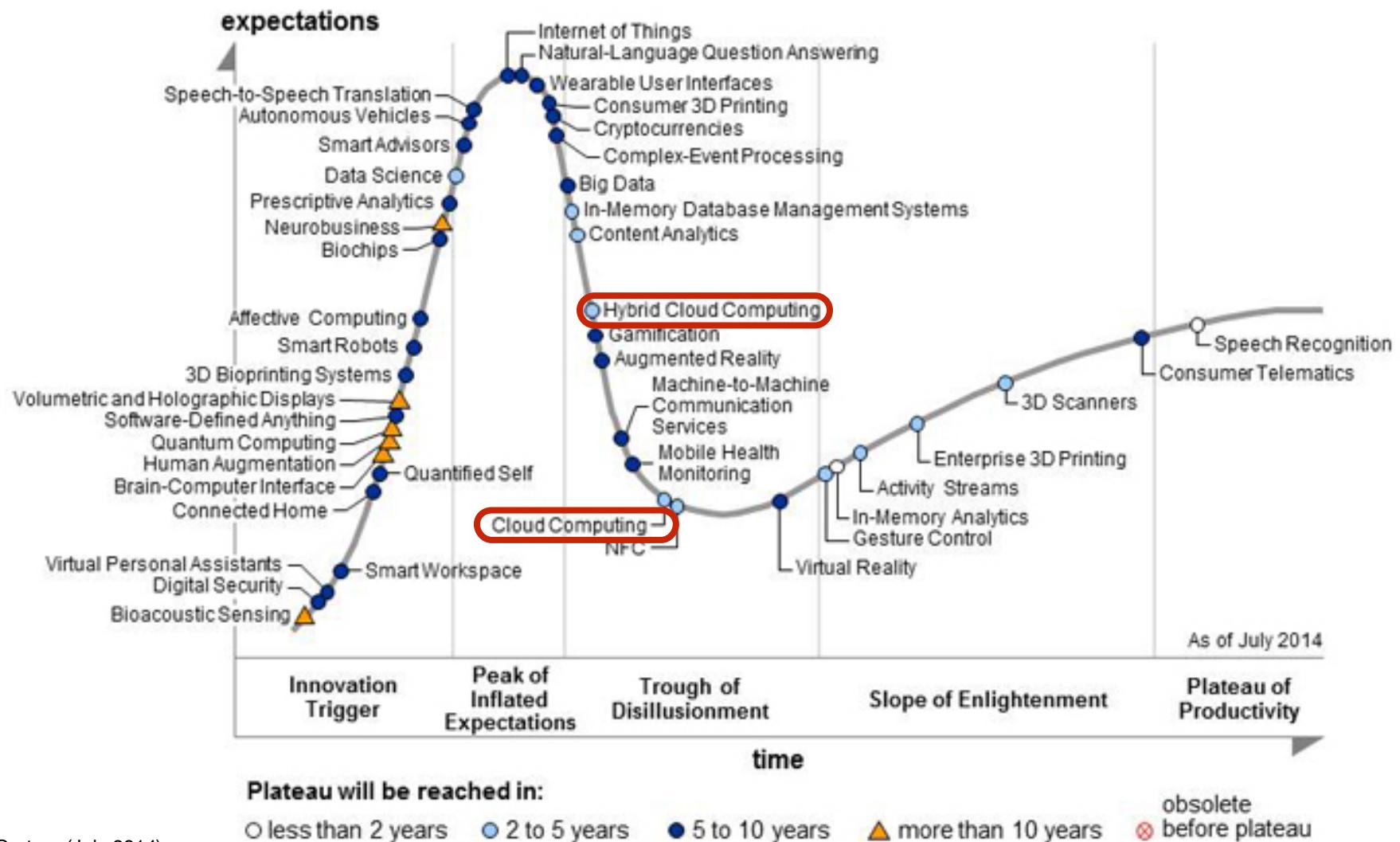
Hype Cycle for emerging technologies, 2010



Source: Gartner (August 2010)

Context

Hype Cycle for emerging technologies, 2014



Source: Gartner (July 2014)

Content

- Context
- **Definition of cloud computing**
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How can we define cloud computing?



Microsoft Azure



IBM Bluemix™

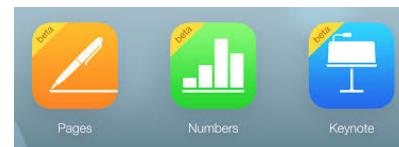


force.com™
platform as a service

Google docs



Office
online



salesforce
SOFTWARE

workday.

NETSUITE

OneDrive



Definition of Cloud Computing

- There are several existing definitions of the term cloud computing from different points of view
 - Analyst firms
 - Academics
 - Industry
 - IT companies

Definition of Cloud Computing

Definitions by analyst firms

- A *style of computing* in which massively scalable IT-related capabilities are provided “as a service” using internet technologies to **multiple external customers** (**Gartner 2008**)
- An *emerging IT development, deployment and delivery model*, enabling real-time **delivery of products, services and solutions** over the internet (**IDC 2008**)
- “the *idea of delivering personal and business productivity applications* from centralized servers (**Merrill Lynch 2008**)

Definition of Cloud Computing

Definitions by analyst firms

- These definitions have a common characteristics:
 - They define cloud computing from the perspective of the endusers
 - They focus on how it might be experienced by endusers
 - The core feature of cloud computing is the provisioning of IT infrastructure and applications as a **service in scalable way**

Definition of Cloud Computing

Definition of the National Institute of Standards and Technology (NIST)

- 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.

Source: NIST Special Publication 800-145, "The NIST Definition of Cloud Computing", September 2011

Definition of Cloud Computing

Definition of the National Institute of Standards and Technology (NIST)

Five essential characteristics:

- **On-demand self service** (automatic provisioning without requiring human interaction)
- **Broad network access** (access via standardized protocols from a variety of clients)
- **Resource pooling** (serve multiple customers in a multi-tenant model, dynamic assignment of resources from a pool, location independence)
- **Rapid elasticity** (rapid provisioning/deprovisioning to scale out/in, seemingly unlimited capacity)
- **Measured service** (usage is monitored and controlled, providing transparency in billing)

Three service models:

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

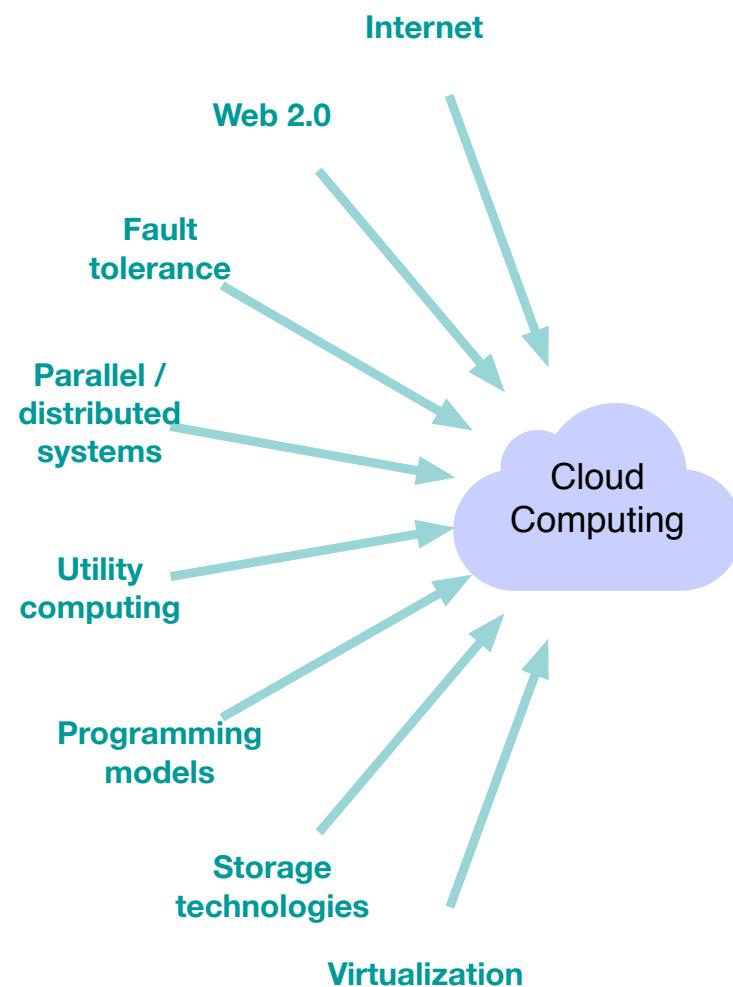
Four deployment models:

- **Private** cloud
- **Community** cloud
- **Public** cloud
- **Hybrid** cloud

Source: NIST Special Publication 800-145, "The NIST Definition of Cloud Computing", September 2011

Is cloud computing a technology?

- No ... It's a combination of pre-existing technologies
 - These technologies have matured at different rates, and were not designed as a coherent whole
 - They have come together to create a technical ecosystem for cloud computing



Cloud access devices

- The range of access devices for the cloud has expanded
- Home PCs, enterprise PCs, smartphones, etc. are connected to the Internet
- The emerging Internet of Things will add a plethora of sensors and actuators
- Example:
 - Growth of the iOS & Android platforms and proliferation of applications available on App Store and Google Play

Browsers and thin clients

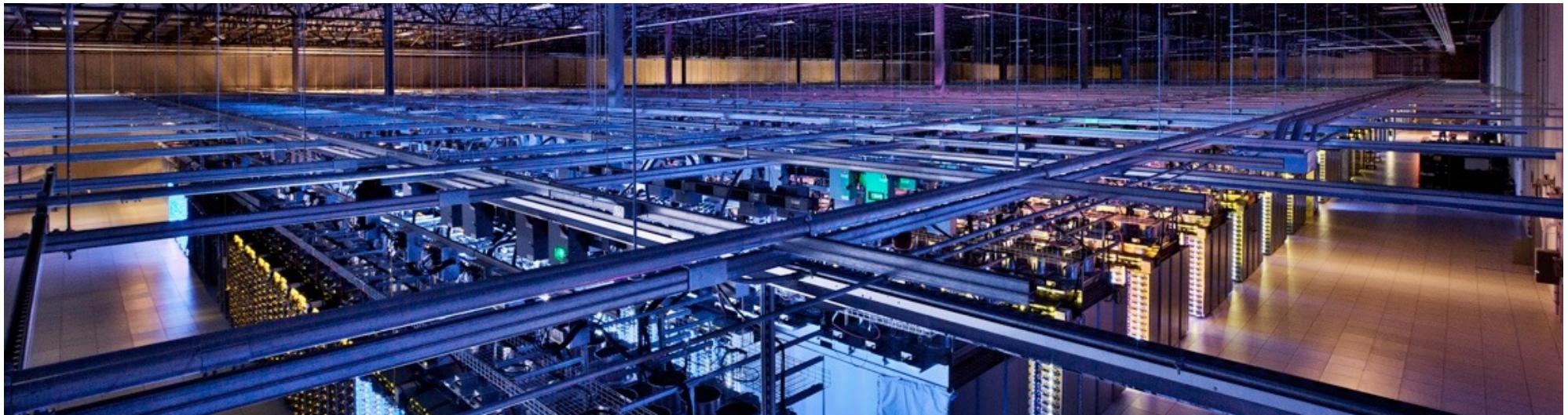
- Users can now access applications from wherever there is a browser
- Web 2.0 technologies (AJAX etc.) make the browser UI almost as powerful as that of native applications
- Even enterprise (SAP, Oracle, etc.) applications use a browser interface
- The browser-based “thin” client replaces the native “fat” client application

High-speed internet access

- One of the most important ingredients of cloud computing
- High-speed mobile networks enable mobile devices to access cloud resources
- It's one of the most substantial differences from “old” utility computing concept (35 years ago)

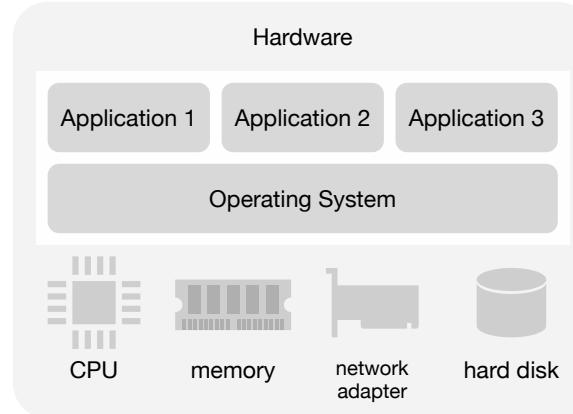
Data centers and server farms

- Cloud services require large computing capacity
 - These resources are usually geographically distributed
 - New type of data centers with homogeneous infrastructure that is centrally managed and behaves like a giant computer: Warehouse-Scale Computing
- Examples
 - Google
 - Amazon Web Services
 - Facebook
 - Apple

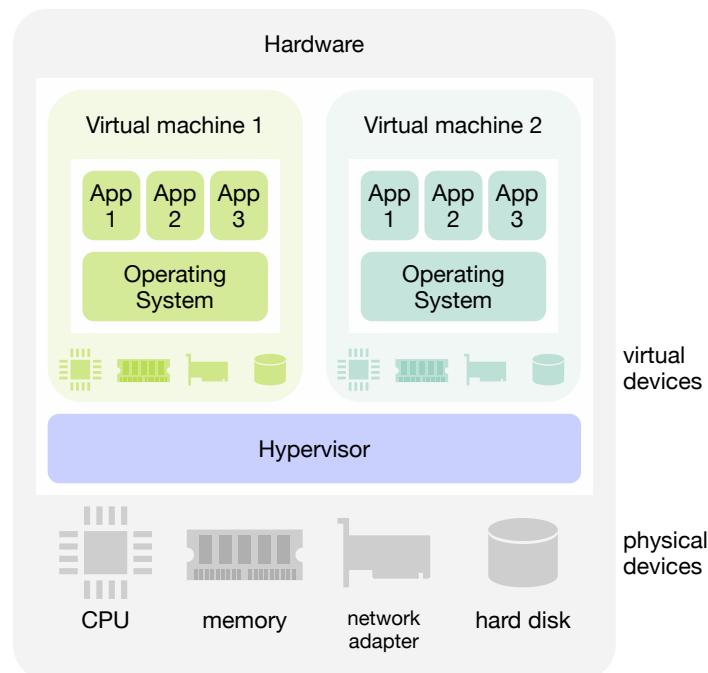


Virtualization

- Virtualization is one of the cornerstones of cloud computing
- IaaS providers use OS and storage virtualization to enable customers run instances of various OS in a cloud.
- In addition to OS and storage virtualisation, SaaS and PaaS providers implement software and database virtualization



Computer without hardware virtualization



Computer with hardware virtualization
(type 1, bare-metal hypervisor)

Cloud APIs

- Used to invoke services supported by the cloud
- “X”-aaS developers need to become familiar with specific API to deploy and manage software modules to the “X”-aaS platform
- Problem: there are as many API as Cloud Service Providers (CSP).
- Challenge: Standardization
 - Universal Cloud Interface (UCI)
 - Open Cloud Computing Interface (OCCI)
 - Cloud Infrastructure Management Interface (CIMI)
 - ...

To summarize ... from a non-technical perspective

- Cloud computing is not the savior of IT.
- It is nothing but **a way to deploy your enterprise architecture** in a way that has the potential to be **more productive** and **cost effective**.
- In essence, **it is a tool, not a way of life**. It is not magic, it is not even new, but if approached correctly, it could be a path towards efficiency.

Cloud Computing and SOA
Convergence in Your Enterprise
2009

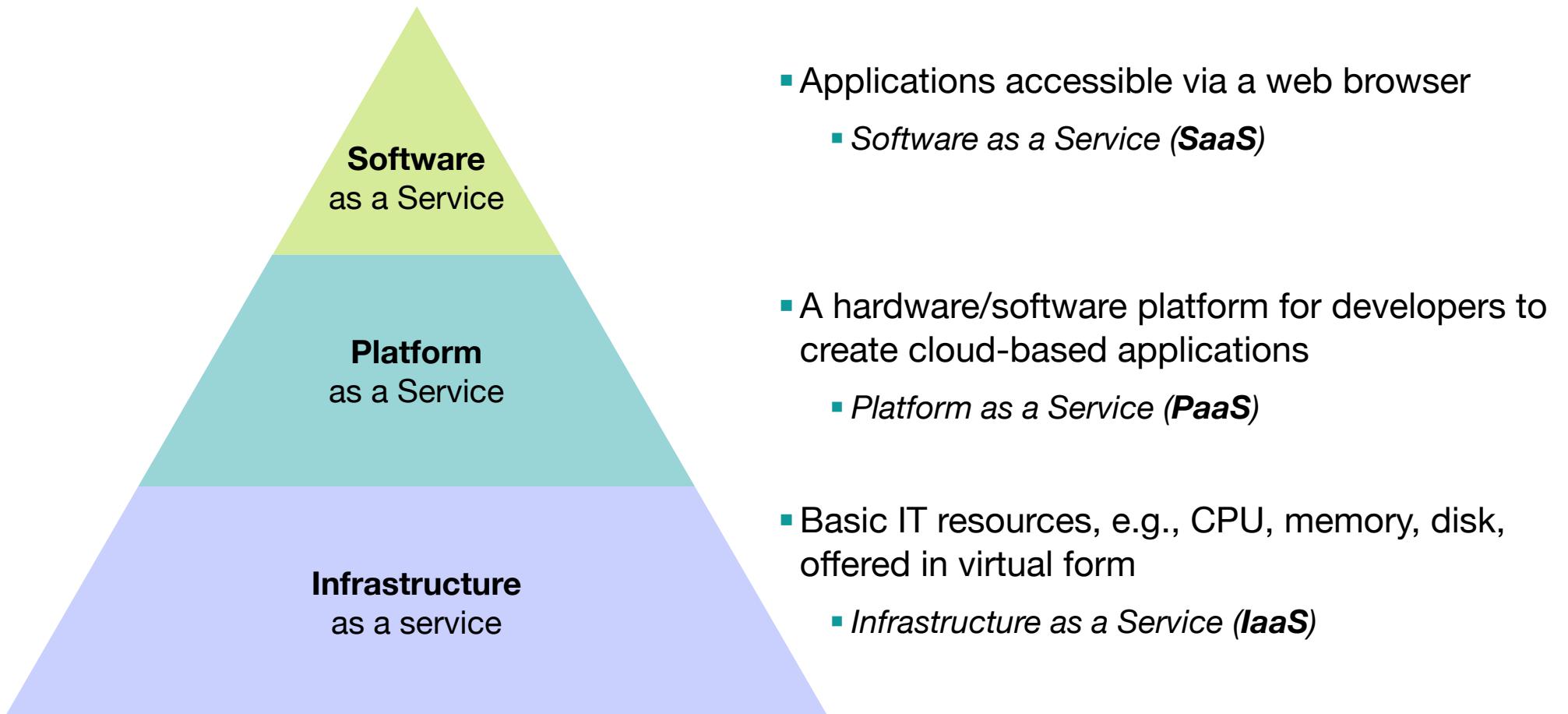
To summarize ... from a technical perspective

- Cloud computing is based on pay-per-use business models
- Main features of cloud computing are based on virtualization and dynamic scalability on demand
- Cloud services are consumed either via a web browser or making calls to an API
- Cloud computing is elastic and massively scalable
- Self-provisioning of resources

Content

- Context
- Definition of cloud computing
- **Cloud computing service models**
- Cloud computing deployment models
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- Key drivers for adoption
- Barriers
- Businesses' view of the cloud today

Cloud computing service models

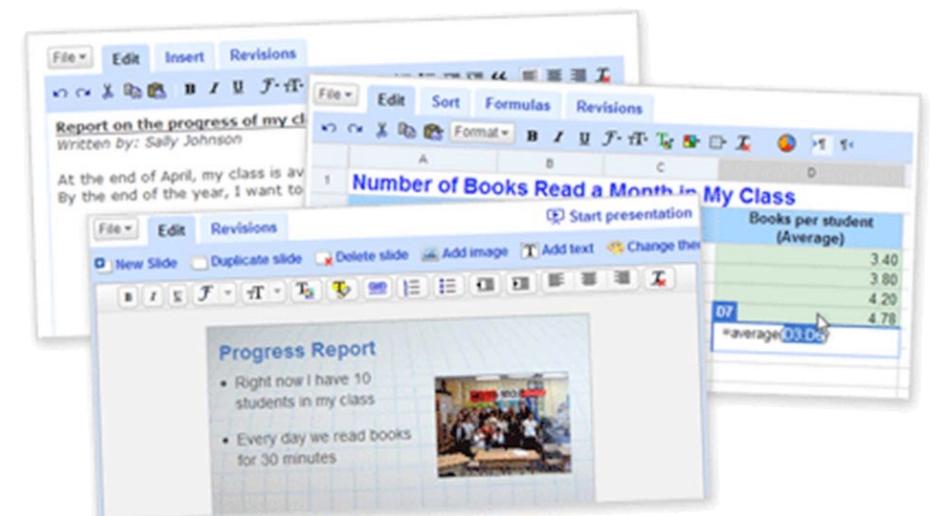
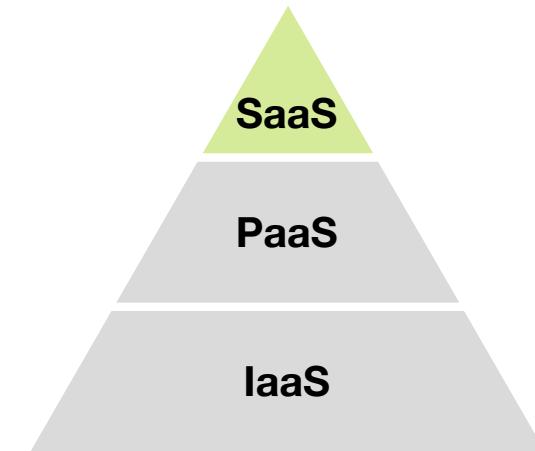


Source: M. F. Sakr, Carnegie Mellon University

Service models

SaaS – Software as a Service

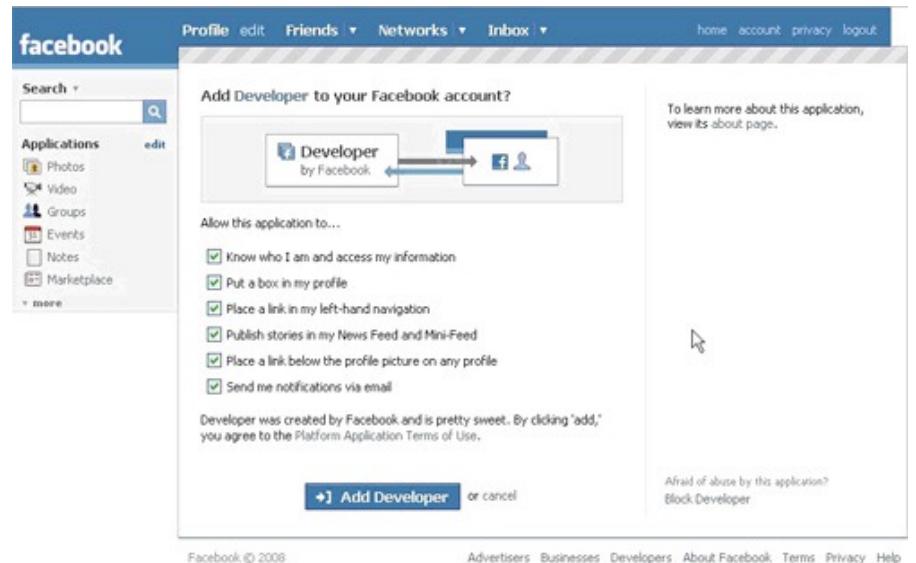
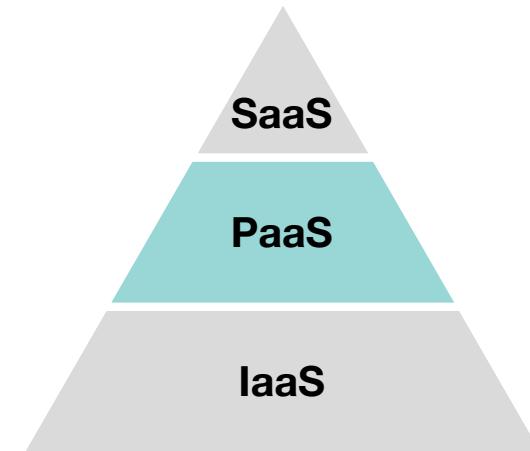
- You are already familiar with this!
- Software is offered as a service accessible over Internet. Eliminates the need to install the software on your own computer.
- Simplification of maintenance and support.
- Examples : Google Docs, Office online, Dropbox, iCloud, Salesforce



Service models

PaaS — Platform as a Service

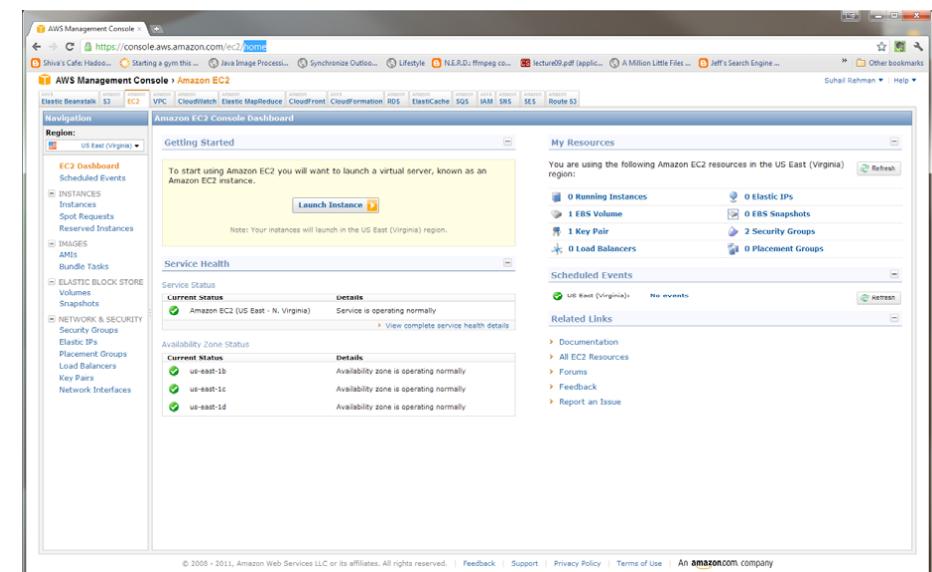
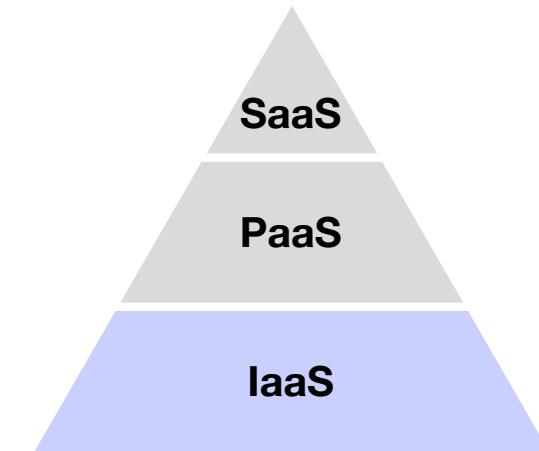
- The cloud provider makes a number of tools (the platform) available which enables its clients (who are developers) to create applications. Most of the time web applications.
- The application runs on the infrastructure of the cloud provider.
- The provider manages the tools and the underlying hardware.
- Examples : Google App Engine, Force.com, Heroku, AppFog, Facebook development platform



Service models

IaaS – Infrastructure as a Service

- The service provider rents to its clients
 - machines (CPU)
 - disks
 - network connections
- ... using **virtualization** technology.
- On a virtual machine the user accesses a standard operating system environment and is able to install and configure all the layers on top of it.
- Examples : Amazon Web Service Elastic Compute Cloud (EC2), Microsoft Azure, Google Compute Engine, IBM Bluemix



Google Compute Engine



Service models

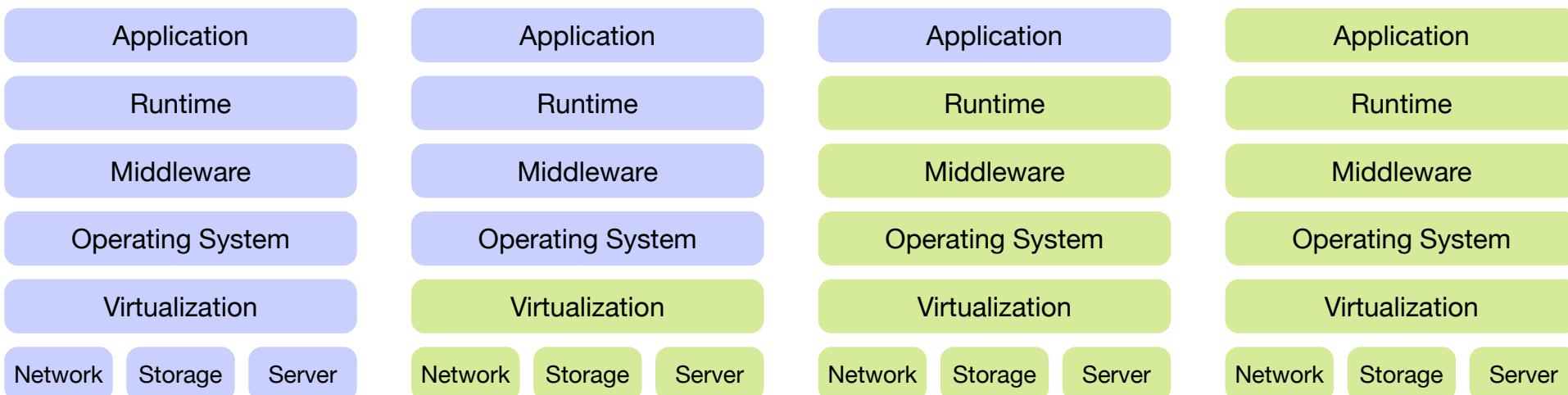
Summary

(Not using the cloud)

Infrastructure as a Service

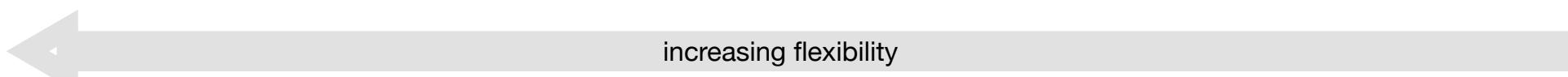
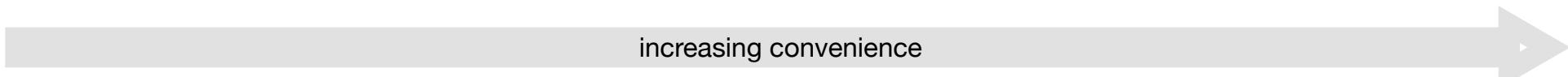
Platform as a Service

Software as a Service



 Client has responsibility / control

 Service provider has responsibility / control



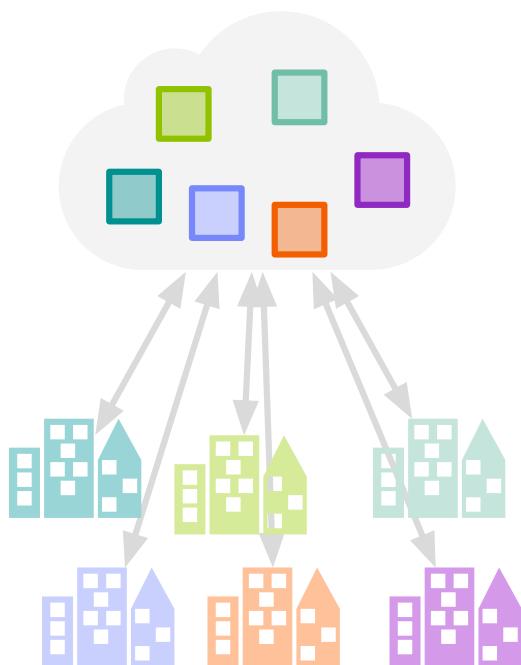
Content

- Context
- Definition of cloud computing
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- Key drivers for adoption
- Barriers
- Businesses' view of the cloud today

Cloud computing deployment models

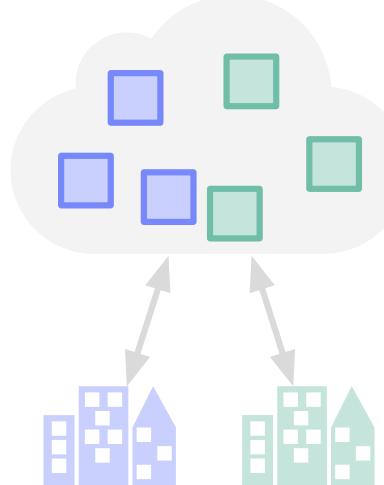
Public cloud

A cloud hosted and operated by a service provider
- Everybody can become a client
- Common infrastructure shared by everyone



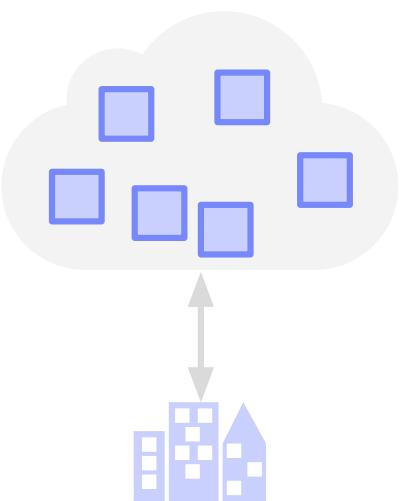
Community cloud

A cloud hosted and operated by a service provider for a limited number of clients with common interests (e.g., hospitals).
- Special security / reliability / availability requirements



Private cloud

A cloud for a single client only.
Hosted and operated by a service provider or the organization itself.
- Strict security / reliability / availability requirements



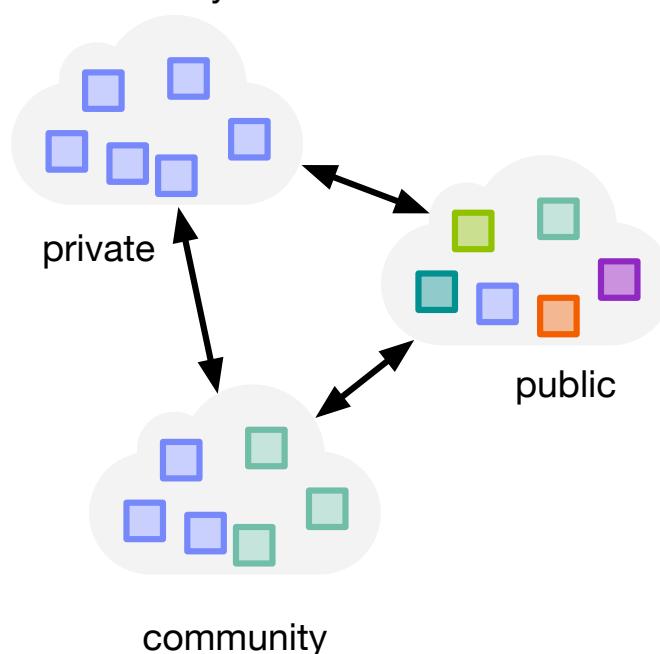
Source: NIST Special Publication 800-145, "The NIST Definition of Cloud Computing", September 2011

Cloud computing deployment models

Hybrid cloud

Simultaneous usage of two or more clouds.

- Sensitive data and applications in private cloud
- Non-sensitive in public / community cloud



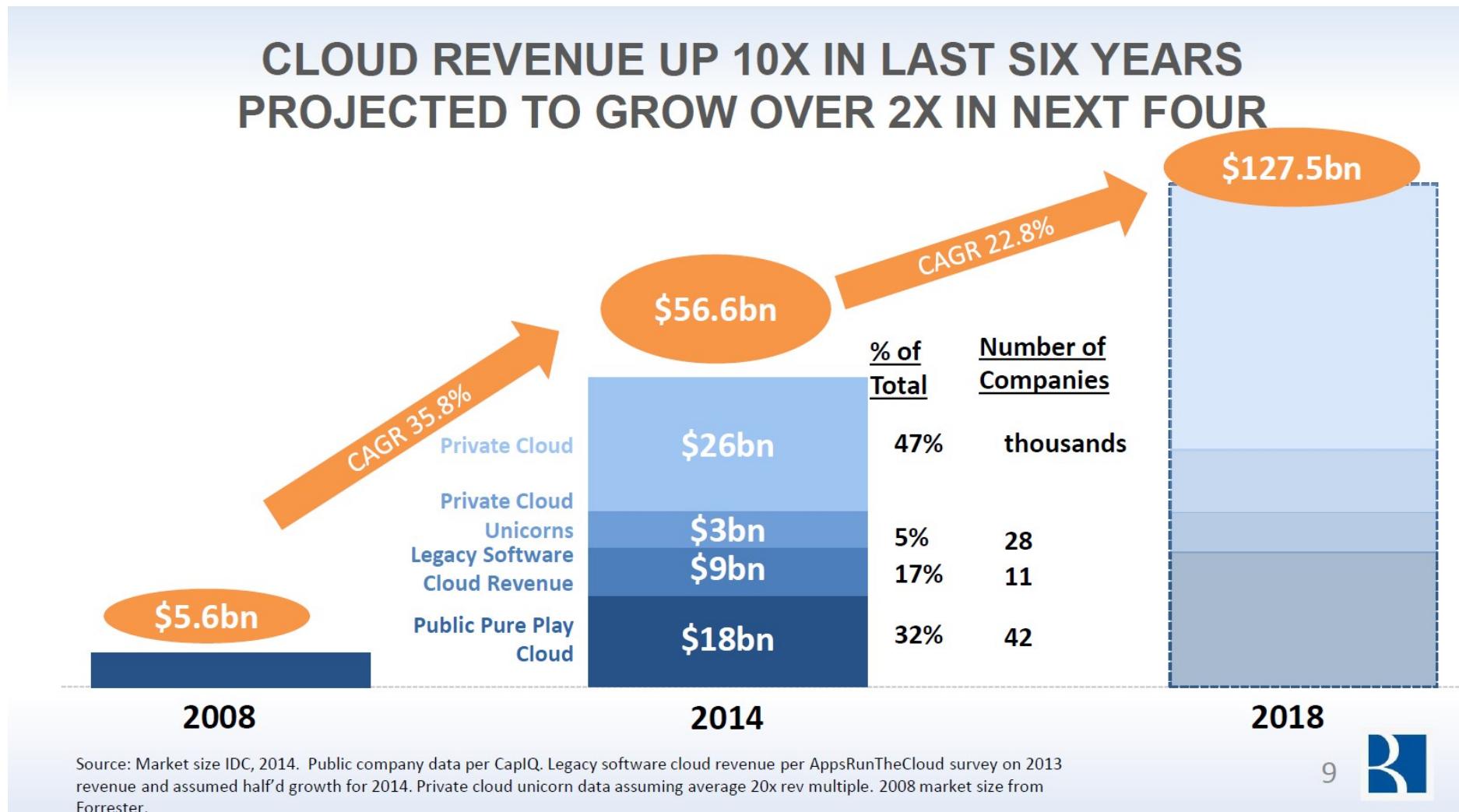
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Content

- Context
- Definition of cloud computing
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- **Cloud computing market**
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Cloud market

Recent (2015) estimate from a venture capitalist firm specializing in cloud computing investments



Source: Bessemer Venture Partners "State of the Cloud Report 2015" <http://www.bvp.com/cloud/clouddreport>

Cloud market

The case of Amazon Web Services

- Dearth of information about just how big the cloud market is
- Amazon Web Services (AWS) is the biggest cloud vendor by far, but Amazon does not share its revenue
- ... until April 2015. Amazon, in its first-quarter results, announced for the first time AWS figures:
 - \$1.57 billion revenue
 - revenue increased 49% from a year earlier
 - operating income of \$265 million
- Bezos: "Amazon Web Services is a \$5 billion business and still growing fast — in fact it's accelerating."

Content

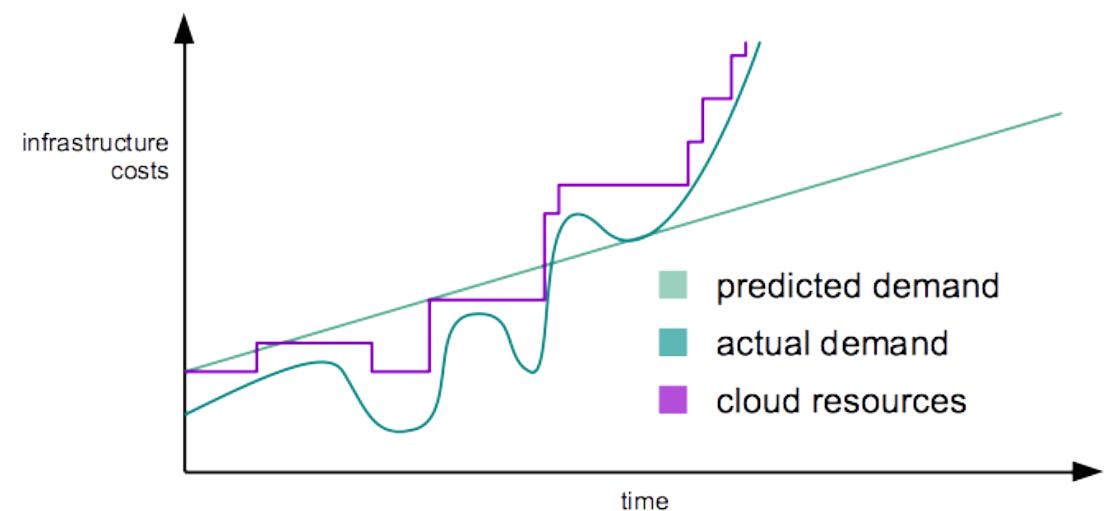
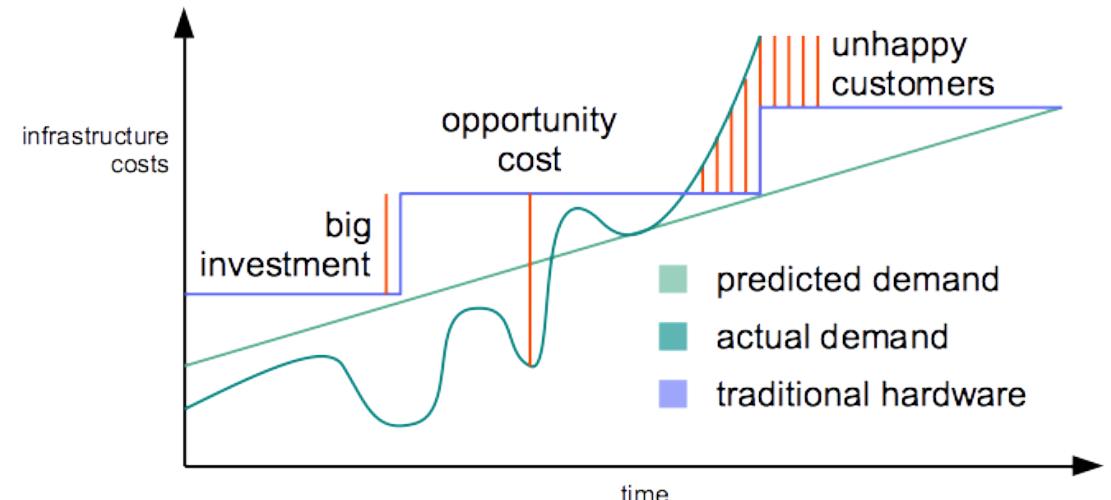
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- Definition of cloud computing
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- Cloud computing deployment models
- Cloud computing market
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- Barriers
- Businesses' view of the cloud today

Key drivers to adopting the Cloud

- Small initial investments and low ongoing costs
- Economies of scale
- Open standards
- Sustainability of IT

Small initial investments and low ongoing costs

- When setting up a new business, building an IT department is a low priority compared to R&D, marketing, securing the next round of funding
- No hardware, software, network devices have to be purchased
- Cloud is treated as an Operating Expense (opex), not a Capital Expense (capex)



Open standards

- Most of the cloud computing technologies are based on open standards
- Open standards are essential to allow for continued growth in the cloud, they are the foundation of the cloud
- Examples
 - GNU/Linux
 - SSH
 - HTTP
 - ...

Sustainability of IT

- Traditionally, companies periodically invest in order to keep their IT services up-to-date. The objective is to
 - avoid failure
 - keep pace with business changes
- With Cloud computing, companies rely on their Cloud Service Providers to minimise failures

Content

- Context
- Definition of cloud computing
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- Cloud computing deployment models
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- Key drivers for adoption
- **Barriers**
- Businesses' view of the cloud today

Barriers to cloud adoption

Technical challenges

- New cloud services are introduced in rapid pace
- Tools are continuously evolving
- Moving large data is expensive
- Security
- Quality of Service
- Green computing
- Internet dependence

Barriers to cloud adoption

Non-technical challenges

■ Vendor lock-in

- Company does not want to become dependent on a single cloud vendor
- Avoid by insisting on cloud standards

■ Security risks

- Data travels over the open Internet
- Applications run in shared infrastructure, isolation provided by virtualization
- Data and applications can potentially be accessed by cloud provider's employees
- Mitigate by (1) using encryption for data in transit and at rest, (2) insist on security certification of the cloud provider

■ Service Level Agreements (availability, reliability)

- Liability of the cloud provider if the SLA is not met?

- Avoid by (1) insisting on clear contract language, (2) planning for redundancy

■ Legal

- Company has to obey national privacy laws; often forbid data leaving the country
- US cloud providers are subject to Patriot Act; US government may obtain access to data even if it is located outside the US
- Avoid by choosing a local cloud provider

■ Political

- Cloud computing increases exposure to the NSA
- Avoid by choosing a local cloud provider or operating a private cloud

Content

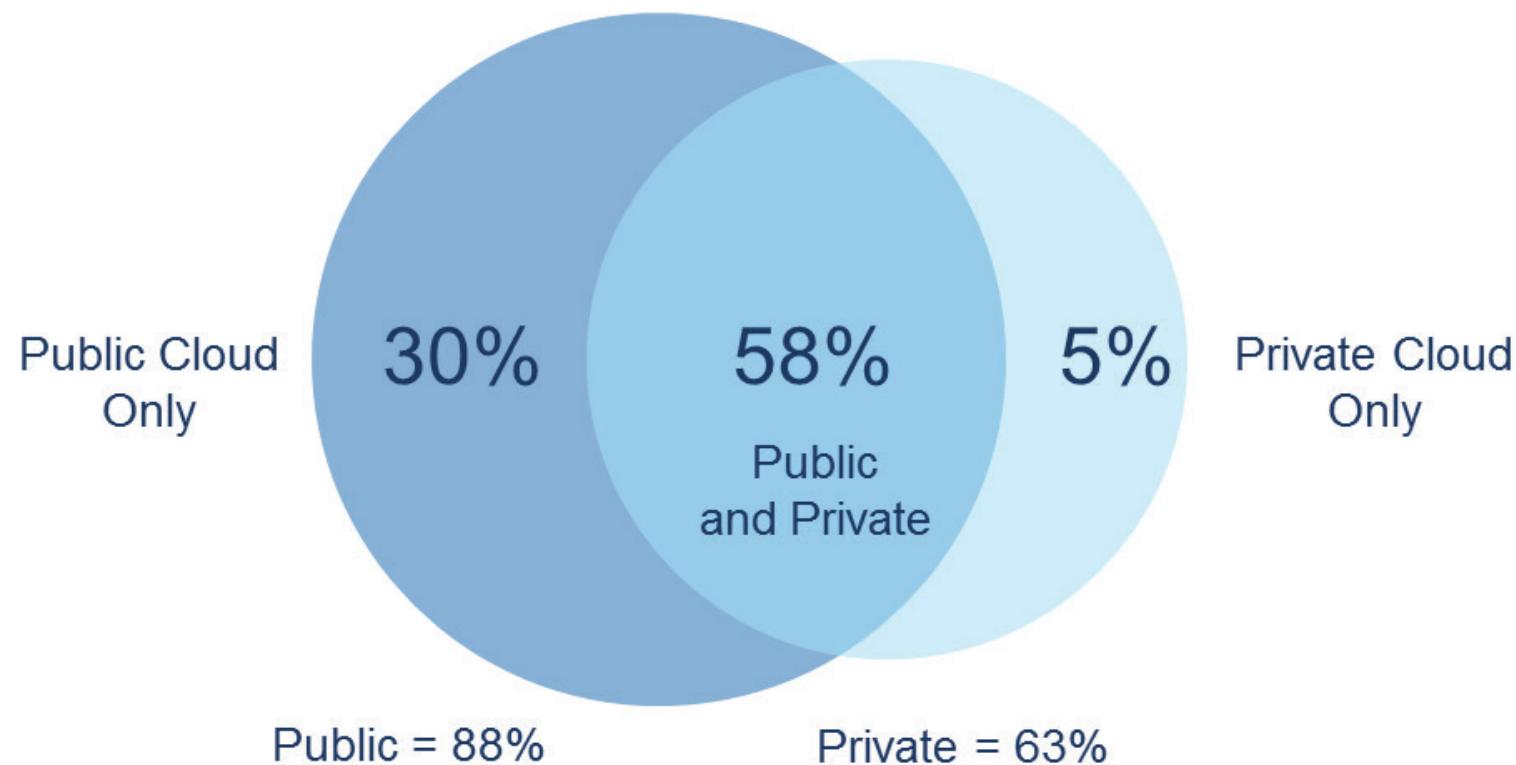
- Context
- Definition of cloud computing
- Cloud computing service models
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- Barriers
- **Businesses' view of the cloud today**

How do businesses view the cloud in 2015?

- RightScale, a SaaS vendor of a cloud computing management solution, regularly conducts a survey of IT decision makers.
- In January 2015, RightScale surveyed 930 technical professionals across a broad cross-section of organizations about their adoption of cloud computing.
- In the following we show a selection of results, focusing on Small and Medium Businesses (SMBs) whenever the results are separated between SMBs (< 1000 employees) and enterprises (1000+ employees)

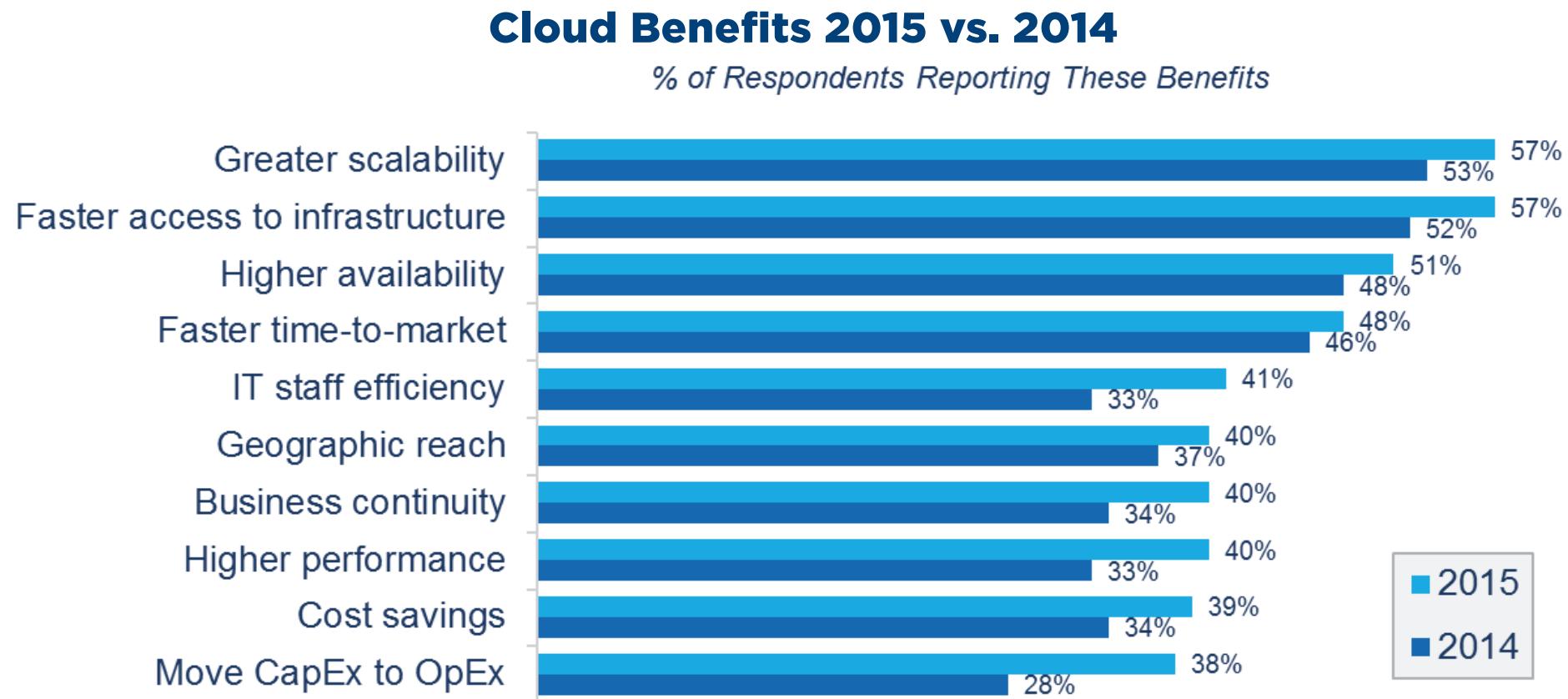
How far is cloud computing being adopted? Public or private cloud?

93% of Respondents Are Using Cloud



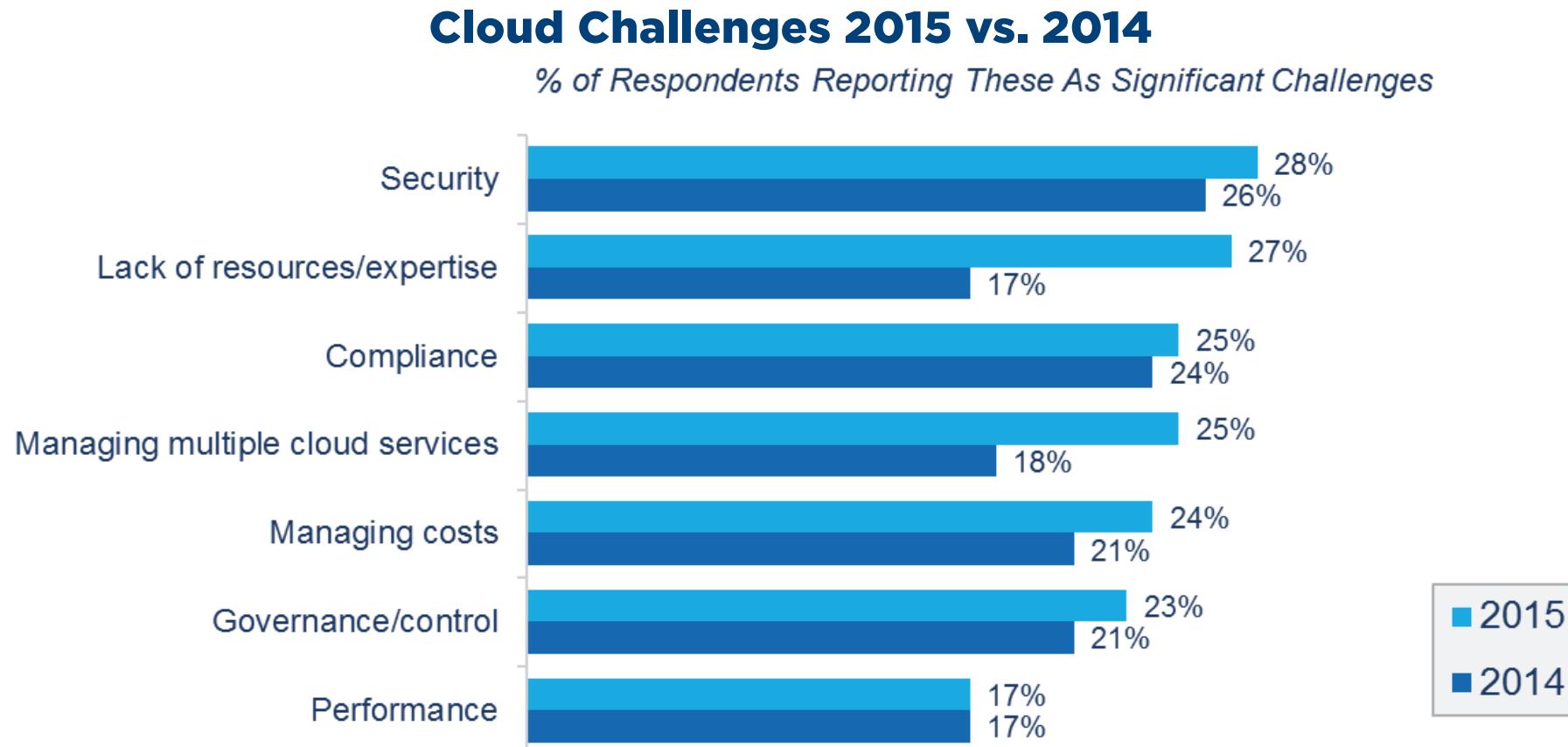
Source: RightScale 2015 State of the Cloud Report

What are the perceived benefits of using the cloud?



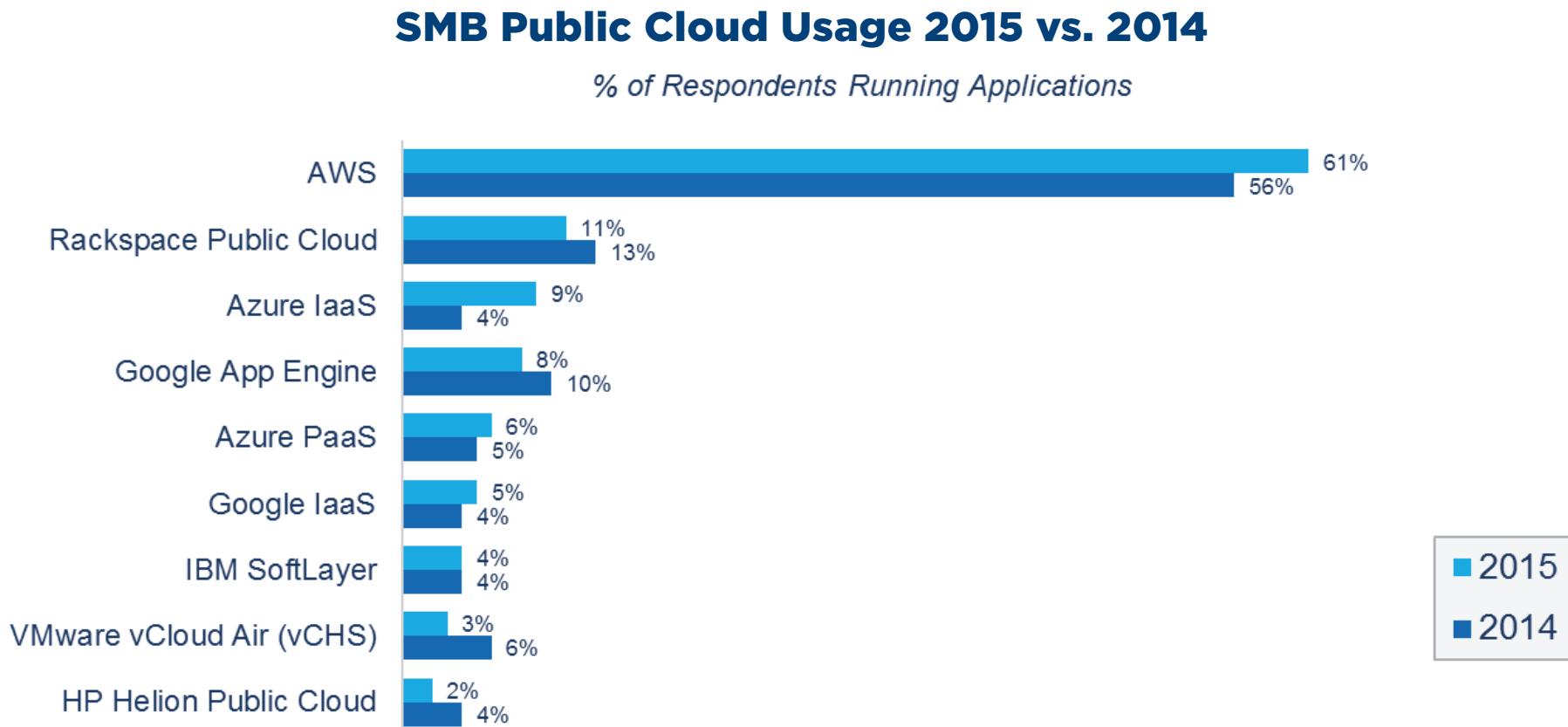
Source: RightScale 2015 State of the Cloud Report

What are the perceived challenges of using the cloud?



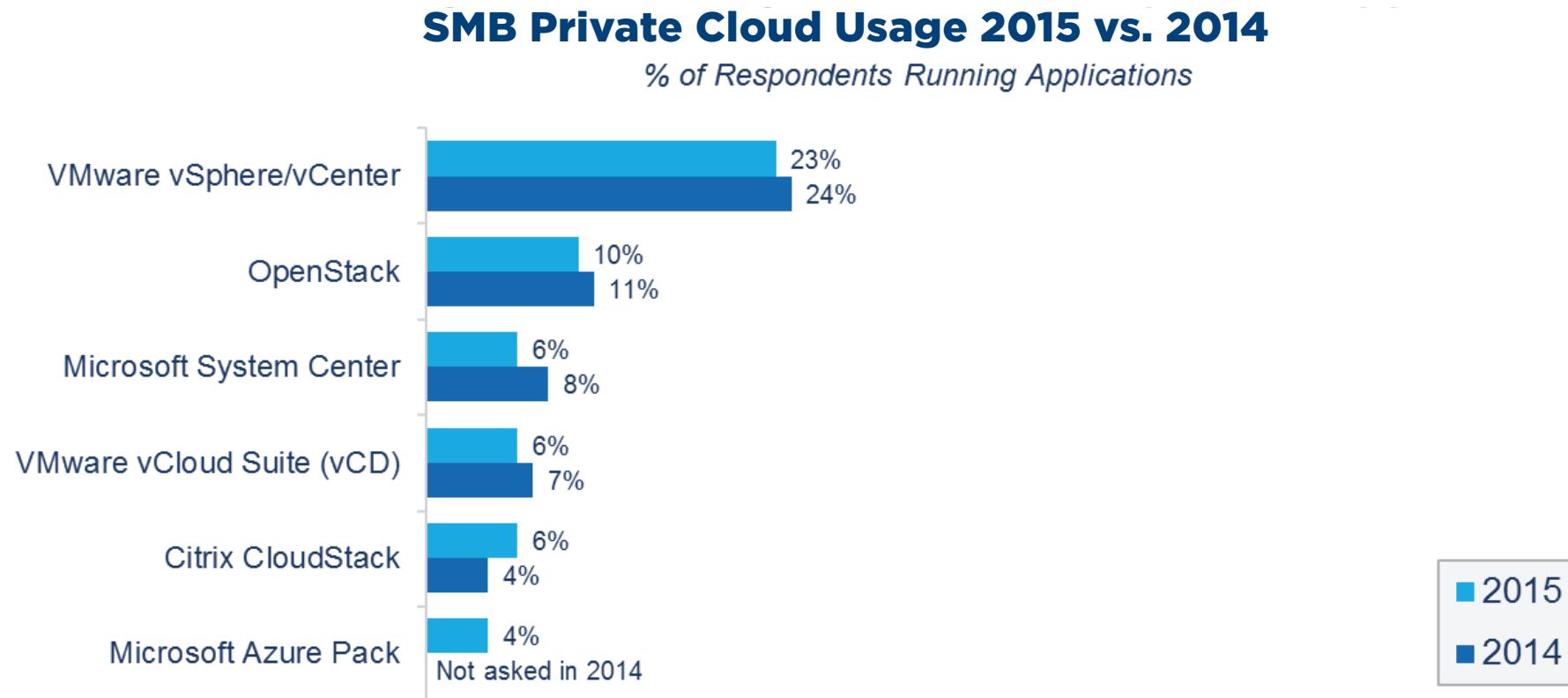
Source: RightScale 2015 State of the Cloud Report

Which public cloud services are most popular among SMBs?



Source: RightScale 2015 State of the Cloud Report

Which private cloud software is most popular among SMBs?



Source: RightScale 2015 State of the Cloud Report

Acknowledgements

- Parts of this presentation are based on material from
 - Nabil Abdennadher, Haute école du paysage, d'ingénierie et d'architecture de Genève
 - Majd Sakr, Carnegie Mellon University