

Cloud Computing Models and Business Impacts

Luis Gustavo Nardin
gnardin@emse.fr

Cloud and Edge Infrastructures

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Question 1

- ▶ What does Cloud Computing refer to?
 - ① A software package
 - ② Technology that enables run applications in a distributed network using virtualized resource
 - ③ On-demand availability of computing resources without direct active management by the user
 - ④ Free large-scale distributed computing platform available on the Internet

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- ▶ What does Cloud Computing refer to?
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Question 2

- ▶ What are the 5 essential characteristics of Cloud Computing?

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 - On demand
 - Broadband network
 - Resource pooling
 - Rapid elasticity
 - Measured service

Question 3

- ▶ What are other characteristics of Cloud Computing?

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- ▶ What are other characteristics of Cloud Computing?
 - Massive Scale (Economics of Scale)
 - Homogeneity
 - Virtualization
 - Low Cost Software
 - Resilient Computing
 - Geographic Distribution
 - Service Orientation
 - Advanced Security

Question 4

- ▶ Which are Cloud Computing enabling technologies?
 - ① Internet Technologies
 - ② Virtualization
 - ③ Autonomic Computing
 - ④ Distributed Computing
 - ⑤ All of the above

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Outline

Service Models

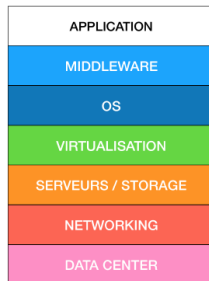
Cloud Deployment Models

Business Impacts and Potentials

Service Models

Cloud Computing Layers

- ▶ Cloud Computing is a pilling of several technologies corresponding to two main layers
 - Hardware
 - Software
- ▶ Each layer corresponds to a different level of services



Based on slides of Charlotte Laclau – Télécom Saint-Étienne

Hardware Layer

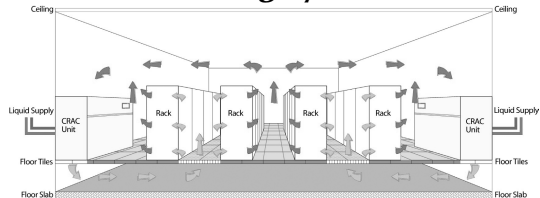
- ▶ Hardware: servers, routers, electrical systems and cooling systems
- ▶ Located in data centers containing millions of servers organized in racks
- ▶ Challenges
 - Fault Tolerance
 - Traffic Management
 - Cooling Management
 - etc.



This data center is 11.5 times the size of a football field

Hardware Layer

Cooling System



Built-in Container

Inside Project Blackbox, racks of up to 38 servers apiece generate tremendous heat. A panel of fans in front of each rack forces warm exhaust air through a heat exchanger, which cools the air for the next rack (*detail*), and so on in a continuous loop.

DESIGN SPECS

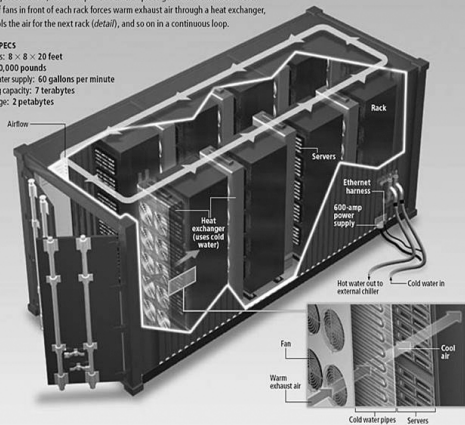
Dimensions: $8 \times 8 \times 20$ feet

Weight: 20,000 pounds

Cooling water supply: 60 gallons per minute

Computing capacity: 7 terabytes

Data storage: 2 petabytes



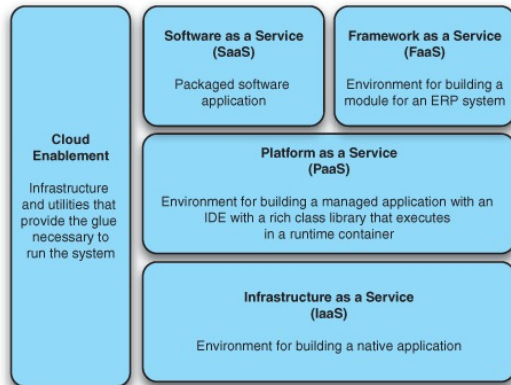
Software Layer

- ▶ **Virtualization:** enable partition hardware resources to create pool of storage and computation virtual resources
 - Hypervisors: Xen, KVM, VMWare
- ▶ **OS:** exploitation system installed on the virtual machine
- ▶ **Application:** software ready to be used

Delivery Models

Delivery Models are the reference models on which the Cloud Computing is based. They can be categorized into

- 1 Infrastructure as a service (IaaS)
- 2 Platform as a service (PaaS)
- 3 Software as a service (SaaS)
- 4 Framework as a service (FaaS)



(Rosenberg & Mateos, 2011)

Infrastructure as a Service (IaaS)

- ▶ IaaS is a delivery of technology infrastructure as an on demand scalable service
- ▶ IaaS provides access to fundamental on demand resources such as physical machines, instances of virtual machines and blocks of storage
- ▶ Instead of the user purchasing servers, software, data center space and network equipment, they buy these resources as a fully outsourced service
- ▶ e.g., Amazon EC2, VMWare vCloud

(Conway, 2011)

Platform as a Service (PaaS)

- ▶ PaaS provides runtime environment for applications, development and deployment tools
- ▶ PaaS provides all the facilities required to support the complete life cycle of building and delivering web applications and services entirely from the Internet
- ▶ PaaS provides a way to rent hardware, operating systems, storage and network capacity over the Internet. It allows the user to rent virtualized servers and associated services for running existing applications or developing and testing new ones
- ▶ e.g., Google AppEngine, Windows Azure

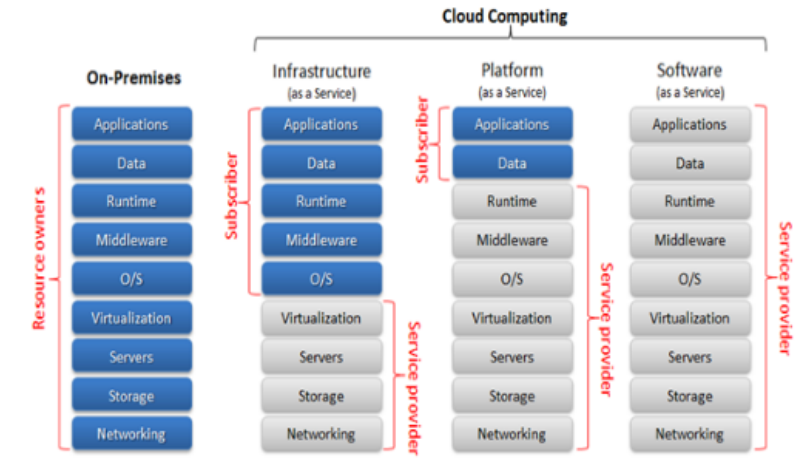
(Conway, 2011)

Software as a Service (SaaS)

- ▶ SaaS is a software distribution model in which a third-party provider hosts applications and makes them available to customers over the Internet
- ▶ SaaS is a software delivery methodology that provides licensed multi-tenant access to software and its functions remotely as a Web-based service
- ▶ The supplier provides an application to customers as a service on demand. It includes the hardware infrastructure and the software product and it interacts with the user through a front-end portal
- ▶ e.g., Salesforce.com, Gmail, Microsoft Office

(Conway, 2011)

Delivery Models

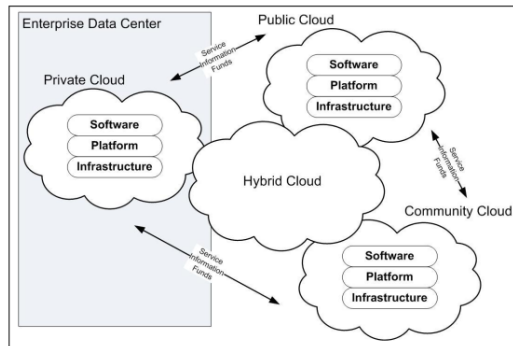


(Conway, 2011)

Cloud Deployment Models

Types of Deployment Models

- ▶ Represent a specific type of cloud environment
- ▶ These models are primarily distinguished by
 - Ownership
 - Size
 - Access
- ▶ There are four common cloud deployment models
 - Public Clouds
 - Private Clouds
 - Hybrid Clouds
 - Community Clouds



Source: Malik Lindner SAP

Public Cloud

- ▶ The customer is not responsible for any of the management of a public cloud hosting solution
- ▶ Data is stored in the provider's data center and the provider is responsible for the management and maintenance of the data center
 - + Reduces lead times in testing and deploying new products
 - + Customers benefit an almost unlimited elasticity
 - Data security concern: sensitive data is stored in a public/open cloud

Based on slides of Charlotte Laclau – Télécom Saint-Étienne

Private Cloud

- ▶ Also known as an internal or enterprise cloud, resides on company's intranet or hosted data center where all of your data is protected behind a firewall
- ▶ Great option for companies who already have expensive data centers because they can use their current infrastructure
- + offer an increased level of security and they share very few, if any, resources with other organizations
- resource pooling is very limited
- all management, maintenance and updating of data centers is the responsibility of the company

Hybrid Cloud

- ▶ A mixed structure to combine the private cloud and the cloud public
- ▶ The company owns a local data center, but also uses the public cloud
 - + can choose to store sensitive data in the private part
 - + can benefit from the same unlimited resources provided by the public cloud
- ▶ Example: Eucalyptus, an open-source O/S for the cloud
 - Eucalyptus provides HPE Helion Eucalyptus, a solution to create a hybrid cloud
 - Compatible the API of AWS

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Community Cloud

- ▶ A cloud shared between a limited set of organizations that share certain goals and concerns
- ▶ Hybrid form of private clouds built and operated specifically for a targeted group
- ▶ These communities have similar cloud requirements and their ultimate goal is to work together to achieve their business objectives
- ▶ Designed companies working on joint projects, applications, or research, which requires a central cloud computing facility

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Deployment Models

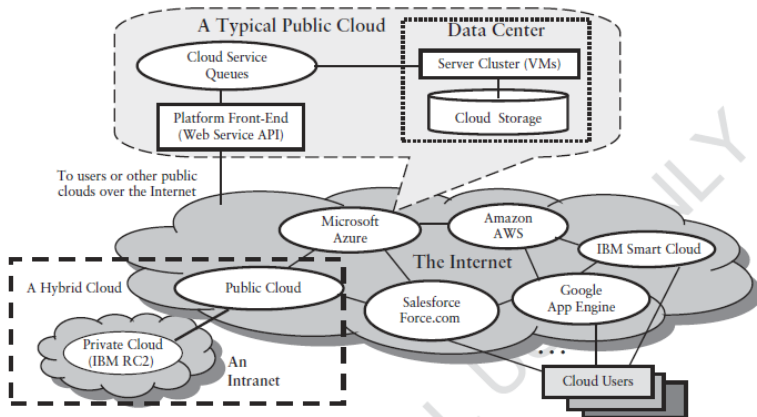


Figure 1.7

Public, private, and hybrid clouds. The callout box shows the architecture of a typical public cloud. A private cloud is built within an Intranet. A hybrid cloud involves both types in its operation range. Users access the clouds from a web browser or through a special API tool.

Deployment Models

Advantages

- ▶ Public clouds move expenses from Capital Expenditure (CAPEX) to Operating Expenditures (OPEX)
- ▶ Private cloud reduce the risk to security and data access because of the control of the infrastructure
- ▶ Hybrid clouds allow organizations to select the correct combination of cloud deployment models to suit their needs

Disadvantages

- ▶ Public clouds impose risk to security and data access due to shared infrastructure
- ▶ Private clouds require buying, building, and managing the infrastructure, thus eliminating any benefit from the lower up-front capital costs and the elimination of hands-on management costs

Business Impacts and Potentials

On Premises vs. Public Cloud

- ▶ Assume you are the about to start a new project in your company
- ▶ What would you choose an **On Premises** or **Public Cloud**?
- ▶ What may motivate your choice?

On Premises vs. Public Cloud

On Premises

- ▶ Higher pay, less scalability
- ▶ Allocate physical space for servers
- ▶ Appoint a team of hardware and software maintenance
- ▶ Limited data security
- ▶ Less chance of data recovery

Public Cloud

- ▶ Pay for what you use
- ▶ No server space required
- ▶ No hardware expert and software maintenance required
- ▶ Good data security
- ▶ Disaster recovery

Based on slides of Charlotte Laclau – Télécom Saint-Étienne

On Premises vs. Public Cloud

On Premises

- ▶ Lack of flexibility
- ▶ No automatic updates
- ▶ Less collaboration
- ▶ Data cannot be easily accessed remotely
- ▶ Take longer implementation time

Public Cloud

- ▶ High flexibility
- ▶ Automatic software updates
- ▶ Collaboration from widespread locations
- ▶ Data can be accessed and shared from anywhere
- ▶ Rapid implementation

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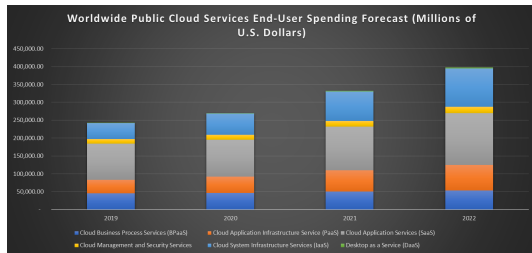
Benefits of Cloud Computing

Speed and Agility	Vast amount of computing resources can be provisioned in minutes
Cost	Eliminate the expense of buying computer hardware and software (CAPEX vs OPEX) Free up internal resources Pay structure (pay-as-you-go)
Scalability and Adaptability	Easy to scale up or down the resources capacity
Accessibility and Mobility	Easy to access from anywhere
Better Security	Data is stored in a centralized secure location
Better Quality of Service	Facilitate the measurement and management of the quality of service

Business Implications

- ▶ Maturity of the Organization
- ▶ Security
 - Privileged user access
 - Data location
 - Data segregation
- ▶ Data Ownership
- ▶ Increased Risk
 - Lock-in and interoperability
 - Require good network (Internet) connectivity
 - Limited infrastructure control

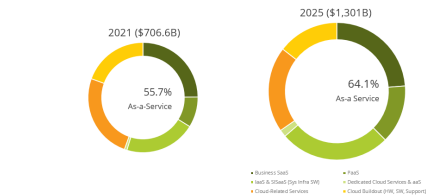
Business Potential



Source: Gartner (April 2021). Gartner Forecasts Worldwide Public Cloud

End-User Spending to Grow 23% in 2021.

Worldwide Whole Cloud Outlook



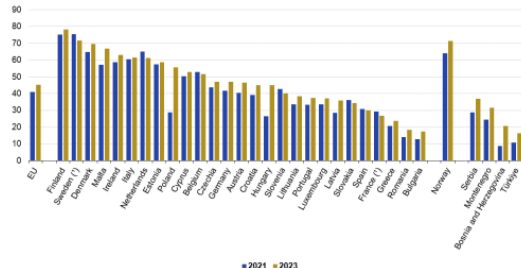
Source: IDC Whole Cloud Forecast 2021-2025: The Path Ahead for Cloud in a Digital-First World, IDC #US47397521, Sept. 2021

© IDC

Source: IDC (Sept 2021). IDC Forecasts Worldwide “Whole Cloud” Spending to Reach \$1.3 Trillion by 2025.

European Statistics

Enterprises buying cloud computing services, EU, 2021 and 2023
(% of enterprises)



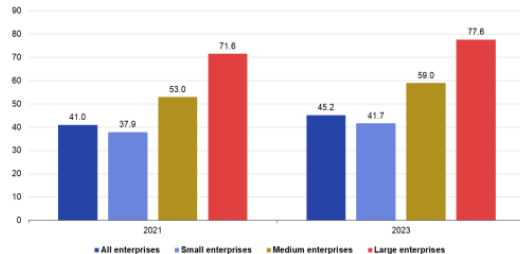
Note: North Macedonia and Albania: 2023 data not available at the time of update.

(*) Break in the time series.

Source: Eurostat (online data code: isoc_cicce_use)

eurostat

Enterprises buying cloud computing services by size class, EU, 2021 and 2023
(% of enterprises)



Source: Eurostat (online data code: isoc_cicce_use)

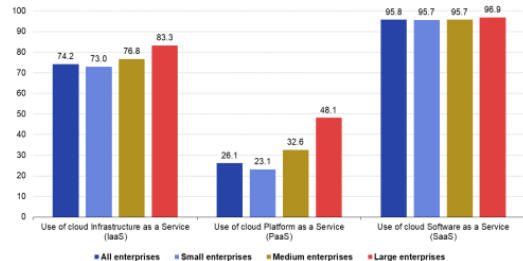
eurostat

Source: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Cloud_computing_-_statistics_on_the_use_by_enterprises

European Statistics

Types of cloud computing services purchased by service model and size class, EU, 2023

(% of enterprises buying cloud services)

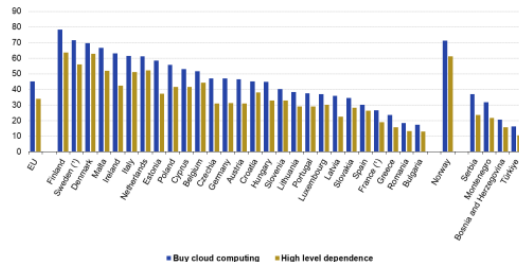


Source: Eurostat (online data code: isoc_cicce_use)

eurostat

Enterprises buying cloud computing services and high level dependence on the cloud, 2023

(% of enterprises)



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