Cloud and Edge Infrastructures

Introduction

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Cloud and Edge Infrastructures

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Outline

Origins and Influences

Question

Do you use Cloud Computing?

Cloud Applications

1	Microsoft Office 365 OneDrive for Business	Cloud Storage	11	Microsoft 0365 SharePoint	Cloud Storage/ Collaboration
2	Microsoft Office 365 Outlook.com	Webmail	12	YouTube	Consumer
3	Facebook	Social	13	LinkedIn	Social
4	Twitter	Social	14	Salesforce	CRM / SFA
5	Gmail	Webmail	15	Microsoft Live Outlook	Webmail
6	Google Drive	Cloud Storage	16	Yahoo! Mail	Webmail
7	iCloud	Cloud Storage	17	AOL Mail	Webmail
8	Skype	Collaboration	18	Microsoft Live OneDrive	Cloud Storage/ Collaboration
9	WebEx	Collaboration	19	Pandora	Consumer
10	Dropbox	Cloud Storage	20	Slack	Collaboration

Vision of Computing as a Utility

- **Utility computing** is a **service provisioning model** in which a service provider makes **computing resources and infrastructure management** available to the customer **as needed**, and **charges them for specific usage** rather than a flat rate
- **Cloud Computing** is a relatively recent computing model that implements this vision
- Utility computing models date back to the 1960s

Source: https://en.wikipedia.org/wiki/Utility_computing

Vision of Computing as a Utility

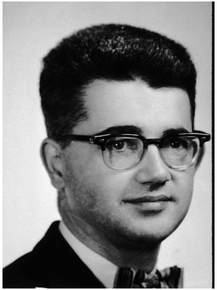
- "**Ubiquitous computing**" coined by Mark Weiser in 1988
  - Computing power distributed everywhere
- "**Autonomic Computing**" proposed by IBM and popularized by Kephart and Chess (2003)
  - Systems that can manage themselves giving high-level objectives expressed in terms of service-level objectives or utility functions
- "**Grid Computing**" as a metaphor to electric power grid coined by Foster and Kesselman (1998)
  - Use of a widely distributed computer resources to reach a common goal

Based on slides of Amro Najjar – Télécom Saint-Étienne

Vision of Computing as a Utility

"If computers of the kind I have advocated become the computers of the future, then **computing may someday be organized as a public utility** just as the telephone system is a public utility... The computer utility could become the basis of a new and important industry."

(McCarthy, 1961, as quoted in Garfinkel, 1999)



John McCarthy (1927-2011), pioneer in AI (Creator of LISP language)

Based on slides of Amro Najjar – Télécom Saint-Étienne

Vision of Computing as a Utility

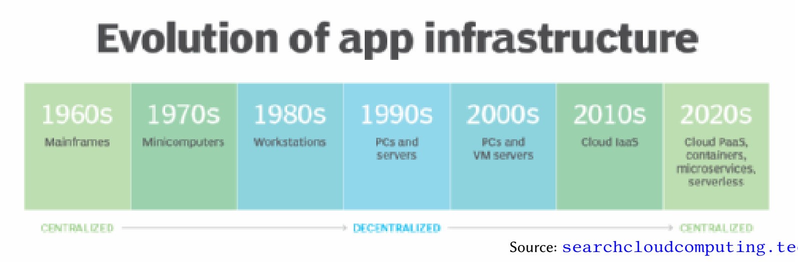
"..., we will probably see the spread of '**computer utilities**' like the present electric and telephone utilities service homes and offices across the country."

UCLA Press Release (Kleinrock, 1969)

Leonard Kleinrock (1934-), one of the founders of the ARPANET

Based on slides of Amro Najjar – Télécom Saint-Étienne

Computing Evolution



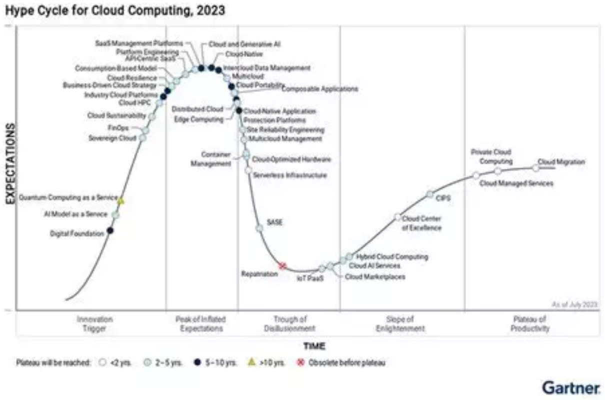
Source: searchcloudcomputing.techtarget.com

- **Extreme Centralization**: Mainframe and time sharing
- **Extreme Decentralization**: Everyone with their own computer, but nothing shared
- **Decentralized Access**: Web and early decentralized applications
- **Re-Centralized Computing**: Web applications & Cloud Computing

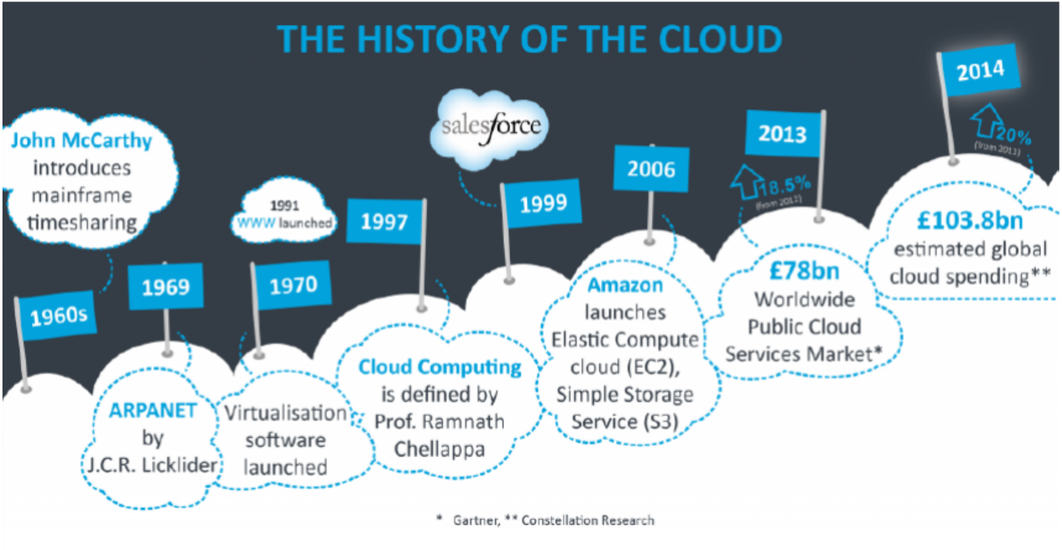
(Peak & Azadmanesh, 1997; Elliot, 2019)

Cloud Computing: Hype

- Some thought Cloud Computing could revolutionize the world
- Others thought Cloud Computing was only a **buzz word**



Summary


THE HISTORY OF THE CLOUD
John McCarthy introduces mainframe timesharing
1960s
1969
ARPANET by J.C.R. Licklider
1970
Virtualisation software launched
1991 WWW launched
1997
Cloud Computing is defined by Prof. Ramnath Chellappa
salesforce
1999
2006
Amazon launches Elastic Compute cloud (EC2), Simple Storage Service (S3)
2013
18.5%
£78bn Worldwide Public Cloud Services Market*
2014
20%
£103.8bn estimated global cloud spending**
* Gartner, ** Constellation Research

Basic Concepts

Question

What do you understand for Cloud Computing?

Definition (1)

- Cloud Computing **provides the means** by which applications can be **manipulated**, **configured**, and **accessed** as utilities through the **Internet**
- Cloud Computing is a set of **computing services** provided **over the network** whereby shared resources, software, and information are provided to computers and other devices **on demand**

(Rosenberg & Mateos, 2011)

Definition (2)

Cloud Computing is “a **large-scale distributed computing paradigm** that is driven by **economics of scale**, in which a pool of abstract **virtualized**, **dynamically-scalable**, managed **computing power**, **storage**, **platforms**, and **services** are delivered **on demand** to external customers over the **Internet**.”

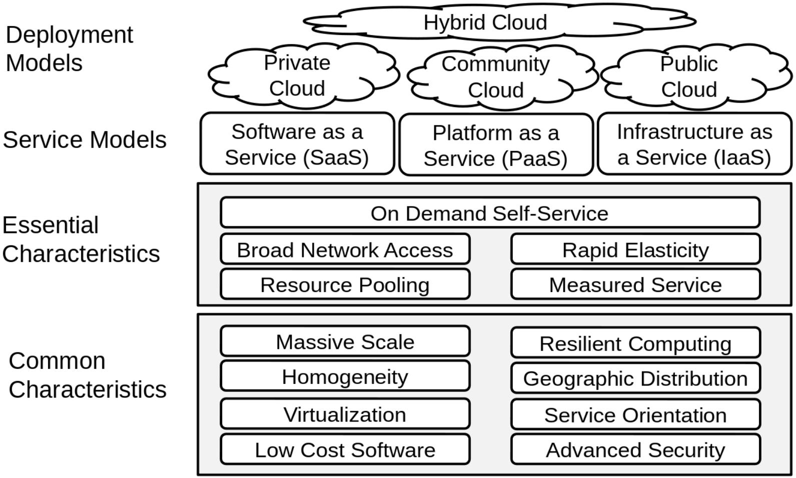
(Hwang, 2017)

Definition (3)

"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."

(National Institute of Standards and Technology [NIST], 2011)

NIST Cloud Definition Framework



(National Institute of Standards and Technology [NIST], 2011)

Five Essential Characteristics

- **On-demand self-service**
  - Consumers can unilaterally provision computing capabilities (e.g., servers, storage) as needed
  - The resources should be available immediately
- **Measured service**
  - Automatic control and optimization of resources usage by leveraging a metering capability at some level of abstraction
  - The consumer and the service provider must be able to measure the use of resources, i.e., the consumer only pays for what is used

(National Institute of Standards and Technology [NIST], 2011)

Five Essential Characteristics

- **Resource pooling**
  - Pool of resources provide services to multiple consumers using a multi-tenant model
  - These services can be adjusted to suit each consumer's needs
- **Rapid elasticity**
  - Ability to dynamically allocate resources
  - Capabilities can be provisioned and released to scale rapidly outward and inward commensurable with demand
- **Broad network access**
  - Capabilities are available over the network

(National Institute of Standards and Technology [NIST], 2011)

Cloud-Enabling Technologies

Question

Is Cloud Computing a new technology?

Is Cloud Computing a New Technology?

- Cloud Computing is **NOT a new technology**. Relies on pre-existing technologies
- Cloud Computing is a set of technologies that make it possible to create a concrete platform for the vision of "**utility computing**"
- Cloud Computing enables these technologies **to interact in a new way**

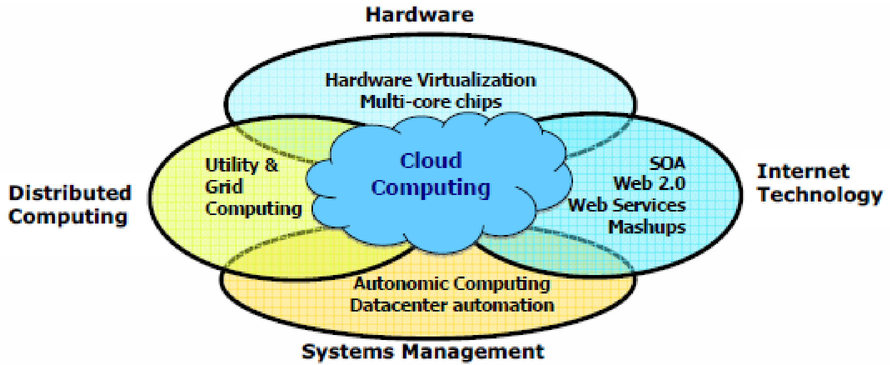
Based on slides of Amro Najjar – Télécom Saint-Étienne

Enabling Technologies

Technology	Requirements and Benefits
Fast Platform Deployment	Fast, efficient, and flexible deployment of cloud resources to provide dynamic computing environment to users.
Virtual Clusters on Demand	Virtualized cluster of VMs provisioned to satisfy user demand and virtual cluster reconfigured as workload changes.
Multitenant Techniques	SaaS distributes software to a large number of users for their simultaneous uses and resource sharing if so desired.
Massive Data Processing	Internet search and web services often require massive data processing, especially to support personalized services.
Web-Scale Communication	Support e-commerce, distance education, telemedicine, social networking, digital government, digital entertainment, etc.
Distributed Storage	Large-scale storage of personal records and public archive information demand distributed storage over the clouds.
Licensing and Billing Services	License management and billing services greatly benefit all types of cloud services in utility computing.

(Hwang, 2017)

Enabling Technologies



(Hwang, 2017)

Virtualization

- Overview
  - The process of creating a **virtual version of a physical entity**
  - **Applicable to all computing physical entities** like computers, operating systems, storage devices, applications, and networks
- Advantages
  - Hide the hardware layer
  - Enable resource flexibility
- Tools
  - VMware, Xen, Oracle VM, Hyper V, JVM

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Web 2.0

- Consider the web as a platform
- Collective intelligence
  - Synergies between individuals to write a text, debug a code to build a sum of knowledge

Blog	Blogger	Skyblog
Wiki	Wikipedia	Jurispedia
Messenger	Hotmail	Gmail
Social networks	Facebook	LinkedIn
Sharing photos	Picasa	Flicker
Sharing videos	Youtube	Dailymotion
Cartography	MS Live Mpas	Google Maps

Web Services

- The services offered by the cloud computing are based on **web services technologies** like SOAP, WSDL, REST
- Cloud Computing providers offer Application Programming Interface (APIs) that can be RESTful, SOAP, etc.
- Cloud ecosystem can adopt the **Service Oriented Architecture** (SOA)

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Service Oriented Architecture

- SOA involves the deployment of services, which are units of logic that run in a network
- A service has the following characteristics:
  - handles a business process; handles a technical task; provides business data and the technical details to construct an interface
  - can access another service
  - is relatively independent of other software
- A service can handle interactions within a company and between a company and its suppliers, partners, and customers
- The term service refers to a service in the sense that the supplier is selling an operational function
- Emphasis on **Service Level Agreement** (SLA)

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Economics

Economics Aspects of Cloud Computing

- Cloud brings new business models and economics
- Large companies save costs, reduce staff, and improve system scalability by moving from on-premise data centers to the cloud
- Small companies leverage pay-on-demand models to "right size" their computing needs quickly and cost effectively

(Hennessy & Patterson, 2019)

Total Cost of Ownership

- **Total Cost of Ownership** (TCO) is a type of calculation designed to **assess both direct and indirect costs**, including capital and operational expenses, and benefits related to the purchase of any component
- TCO aims to calculate the **effective cost of purchasing**, all things considered
- TCO looks at the **complete cost from purchase to disposal**. It adds to the initial purchase price other costs expected to be incurred during the useful life of the product, such as service, repair, maintenance, and insurance
- TCO is useful to do a **fair financial comparison** between two choices or among several choices

(Jamsa, 2013)

Total Cost of Ownership

Software	Hardware	Data Storage	Network Equipment
Pre-purchase research	Pre-purchase research	Pre-purchase research	Internet access
Purchase or licensing	Purchase	Purchase	Pre-purchase research
Installation	Installation	Installation	Purchase
Training	Testing	Testing	Installation
Version and patch mgmt.	Footprint and space	Security considerations	Training
License mgmt.	System downtime	Footprint and space	Security considerations
Security considerations	Electricity and air conditioning	Electricity and air conditioning	System downtime
Administration	Insurance	Backup operations	Maintenance
	Replacement costs of failed components	Replacement costs of failed components	Administration
	Decommission, remove, and disposal	Maintenance	
	Cost of scaling solutions		
	System maintenance		

(Jamsa, 2013)

Total Cost of Ownership Calculators

- AWS Total Cost of Ownership Calculators
  - https://calculator.aws/#/
- Microsoft Azure Total Cost of Ownership Calculator
  - https://azure.microsoft.com/en-us/pricing/calculator/
- Google Cloud Calculator
  - https://cloud.google.com/products/calculator

(Jamsa, 2013)

Capital Expenditures (CapEx)

- Capital Expenditures (CapEx) is the money an organization or corporate entity spends to buy, maintain, or improve its fixed assets, such as buildings, vehicles, equipment, or land
- It is considered a CapEx when the asset is newly purchased or when money is used towards extending the useful life of an existing asset, such as repairing the roof

(Jamsa, 2013)

Operational Expenditures (OpEx)

- Operational Expenses (OpEx) is an ongoing cost for running a product, business, or system
- OpEx include, but are not limited to
  - Power and air conditioning
  - Rent and facilities
  - Equipment maintenance and repair
  - Internet accessibility
  - Software maintenance an administration
  - Insurance

(Jamsa, 2013)

CapEx vs. OpEx Explanation

https://www.youtube.com/watch?v=na4jbAh_vkQ&feature=youtu.be

Key Performance Indicators

Key Performance Indicators

Metric / Indicator	Measure
System availability	Through system redundancy and colocation, cloud-based service providers typically provide 99.9% uptime and system availability.
Processor utilization	Because cloud-based providers can scale processors on demand, a company does not have to deploy a large number of processors to meet potential demand.
Time-of-day utilization	Many applications experience spikes of utilization during specific times of the day. Cloud-based solutions can dynamically scale resources to meet user demand.
Resource demand/utilization	A cloud service provider may be able to scale resources to best align user demand with costs.

(Jamsa, 2013)

Key Performance Indicators

Metric / Indicator	Measure
Time to market	Most companies can turn on a cloud service solution immediately, without the cost and time involved in establishing a data center.
Opportunity costs	There are costs associated with an activity's potential that a company must forgo when selecting an alternative.
User experience	Most cloud service providers have an experienced team of administrators and security personnel.
Market disruption	Cloud solutions allows companies to be first to market

(Jamsa, 2013)

Challenges

Introduction

- Cloud computing exposes **multiple challenging issues** inherent to pushing both services and data from local servers into data centers which belong to an external party
- **Traditional IT**
  - Enterprises buy their own computing infrastructures to run their applications
  - Data and services were stored and processed on-premise, which results in much more control and protection on data
- **Cloud Computing**
  - Controls and responsibilities are shared between the application owner and Cloud providers
  - Unauthorized access to data can be achieved in a shared infrastructure model

(Timmermans et al., 2010; Faragardi, 2017)

Challenges

- **Control**
  - Loss of (direct) control
  - Difficult to discern who has caused the problem
  - Blurred border between own IT infrastructure and what lies outside
  - Span the boundaries of multiple parties

Problem of many hands

  - *"in a complex chain of events or systems, many people will have had a share in an action that leads to undesirable consequences. As such many people will also have had the opportunity to prevent these consequences, and therefore no one can be held responsible."*
  - Split of responsibility does not put neither of the parties involved in a good position to address problems

(Timmermans et al., 2010)

Challenges

- **Self-determination**
  - *"Informational self-determination refers to the right or ability of individuals to exercise personal control over the collection, use and disclosure of their personal data by others."*
- **Accountability**
  - Data, especially personal data, stored in the cloud should be managed properly
  - Users of an accountable cloud would be able to check whether the cloud is performing as agreed
  - Since accountability requires detailed records of actions by its users in the cloud, there can be a tension between privacy and accountability

(Timmermans et al., 2010)

Challenges

- **Ownership**
  - The off shoring of data also raises the question of who owns the data a user stores in the cloud and what can the providers of cloud services do with this information
  - The cloud also generates data itself for different purposes: to provide accountability, to improve the services provided, or other reasons such as performance or security
  - This leaves a trail of often extraordinarily detailed personal information that, if not properly protected, may be exploited and abused
- **Function creep**
  - Data collected for a specific purpose, over time may become used for other (unanticipated, unwanted) purposes

(Timmermans et al., 2010)

Challenges

- **Monopoly & lock-in**
  - The position of users may further be in jeopardy because of the tendencies for power to centralize in cloud computing
  - If only a handful of companies are able to achieve a dominant position in the market for cloud services, this might lead abuse or could be harmful otherwise to the interests of the users
- **Privacy**
  - Although there is consensus that privacy is important, the concept remains hard to explicate or pin down. In general it aims to constrain access to certain types of personal data and prevent persons to acquire and use information about other persons
  - Vagueness about privacy can be potentially harmful especially with personal data stored in the cloud

(Timmermans et al., 2010)

Challenges

- **Privacy across (cultural) borders**
  - Different views on privacy
  - Western countries more individual-based vs. Eastern countries more community-based
- **Cultural imperialism and dealing with diversity**
  - Avoid the dominance by a single player, i.e., United States
  - Implement regulations to avoid the suppression of local cultures

(Timmermans et al., 2010)

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