High Performance and Distributed Computing for Big Data

Unit 3: Cloud Computing

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Universitat Rovira i Virgili and Universitat de Lleida

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Big Data

This term leads to using large and complex data sets that are difficult to process using traditional data processing applications.

Who am I?

Dr. Jordi Mateo is a Computer Engineer and holds a PhD in Computer Science. My PhD thesis was focused on exploring methods, mathematical models and algorithms for managing cloud systems cost-effectively (Mateo Fornés et al. 2019). I have been working in the cloud computing field for more than 5 years, and I have experience in both academia and industry.

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Just to set the record straight, while I'm not a specialist in Biology, Medicine, or Health, I do have a knack for analyzing data from the healthcare sector. And when it comes to distributed computing, well, that's my jam!

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Introduction

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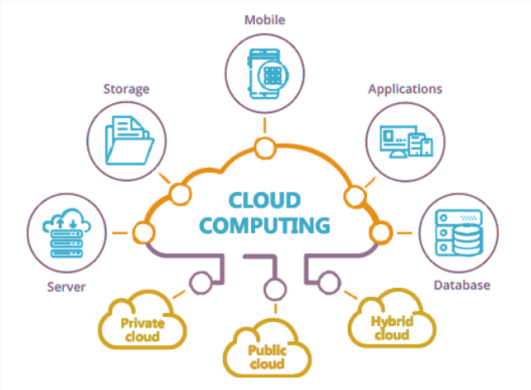

Figure 1: Overview of Cloud Computing

Definition

Cloud computing refers to the **on-demand delivery of computing services**, including servers, *storage, databases, software, analytics*, and more, over the internet (*the cloud*) with **pay-as-you-go** pricing (Mell, Grance, et al. 2011).

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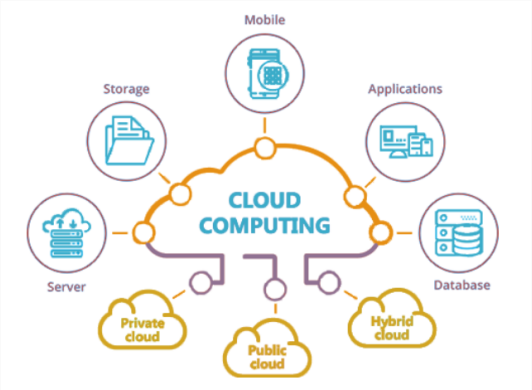

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Vision

In cloud computing, users can access these services remotely from any location with an internet connection. Rather than owning and maintaining their own computing infrastructure or data centers, users and companies can rent access to anything from applications to storage from a cloud service provider.

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Take Home Message

Stop thinking about the physical infrastructure and start thinking about software.

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Cloud computing is elastic, allowing organizations to scale resources based on demand efficiently.

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What happens if you need to change or upgrade the hardware?

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The user does not need to buy the server, the user can rent the server and the web server (cloud provider responsibility), and then upload the website (user responsibility).

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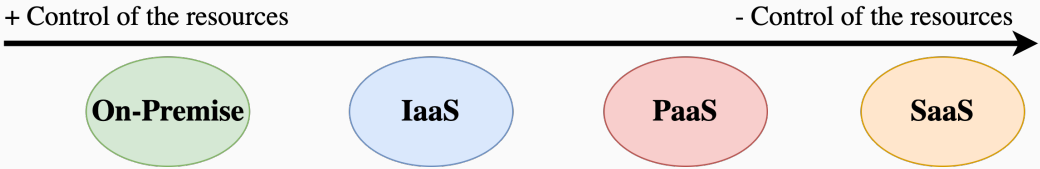
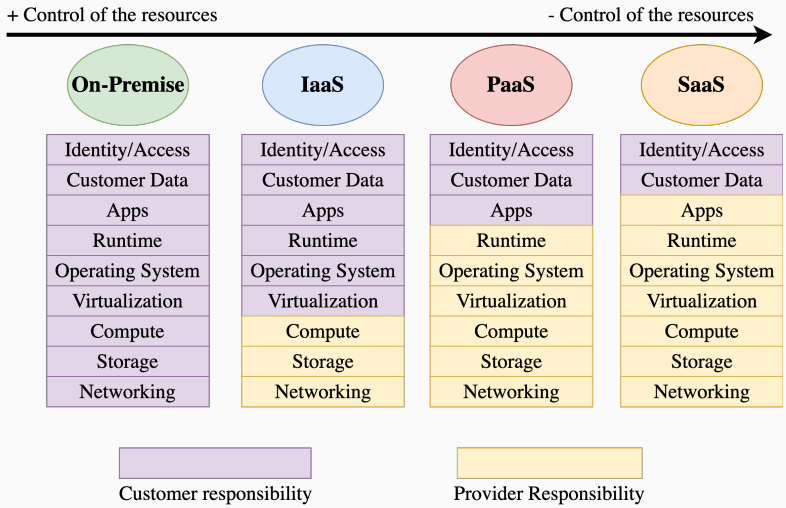


Figure 2: Cloud Services Models

Examples of Cloud Computing Models

SaaS	GMAIL	Office 365	Slack
FaaS	AWS Lambda	Apache OpenWhisk	Cloud Functions
DaaS	AWS Dynamo DB	Oracle Data Cloud	Mongo Atlas
PaaS	Microsoft Azure	AWS	App Engine
STaaS	One Drive	AWS S3	Dropbox
IaaS	AWS EC2	OpenNebula	Google Compute Engine

Shared Responsibility Model



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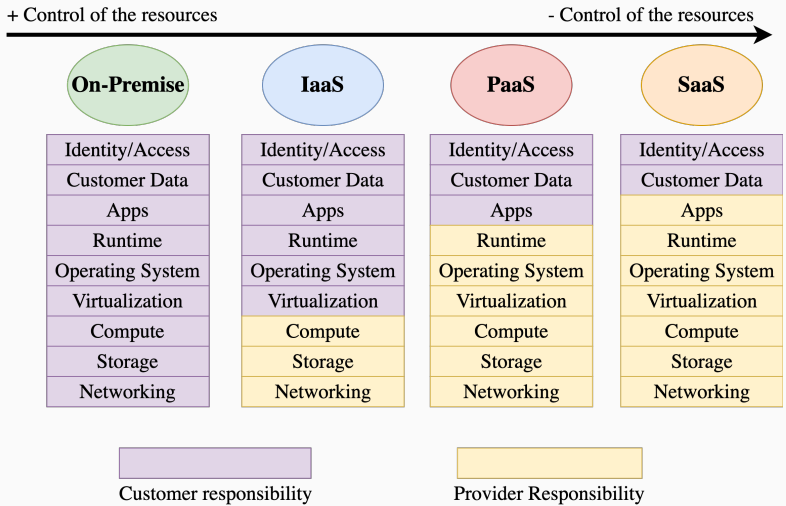

The shared responsibility model outlines where a cloud provider's role and responsibility ends and the customer's begins.

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- On-premises: You make the pizza at home from scratch. You are responsible for everything, from the ingredients to the baking and for preparing the table and the drinks too.

Deployment Models

PUBLIC CLOUD
To USE
Massive Space -> High Scalability

HYBRID CLOUD
To MOVE
Local Resources -> Cloud Resources

PRIVATE CLOUD (On-Premises)
To BUILD
Dedicated Resources -> Optimization

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- More expensive than public cloud but provides greater control and flexibility.

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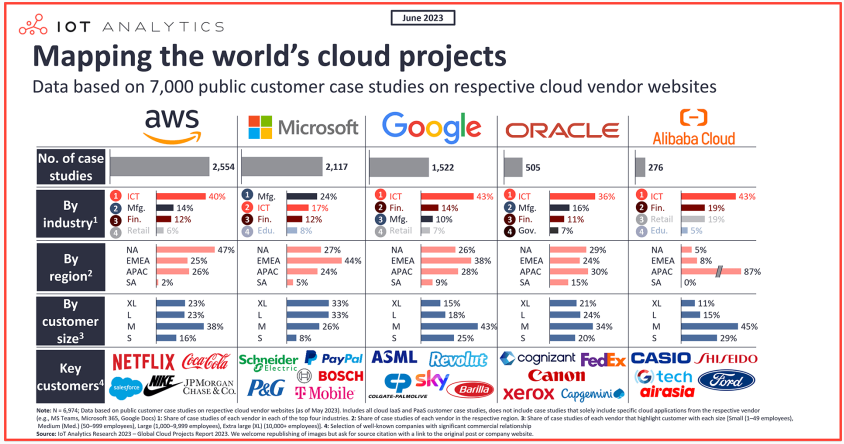

Figure 4: Extracted from IoT Analytics

Advantages of Cloud Computing

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If you want a suite, you can rent a suite. If you want a single room, you can rent a single room. Each time you can rent the room that you need. You need more rooms? You can rent more rooms.

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Example: Hotel Analogy

If you want a suite, you can rent a suite. If you want a single room, you can rent a single room. Each time you can rent the room that you need. You need more rooms? You can rent more rooms.

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Dropbox using Public Cloud

In its early stages, Dropbox leveraged AWS's S3 service for file storage. This decision offered Dropbox the ability to:

- Rapidly scale storage capacity as user demand increased.
- Achieve swift production deployment, enhancing their market responsiveness.

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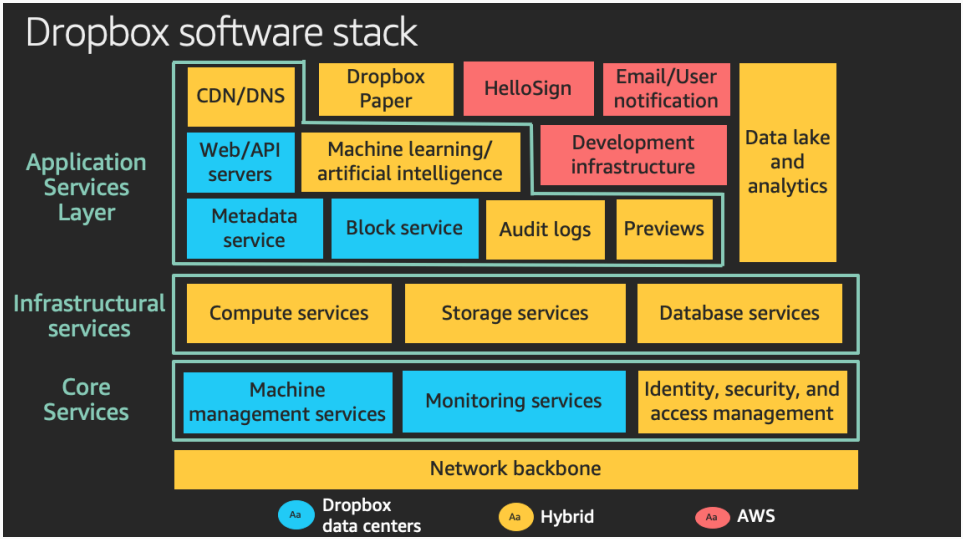
Dropbox migrating to an Hybrid Cloud

As Dropbox expanded, the costs associated with AWS usage escalated. To address this, Dropbox migrated to a hybrid cloud model, which allowed them to:

- Maintain control over their growing storage needs while managing costs effectively.
- Customize their infrastructure to suit their specific requirements, enhancing efficiency and performance.


Dropbox software stack
Application Services Layer
CDN/DNS
Dropbox Paper
HelloSign
Email/User notification
Web/API servers
Machine learning/ artificial intelligence
Development infrastructure
Data lake and analytics
Metadata service
Block service
Audit logs
Previews
Infrastructural services
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Storage services
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Machine management services
Monitoring services
Identity, security, and access management
Network backbone
Aa Dropbox data centers
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Risks and Challenges of Cloud Computing

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You need to be aware of the security measures of your cloud provider and yours, it is a shared responsibility.

Real Cases of Security Breaches

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- In 2023, the Clinic Barcelona Hospital suffered a data breach that exposed the personal information of million of patients. The breach occurred when a subcontractor accidentally uploaded patient data to the internet without proper security measures.

Have I Been Pwned?

Have I Been Pwned is a website that allows internet users to check if their personal data has been compromised by data breaches. The service collects and analyzes hundreds of database dumps and pastes containing information about billions of leaked accounts, and allows users to search for their own data by entering their username or email address.

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You need to be aware of the data compliance regulations that apply to your business.

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There are several strategies to mitigate the risks of vendor lock-in, such as using open standards and APIs, adopting a multi-cloud or hybrid cloud strategy. For instance, **VMWare** provides a multi-cloud strategy that allows customers to run applications across multiple cloud environments, including *AWS, Azure, and GCP*.

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Cloud computing is not without its risks and challenges, and companies need to carefully manage these to ensure a successful cloud deployment.

Case Study: Is Cloud Computing Right for Your Company? (I)

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The company can leverage cloud computing to reduce costs and time to market, while also benefiting from the flexibility and scalability of cloud resources. For instance, ***Amazon Web Services (AWS)*** *offers a pay-as-you-go model that allows startups to only pay for the services they use.*

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The decision depends on the specific needs and resources of the company. If the company has a significant amount of sensitive data, a traditional infrastructure might be more suitable due to the increased control over data security. However, if the company values flexibility and scalability, cloud computing could be a better choice.

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The cost of using public cloud services increases as the company grows, but the company can now afford to invest in a private cloud. At this point, a hybrid cloud solution can help to balance between the advantages of public and private clouds. For example, ***Microsoft Azure*** *offers hybrid cloud solutions that combine the best of both worlds.*

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Take Home Message

There's no one-size-fits-all answer when it comes to choosing between Cloud or Traditional infrastructure. The optimal solution hinges on the specific needs and resources of the company. A thorough analysis of the costs, benefits, and potential risks associated with each option is crucial to making an informed decision.

Cloud Computing in Health

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In his PhD thesis, **Management of Cloud Systems Applied to eHealth**, (Vilaplana Mayoral et al. 2015) conducts a comprehensive analysis of the adoption of cloud computing within the healthcare sector. He implemented various cloud-based tools for telemedicine and remote patient monitoring, highlighting their transformative impact on healthcare delivery.

Which are the opportunities of Cloud Computing in Health?

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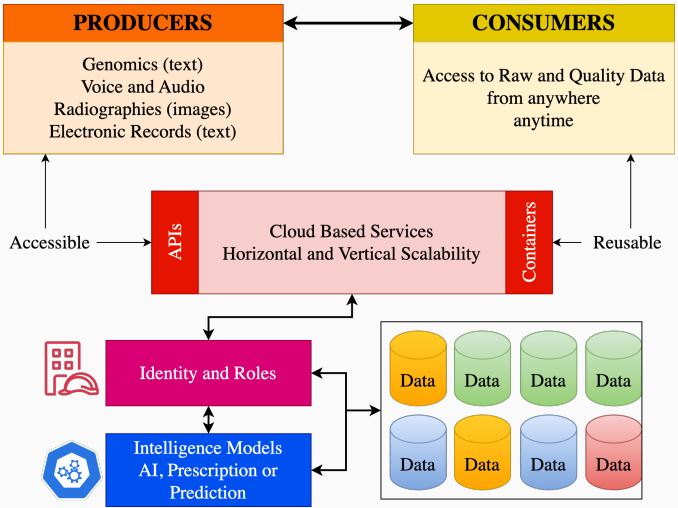
More opportunities in the healthcare sector are discussed in (Ali et al. 2018).

Conceptual Framework for Cloud Computing in Health



Adapted from (Navale and Bourne 2018).

Use Cases

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- **Remote Patient Monitoring**: IBM Watson Health offers solutions for remote patient monitoring. It uses AI to analyze data from various sources such as electronic health records and wearable devices, providing healthcare professionals with insights to improve patient care.

Challenges in Health

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- **Security and Privacy**: Healthcare organizations are obligated to adhere to stringent regulations and standards to safeguard patient data. LOPD in Spain or HIPAA in the United States mandate the protection of personal data and guarantees digital rights
- **Data Integration**: Healthcare organizations are required to integrate data from diverse sources and systems to deliver comprehensive care. This integration is crucial in transforming isolated information units into a unified system of knowledge and action. However, achieving seamless data integration in healthcare is a significant challenge. For instance, the integration of Electronic Health Records (EHRs) with telemedicine platforms provides clinicians with comprehensive patient data during consultations, but it is a complex process.

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Big ⇒ Quality

There is a growing demand for high-quality data in healthcare. Cloud computing can help healthcare organizations manage and analyze large volumes of data to improve patient care and outcomes. But it is not only about the **quantity of data**, it is about the **quality of the data**. Distributed Artificial Intelligence can help to analyze data and identify patterns and trends in real time.

Conclusion

Recap: Cloud Computing vs Traditional Computing

Cloud Computing

- Pay what you use
- No server space needed
- No expertes required for hardware and software maintenance
- Disaster recovery
- High flexibility
- Automated software updates
- Teams can collaborate from different locations
- Data can be accessed and shared from anywhere
- Rapid implementation

Traditional

- Costly and less scalable
- Space needed for the servers
- Hardware and software team for maintenance
- Less flexibility
- No automated updates
- Less collaboration
- Data cannot be accessed remotely
- Takes long time for implementation

Tasks

Homework

HandsOnLab01: **Deploying your personal website**

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For this hands-on lab, you will need to follow the instructions: HOL01

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Cloud Computing Fundamentals Quiz: This quiz will test your understanding of the fundamental concepts of cloud computing. Quiz.

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