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MASTER DISSERTATION

Submitted to obtain an Academic Master's degree in

« MANAGEMENT STARTEGIC AND INFORMATION SYSTEME »

THE CONTRBUTION OF CLOUD COMPUTING FOR ORGANIZATION

CASE: OOREDOO

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Abstract

Migrating to cloud computing is a significant goal for many organizations due to the numerous benefits it offers. This research aims to explore the contribution of cloud computing migration for organizations, focusing on key advantages such as cost savings, improved security, operational efficiency, increased flexibility, scalability, and high availability. The study adopts a qualitative approach, conducting semi-structured interviews with two deputy directors and all seven members of the cloud team at OOREDOO, who were selected as a case study. The findings of the study reveal that cloud computing has a substantial impact on organizations across multiple levels, providing a range of benefits. These benefits were extracted from six key categories, namely cost, security, organizational impact, time optimization, flexibility/scalability, and high availability. By examining the state of the company before the cloud migration and the challenges they encountered, as well as the benefits they obtained after the migration, this research provides valuable insights into the influence of cloud computing migration for organizations.

Key words: cloud computing, cloud migration, cost saving improved security, operational efficiency, increased flexibility, scalability, high availability.

Résumé

La migration vers l'informatique en nuage est un objectif important pour de nombreuses organisations en raison des nombreux avantages qu'elle offre. Cette recherche vise à explorer la contribution de la migration de l'informatique en nuage pour les organisations, en mettant l'accent sur les principaux avantages tels que les économies de coûts, l'amélioration de la sécurité, l'efficacité opérationnelle, la flexibilité accrue, l'évolutivité et la haute disponibilité. L'étude adopte une approche qualitative, en menant des entretiens semi-structurés avec deux directeurs adjoints et les sept membres de l'équipe cloud de l'OOREDOO, qui ont été sélectionnés comme étude de cas. Les résultats de l'étude révèlent que l'informatique en nuage a un impact considérable sur les organisations à de multiples niveaux, offrant une gamme d'avantages. Ces avantages ont été tirés de six catégories clés, à savoir les coûts, la sécurité, l'impact organisationnel, l'optimisation du temps, la flexibilité/évolutivité et la haute disponibilité. En examinant l'état de l'entreprise avant la migration vers le cloud et les défis rencontrés, ainsi que les avantages qu'ils ont obtenus après la migration, cette recherche fournit des informations précieuses sur l'influence de la migration vers le cloud computing pour les entreprises

.**Mots clés:** le cloud computing, migration du cloud, économie de coûts, sécurité améliorée, efficacité opérationnelle, flexibilité accrue, évolutivité, haute disponibilité.

مـــلخـــص

يعد الانتقال إلى الحوسبة السحابية هدفًا مهمًا للعديد من المؤسسات نظرًا للفوائد العديدة التي تقدمها. يهدف هذا البحث إلى استكشاف مساهمة هجرة الحوسبة السحابية للمؤسسات، مع التركيز على المزايا الرئيسية مثل توفير التكاليف، وتحسين الأمن، والكفاءة التشغيلية، وزيادة المرونة، وقابلية التوسع، والتوافر العالي. تعتمد الدراسة نهجًا نوعيًا، حيث تجري مقابلات شبه منظمة مع نائبين للمدير وجميع أعضاء فريق السحابة السبعة في OOREDOO، الذين تم اختيارهم كدراسة حالة. تكشف نتائج الدراسة أن الحوسبة السحابية لها تأثير كبير على المؤسسات عبر مستويات متعددة، مما يوفر مجموعة من الفوائد. وقد استخلصت هذه الفوائد من ست فئات رئيسية، هي التكلفة، والأمن، والأثر التنظيمي، وتحسين الوقت، والمرونة/قابلية التوسع، وارتفاع مستوى التوافر. من خلال فحص حالة الشركة قبل الهجرة السحابية والتحديات التي واجهتها، بالإضافة إلى الفوائد التي حصلت عليها بعد الهجرة، يوفر هذا البحث رؤى قيمة حول تأثير هجرة الحوسبة السحابية للمؤسسات.

الكلمات الرئيسية: الحوسبة السحابية، والهجرة السحابية، وتوفير التكاليف، تحسين الأمن، الكفاءة التشغيلية، زيادة المرونة، قابلية التوسع، التوافر العالي.

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MERIEM

قال تعالى: "قل اعملوا فسيرى الله عملكم والمؤمنون"

الحمد لله عدد ما كان وعدد ما يكون وعدد الحركات والسكون. الحمد لله الذي امدني بالقوة الذهنية والجسدية لأتمكن من اتمام هذا العمل ورد الدين لأصحابه، فأسال الله ان يكون هذا بداية التوفيق والنجاح.

الى من بفضلهما انا هنا ولولاهما لما تم هذا العمل والديَّ

الى صديقي وحبيبي وداعمي وسندي الخفي لمن البسني تاج الوقار والدي **سالم حسين**.

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الى كل من علمني ولهم الفضل علي من بعد الله.

كما اهدي هذا العمل للسيدة **ليلى الهامل** على نصائحها القيمة، و**حسيبة بن صغير** .

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هـــــدايـــــة

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LIST OF ABBREVIATIONS

VM virtual machine

OS operating systems

SaaS Software as a Service

PaaS Platform as a Service

IaaS Infrastructure as a Service

IT Information Technology

CSP Cloud service providers

CSA Cloud Security Alliance

API application programming interface

CRM Customer Relationship Management

CPU Central Processing Unit

OPEX operational expenditure

CAPEX capital expenditure

IDC International Data Corporation

Rad Lab Radiation Laboratory

INTRODUCTION

Technological advancements have played a pivotal role in shaping our modern world, revolutionizing industries and driving organizational transformation. The rapid progression of information technology has led to the emergence of innovative solutions that have redefined the way businesses operate and manage their resources. This continuous evolution has fostered an environment of constant innovation, where new technologies are introduced at an ever-increasing pace, offering organizations the opportunity to optimize processes, automate tasks, and make data-driven decisions.

Within the realm of technology development, virtualization has emerged as a significant breakthrough. Virtualization allows multiple virtual machines to operate on a single physical server, effectively decoupling software and applications from the underlying hardware infrastructure. (Chaturvedi, April 2019) This innovation has paved the way for the rise of cloud computing, which represents a paradigm shift in IT service delivery. Cloud computing takes virtualization to new heights by providing organizations with on-demand access to computing power, storage, and software applications through the internet.

Cloud migration, the process of transitioning from traditional on-premise infrastructure to cloud-based solutions, has gained substantial traction as businesses recognize the transformative potential it holds (Jayachander & Chunming, 2019). By migrating to the cloud, organizations can unlock numerous benefits, including enhanced agility, improved resource utilization, cost savings, and access to a vast array of cloud-based services (Ayob, January 2016). Cloud computing offers scalability, allowing organizations to scale their IT resources up or down based on demand, thereby enabling flexibility and cost optimization. Furthermore, the cloud provides organizations with the ability to leverage advanced technologies such as artificial intelligence, big data analytics, and Internet of Things, empowering them to gain valuable insights, drive innovation, and stay competitive in today's digital landscape. (Lawan, Oduoza, & Buckley, 2021)

However, cloud migration is a complex undertaking that requires careful planning, execution, and consideration of various factors. Organizations must evaluate their existing infrastructure, data security and privacy requirements, regulatory compliance, and potential vendor lock-in issues before embarking on the migration journey. It is crucial to assess the suitability of

different cloud deployment models (public, private, hybrid) and choose the one that aligns with organizational goals and needs.

Cloud migration, enabled by virtualization technology, offers organizations the potential to enhance agility, improve resource allocation, reduce costs, and leverage advanced technologies. However, successful cloud migration requires careful planning, consideration of various factors, and the adoption of appropriate cloud migration solutions. By embracing cloud computing and effectively managing the migration process, organizations can position themselves for long-term success, staying at the forefront of innovation and competitiveness in the digital era. (Fahmideh & al, 2017)

Research Question:

In order to gain a comprehensive understanding of the contribution of cloud computing migration to organizations in terms of cost savings, improved security, operational efficiency, increased flexibility, scalability, and high availability, the following research question is posed:

"What is the impact and significance of cloud computing migration on organizations across these dimensions?"

Research objective

By exploring this research question, our aim is to:

- To explore the contribution of cloud computing migration for organizations.

-To highlight the key advantages of cloud computing migration, including cost savings, improved security, operational efficiency, increased flexibility, scalability, and high availability.

-To provide valuable insights into the influence of cloud computing migration for organizations by examining the state of the company before and after migration, including challenges and benefits.

Research field

Our host company is Ooredoo Algeria, a subsidiary company of the Ooredoo Group, the aim of this internship is to discover the influence of cloud computing migration for organizations .So, the IT department, and more precisely the Cloud service was the most suitable option to carry out this study, since it's the service that interacts the most with this technology.

Method

This study adopts a qualitative research methodology, with a particular emphasis on conducting interviews as the primary research instrument. The interviews were conducted with nine employees of Ooredoo, aiming to gain a deeper understanding of the impact of cloud computing on the organization.

Plan announcement

Our research is structured as follows:

It begins with an introduction providing the motivation behind the chosen topic.

It follows by three chapters

In the first chapter titled Literature Review and Conceptual Framework, the main works of research on which our study relied will be presented, and then the conceptual bases of our research will be listed in a conceptual framework with an emphasis on the notions Virtualization and cloud computing.

In the second chapter, a presentation of our host organization, including their vision and objectives and organizational chart .followed by a methodological framework where we will present our methodological approach, our data collection methods and even our data processing methods.

In the last chapter, results of structured and semi-structured interviews that we conducted will be presented, analyzed then discussed

Finally, the conclusion summarizes the main obtained results, along with theoretical and managerial implications, it clarifies the limits of the study, and it ends with suggesting possible extensions of the study.

Chapter I: Theoretical and conceptual framework

Section One: The literature review

As businesses continue to explore new technologies, cloud computing has emerged as one of the most exciting options available. Regardless of the size of a company, there are many benefits to be gained from embracing cloud computing. However, it's important to be aware of the challenges that come with it, especially when it concerns matters of security and privacy. This literature provides an in-depth analysis of the impact of cloud computing migration on organizations. It explores the factors that influence its adoption, as well as the advantages and challenges that come with it. This review provides a comprehensive understanding of the issues involved, making it an invaluable resource for anyone considering the transition to cloud computing.

1 Cloud computing adoption and its impact on organizations

According to the research conducted by TOUMI AMARA, MAZA in 2022, cloud computing offers significant advantages for organizations, particularly small and medium-sized firms. By leveraging cloud computing technologies, businesses can enhance their information access, communication, and collaboration, as well as their customer and supplier relationships. However, in order to reap the benefits of this technology, organizations must carefully plan challenges related to security and privacy concerns, and highlights the importance of effective design and maintenance. To achieve the research objectives, qualitative and in-depth interviews were conducted with thirteen managers and experts from four small and medium-sized organizations, using a literature review as a basis for an interview guide comprising six open-ended questions. The data collected were analyzed using qualitative content analysis and open coding to determine the influence of cloud computing on enterprises across different themes. The study concludes that cloud computing can have a positive impact on small and medium-sized organizations, provided that potential issues, including security and privacy concerns, are addressed beforehand. (Toumi Amara & Maza, 2022)

In the study conducted by Maina Lawan, Oduoza, and Buckley in 2021, the authors focus on identifying factors influencing the adoption of cloud computing by organizations. The study identifies several significant factors, including technology readiness, top management support, relative advantage, competitive pressure, and compatibility, complexity, and data security. These factors were determined based on a systematic literature review of 174 papers from

various databases, with 37 articles ultimately considered for the investigation. The research indicates that these factors play a crucial role in the decision-making process for cloud computing adoption. In addition, the study reveals that most of the research on cloud computing adoption was conducted on SMEs, followed by different industries, government/public, healthcare, high technology, IT, service and manufacturing, and oil and gas. Furthermore, this study lays the groundwork for future research in conceptualizing a model for cloud computing adoption in the upstream oil and gas sector. (Lawan, Oduoza, & Buckley, 2021)

Wafa Bouaynaya and Marc Bidan's study in 2017 focuses on the migration of the Information Systems function of a medium-sized company to cloud computing solutions. The study aimed to characterize the ecosystems, actors, and interactions involved in this migration and to identify the dominance of cloud operators. To achieve this, the researchers adopted a qualitative methodology with an interpretive stance and presented two case studies focused on the role of Cloud providers in SaaS mode. The first case study examined the migration of a medium-sized company's information systems function from a cloud operator to a cloud-based solution, while the second case study focused on the migration of a company's HR function to a cloud-based solution offered by a cloud operator. These case studies provided valuable insights into the ecosystem, actors, and interactions involved in migrating data to the cloud. Interestingly, the study found that the migration of medium-sized enterprise information system functions to cloud computing solutions involves the interweaving of three types of actors and also highlights the cloud operator dominance mechanism. (Bouaynaya & Bidan, 2017)

2 Challenges and benefits due to the migration to cloud computing

According to the study by Ahmed Abdlrazaq and Asaf Varole in 2021, cloud computing adoption poses challenges related to cost and security risks. To gather information, the researchers employed a mixed-methods approach, using both qualitative and quantitative data collection techniques, such as surveys, interviews, and questionnaires. The senior cloud service providers were interviewed, while enterprises using cloud services were surveyed using questionnaires. The study's sample size was 66 respondents. The survey findings highlighted the primary challenges associated with adopting cloud computing and provided

recommendations for mitigating regulated security and cost risks. However, the authors note that selecting the appropriate type of cloud depends on several factors, including cost, business strategy, current challenges, and future roadmaps. Public clouds are well-suited to small and medium-sized enterprises, while large enterprises prefer private clouds due to security concerns and hybrid clouds due to their flexibility and risk balancing. The study's findings indicate that cost-benefit analysis is the primary driver for companies migrating to the cloud, while security risks are a major concern. These findings can assist companies in making informed decisions about cloud adoption and selecting the appropriate cloud type based on their needs and challenges. Additionally, cloud providers can use the research findings to improve their services and address their customers' concerns. (Ahmed & Asaf, 2021)

The research conducted by Luqman Abdulnabi and Rajab Asaad in 2022 sheds light on the challenges and benefits of cloud computing. Their study holds practical significance as it provides a comprehensive understanding of the issues and obstacles associated with cloud computing, as well as the advantages of its adoption. This knowledge can be useful for individuals and organizations in making informed decisions about cloud computing adoption and addressing its associated challenges. Additionally, this review article can serve as a resource for cloud computing researchers and practitioners to identify potential areas for further study and development. Employing qualitative research methods and conducting a literature review, the authors analyzed the challenges and benefits of cloud computing. Their findings reveal challenges related to security, flexibility, and cost while highlighting the benefits of scalability and speed. In light of these findings, the authors suggest that individuals and businesses should carefully consider these factors when determining whether or not to adopt cloud computing. (Luqman Abdulnabi & Rajab Asaad, 2022)

3 Security issues related to cloud migration and its adoption

Rashmi, Gadadhar, and Mehfuz (2015) systematically categorizes and identifies existing studies on the migration of legacy systems to the cloud, focusing on security issues that impede cloud adoption. The authors conducted a Systematic Literature Review (SLR) of 30 papers published between 2009 and 2014 to comprehend the nuances of the security framework. They suggest a conceptual model for cloud migration to classify selected studies and provide a resource base of existing solutions for cloud migration. The study concludes that

although cloud migration research is still in a seminal stage, it is evolving and maturing, with greater participation from both academics and industry. However, the authors suggest that more real-time case studies from industries are necessary to strengthen trust in cloud migration. The paper offers a model of reference for the current state of research and a scheme for characterizing cloud migration. Moreover, it consolidates research on security issues hindering cloud adoption by categorizing studies on secure cloud migration. This study identifies the need for a secure migration model to reinforce trust in cloud migration and facilitate the necessary tool support for the automation of the migration process. (Rashmi, Gadadhar, & Mehfuz, 2015)

Fatemeh, Chandni, Seema, Hadiseh, and B (2022) analyze security concerns in service-based cloud computing. This study is focused on analyzing the present condition of the field regarding security concerns in service-based cloud computing and categorizing them into a comprehensive classification system. This study aims to provide an overview of cloud computing security issues from the last decade. It creates a system that maps vulnerabilities to appropriate countermeasures. The study offers an in-depth analysis of cloud security and provides a unified classification system for security issues across the three-layer model. It is advantageous because it provides a more comprehensive approach to addressing security concerns in service-based cloud computing. (Fahmideh & al, 2017)

The study of Maniah, Soewito, & Edi (2022) aims to identify and analyze risks associated with cloud migration, using a systematic literature review approach. The study found that information security risk is the most common risk type, along with risk components such as data privacy, compliance, and legal issues. The results highlight the importance of conducting a thorough risk analysis before transitioning to cloud computing, assisting cloud service users in making informed decisions and mitigating potential risks. (Maniah, Soewito, & Edi, 2022)

This literature review provides a comprehensive exploration of various aspects of cloud computing, encompassing its adoption, organizational challenges, and security implications during the migration process. The review incorporates a range of quantitative, qualitative, and systemic studies that have been conducted to gain insights into the impact of cloud computing on organizations, factors influencing adoption decisions, and strategies to address security concerns. The findings reveal that cloud computing offers substantial benefits to

organizations, particularly small and medium-sized organizations, in terms of cost reductions, scalability, and flexibility. However, successful implementation necessitates careful planning and management, considering potential challenges such as security and privacy issues. The adoption of cloud computing is influenced by multiple factors, including technology readiness, senior management support, comparative advantage, competitive pressure, compatibility, complexity, and data security. Factors like cost-benefit analysis and security concerns significantly shape organizations' decisions regarding cloud adoption**.**

Tableau 1: Article Limits.

Article	**Limits.**
Toumi Amara & Maza 2022	-The article could have provided more specific recommendations for addressing security and privacy concerns, which are potential barriers to cloud adoption. -The study did not account for the potential bias or subjectivity of the interviewees' opinions and experiences with cloud computing
Lawan, Oduoza, & Buckley, 2021	-The study's focus on the upstream oil and gas sector limits the generalizability of the findings to other industries. -The study's reliance on a systematic literature review methodology may have excluded relevant studies that were not included in the selected databases.
Bouaynaya & Bidan, 2017	-Narrow scope, as it only examines the migration of a single medium-sized enterprise. This limits the generalizability of the findings and the ability to apply them to other organizations.
Abdlrazaq & Varol, 2021	-The article mainly focuses on cost and security risks, while other important factors that contribute to the success or failure of cloud migration, such as organizational culture and infrastructure readiness, are not adequately explored.
Abdulnabi & Asaad, 2022	-The study did not include any primary data or case studies, which could have provided a more in-depth understanding of the challenges and benefits of cloud computing in the context of real-world situations.
Rashmi, Gadadhar, & Mehfuz, 2015	-The study suggests the need for real-time case studies from industries to strengthen trust in cloud migration, but it does not provide a clear plan for how to conduct such studies or suggest how they can address other challenges and benefits associated with cloud migration

Fatemeh, Chandni, & al, 2022	-The study does not offer any new insights or recommendations for addressing security concerns, but rather consolidates existing research. -The study does not provide any empirical evidence to support its claims or validate its classification system.
Maniah, Soewito, & Edi, 2022	-The study does not provide specific recommendations for addressing or mitigating the identified risks, which may limit its practical value for organizations considering cloud migration.

Source: Elaborated by us.

Section two: The conceptual framework

1 Virtualization

1-1 Principle of virtualization

In recent years, companies have become increasingly interested in virtualization technologies. Although this concept is not new, many solutions are currently being implemented around virtualization, such as cloud computing. If we don't understand virtualization, we can't talk about cloud computing.

- **Definition of virtualization**

Virtualization occurs when a virtual version of something is created instead of the actual version. A combination of hardware and software development that creates a virtual machine (VM) and allows multiple operating systems to run on the same platform. (Rashid & Amit, 2019)

Simply put, virtualization is a method that allows an operating system to be separated from the hardware on which it is working. (Nancy & Sakshi, 2016)

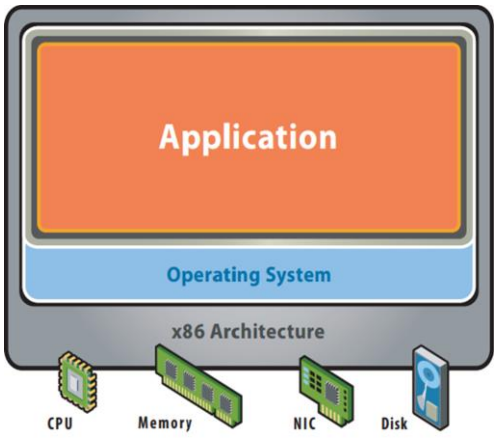
To be operationally relevant, virtualization must respect two fundamental principles (GRASSA, 2014):

- ✓ **Partitioning:** each operating system operates independently, and cannot interfere with others in any way.

- ✓ **Transparency**: Operating in virtualized mode does not change the functioning of the operating system and a fortiori of the applications.
- ✓ **Transparency implies compatibility**: all applications can operate on a virtualized system, and their functioning remains unchanged.

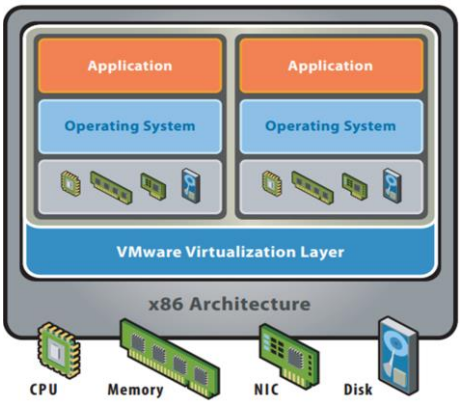
Figure 1: Before and after virtualization

Before Virtualization.



- Single OS image per machine
- Software and hardware tightly coupled
- Running multiple applications on same machine often creates conflict
- Underutilized resources
- Inflexible and costly infrastructure

After Virtualization.



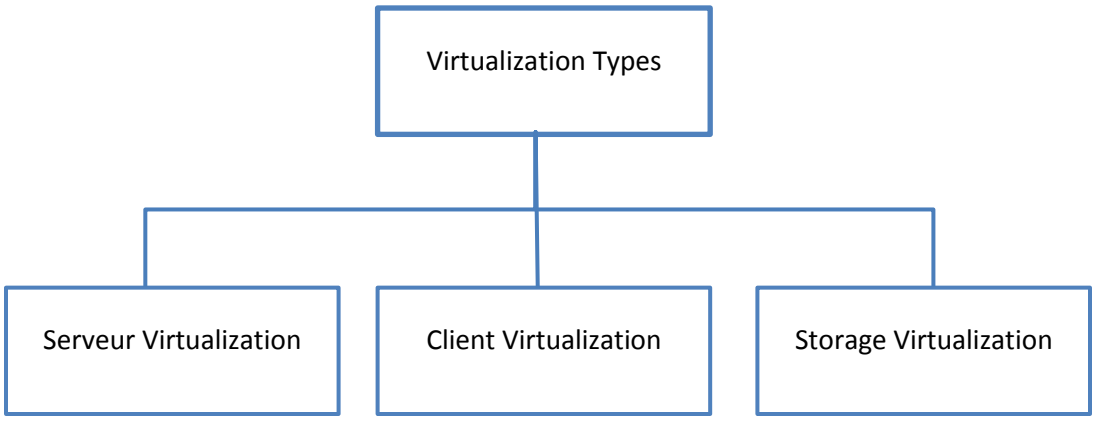
- Hardware-independence of operating system and applications
- Virtual machines can be provisioned to any system
- Can manage OS and application as a single unit by encapsulating them into virtual machines

Source: (VMware, 2006).

2 Virtualization types

There are three major types of virtualization such as server virtualization, client virtualization, and storage virtualization, as illustrated in Figure 02.

Figure 2: Types of virtualization



Source: (Rashid & Amit, 2019)

-2-1 Server virtualization

In server virtualization, a single server performs the task of multiple servers by portioning out the resources of an individual server across a multi-environment. (Chaturvedi, April 2019)

It enables the use of multiple virtual servers on a physical server by using virtualization software. (Nancy & Sakshi, 2016)

Server virtualization in the cloud is the most common type of virtualization and provides advantages such as optimal hardware utilization and application availability. The main idea behind this is to combine many small physical servers into one large physical server to use processors more efficiently. (Rashid & Amit, 2019)

Server virtualization is further subdivided into the following types:

a- Full Virtualization

Full virtualization is a type of virtualization where a virtual machine is created that emulates the complete hardware environment of a physical machine. In it, the complete simulation of the actual hardware takes place to enable the software to execute an unmodified guest OS (Rashid & Amit, 2019).Guest operating systems are unaware that they are running in a

virtualized environment and run unmodified, allowing support for a wide range of operating systems.

b- Para virtualization

In this type of virtualization, the guest operating system is modified to be aware that it is running in a virtualized environment, it can communicate directly with the hypervisor without the overhead of virtualizing every hardware access. It bridges the communication between the guest operating system and the hypervisor to improve performance (Rashid & Amit, 2019).A potential drawback of this approach is that such modified guests cannot be migrated and run on physical hardware. (VMware, 2006)

c- Partial virtualization

Also known as operating system-level virtualization or containerization, Partial virtualization provides a partial emulation of the underlying hardware, which does not allow the guest operating system to function in complete isolation. Partial virtualization allows many applications to work seamlessly, but not every feature of the operating system can be supported like full virtualization. (Rajkumar & Thamara, 2013)

It creates multiple isolated user environments, also known as containers, within a single operating system. Each container can run its own processes and applications, but all containers share the same kernel and host operating system resources. Partial virtualization is lighter-weight and more efficient than full virtualization, but it is limited to running applications that are compatible with the host operating system.

-2-2 Destock/Client Virtualization

This technology lets the system administrator monitor and updates client machines like laptops, workstation desktops, and mobile devices. It improves the client machines management and increases security against hackers and cybercriminals. There are three types of client virtualization: (Pandey, 2017)

- Remote or server-hosted virtualization, where server machines are monitored, and

  Operated by the client over the network.

- Local or client virtualization, where the virtualized operating system runs on the local machine without risk.
- At the application level, virtualization provides a variety of ways to run applications that were not possible in traditional ways. Partitioned or isolated virtualization environments are used to run applications in a variety of ways.

-2-3 Storage virtualization.

Here the logical storage gets separated from physical storage. Three types of data storage are used in virtualization, which is as follows (Sarabjit & Dr.Ajay, 2018):

- **DAS (Direct Attached Storage).** This is a traditional data storage technique where storage drives are attached directly to the server machine.
- **NAS (Network Attached Storage):** This is shared based storage mechanism connected through a network for device sharing, file sharing, and backup storage among machines.
- **SAN (Storage Area Network):** This is a storage device shared by different servers through a high-speed network.

It provides various advantages as follows (Rashid & Amit, 2019):

- Improvement of storage management within a heterogeneous IT environment.
- Easy updates, better availability.
- Reduced downtime.
- Better storage usage.
- Automated management.

2.1 Benefits of visualization

Virtualization is useful for both server deployments and individual desktop stations. One of the main advantages of virtualization is the capability to run several operating systems on a single physical system and efficiently share underlying hardware assets, known as partitioning (Ramandeep & Sumit, 2020).

In addition to facilitating resource management, virtualization technology plays a crucial role in enhancing security in cloud computing environments. By isolating cloud components and

guest virtual machines from each other, virtualization helps protect the integrity of the system and prevents the spread of malicious software.

The benefits of migrating to a virtual environment are numerous, saving money and time while providing better business continuity and the ability to recover from disasters. May include the following virtualization benefits (Rashid & Amit, 2019):

- Cost effective.
- Reduces the workload.
- Offers better uptime.
- Allows for faster deployment of resources.
- Promotes digital entrepreneurship.
- Better disaster recovery solutions.
- Efficient and economic use of energy.
- Isolation.

According to the Red hat guide to virtualization we can find various benefits related to: cost, performance and security (Herrmann & al, 2017):

- **Cost**

Virtualization is a cost-effective solution for businesses as it reduces power consumption and maintenance costs. By consolidating multiple physical platforms into a virtualized environment, the power required for machine operation and cooling is significantly decreased, resulting in lower energy costs. Moreover, the initial costs associated with the purchase of multiple physical platforms and ongoing expenses related to maintenance and upgrades are greatly reduced through virtualization. Migrating physical systems to a virtualized environment also requires less time and resources, leading to reduced spending on parts and labor.

Furthermore, virtualization technology enables the extension of the life of older software versions, which may not be compatible with new bare metal systems. By running older software on virtual machines, performance can be optimized, and the life of the software can be prolonged.

- **Performance**

Modern virtualization technologies have improved the performance of virtual machines to the point where they can run server applications as efficiently as bare metal systems. This high-performance capability ensures that virtual machines can handle a wide range of workloads, making them a reliable option for businesses.

Virtualization technology also enables high availability, ensuring that applications are migrated to another server in the event of a problem with the physical server. This minimizes downtime and ensures that critical applications remain accessible to end-users.

In summary, virtualization offers significant cost savings through reduced power consumption, maintenance costs, and extension of software life. Additionally, modern virtualization technologies have greatly improved the performance of virtual machines, making them a reliable and efficient option for businesses. High availability features further ensure that critical applications remain accessible, reducing downtime and maximizing productivity.

- # Cloud computing

Cloud computing has emerged as a pivotal and indispensable technology that has transformed various aspects of our personal and professional lives. The pervasive use of cloud computing has become paramount for organizations, as it has become virtually impossible for them to operate without leveraging its capabilities. This part aims to explore the key aspects and themes associated with cloud computing, shedding light on its fundamental principles and implications for businesses.

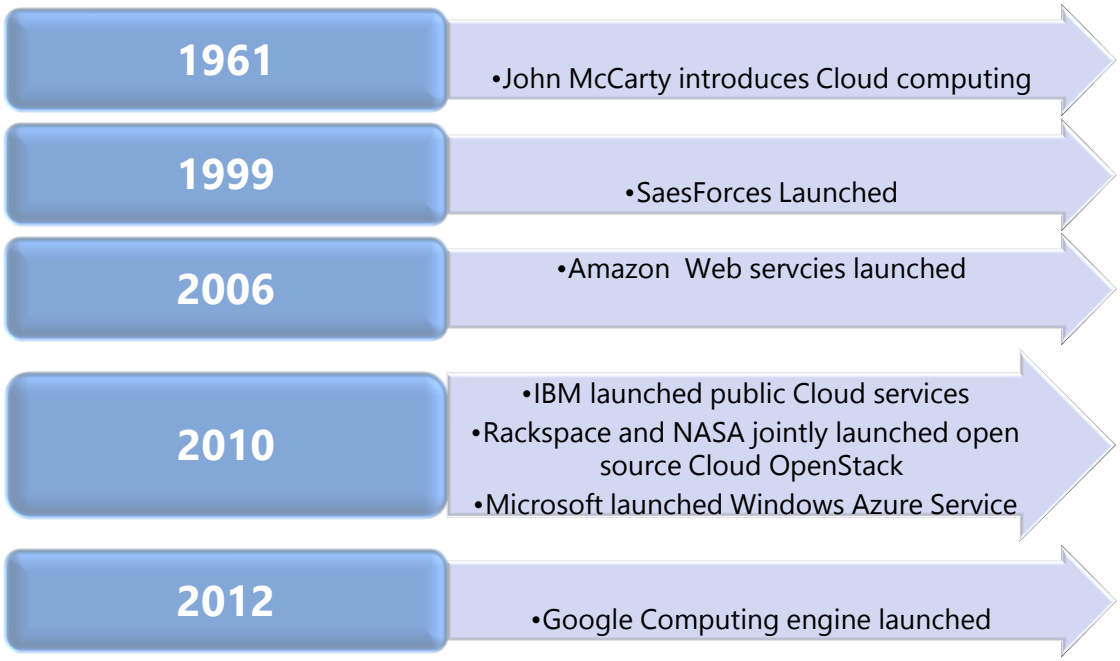
-2 Emergence of the Cloud.

-2-1 History.

Cloud computing has its roots in earlier real-time computing systems. The term "cloud" refers to a provider of services delivered over the internet, while "computing" pertains to the processing or computations provided by a computer. (Jayachander & Chunming, 2019) John McCarthy, a researcher at MIT, first proposed the concept of cloud computing in 1961, envisioning a future where computers could be organized like a public utility. The first company to work with cloud computing was Salesforce, which offered Software as a Service

(SaaS) for customer relationship management in the late 1990s. Since then, cloud computing has evolved to include other typical patterns such as Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). In 2007, Google and IBM collaborated with several US universities to promote cloud computing programs, making it more accessible and cost-effective for academic research. In 2010, NASA and Rackspace launched OpenStack, a joint project with several vendors that promoted cloud services deployment. The OpenStack project is now supported by over 500 companies, with around 6800 companies using it to deploy their cloud services. In 2011, the Cloud Security Alliance (CSA) introduced the Trusted Cloud Initiative, which published a white paper to guide cloud service providers in developing secure, interoperable, and manageable cloud services that meet industry standards. Figure 1 presents a timeline of the history of cloud computing (Jayachander & Chunming, 2019).

Figure 3: History of cloud computing



Source: (Jayachander & Chunming, 2019).

-2-2 Evolution

Cloud computing has undergone several stages of development from traditional technologies. Its evolution can be traced back to earlier concepts such as utility computing and grid computing before it reached its current level of maturity. Utility computing, which originated

in the 1960s, aimed to provide shared computing resources to users globally, including servers, storage systems, and applications. This allowed multiple users to access computer resources and pay only for the services they used during a specified period. Grid computing, on the other hand, involves breaking down large computing problems into smaller tasks and distributing these tasks among several machines or computers to achieve the final result. The concept of cloud computing shares similarities with that of utility and grid computing, and with advancements in technology over the past few decades, it has matured considerably to meet its objectives. The cloud computing service model is currently divided into three main categories: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). (Jayachander & Chunming, 2019)

-3 Definition of the Cloud.

The definition of Cloud Computing has been the subject of various interpretations by analyst firms, industry practitioners, academics, and IT companies. Table 4.1 presents a summary of how specific analyst firms have defined or described Cloud Computing. (Katarina & Thomas, 2010)

Tableau 2: Definition of the Cloud according to many authors

Source	Definition
Gartner	"A style of computing in which massively scalable IT-related capabilities are provided "as a service" using Internet technologies to multiple external customers"
IDC	"An emerging IT development, deployment and delivery model, enabling realtime delivery of products, services and solutions over the Internet (i.e., enabling cloud services)"
The 451 Group	"A service model that combines a general organizing principle for IT delivery, infrastructure components, an architectural approach and an economic model – basically, a confluence of grid computing, virtualization, utility computing, hosting and software as a service (SaaS)"
Merrill Lynch	"The idea of delivering personal (e.g., email, word processing, presentations.) and business productivity applications (e.g., sales force automation, customer service, accounting) from centralized servers"
Berkeley RAD Lab	"Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the datacenters that provide those services.

Reese	"The Cloud service is accessible via a web browser (nonproprietary) or web services API. Zero capital expenditure is necessary to get started. You pay only for what you use as you use it."
Foster et al.	"Large-scale distributed computing paradigm that is driven by economies of scale, in which a pool of abstracted, virtualized, dynamically-scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet."
Vaquero et al.	"Clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services). These resources can be dynamically reconfigured to adjust to a variable load (scale), allowing also for an optimum resource utilization. "

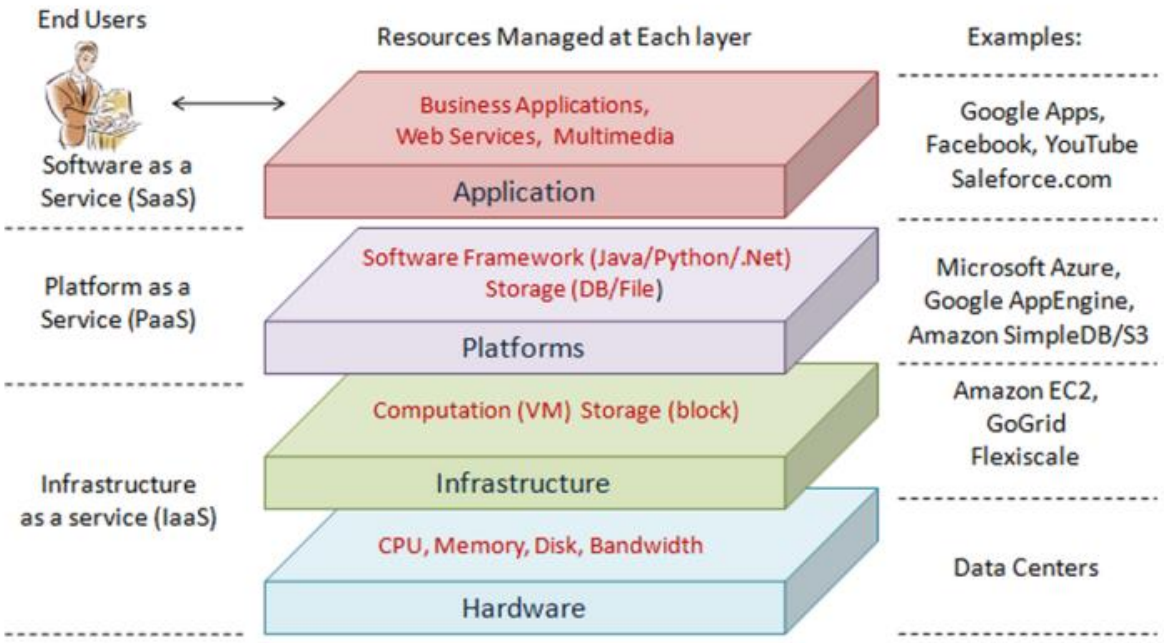
Source: (Katarina & Thomas, 2010)

Indeed, the definitions provided by various sources, such as Gartner, IDC, The 451 Group, Merrill Lynch, Berkeley RAD Lab, Reese, Foster et al., and Vaquero et al., all highlight the fact that Cloud Computing is a multifaceted concept that represents a new approach to the delivery and deployment of IT resources. These resources may include computing power, storage, platforms, and services, all of which can be delivered on demand to external customers over the Internet. The cloud service model is based on economies of scale, virtualization, and dynamic scalability, allowing for optimum resource utilization and cost-effectiveness. Furthermore, cloud computing can be accessed via web browsers or web services APIs, without requiring significant upfront capital expenditure, and users only pay for what they use. Overall, the definitions presented demonstrate the significance of cloud computing as a fundamental shift in the way IT resources are managed, delivered, and utilized.

-4 Cloud computing architecture

The cloud computing environment can be conceptually divided into four distinct layers: the hardware/datacenter layer, the infrastructure layer, the platform layer, and the application layer, as depicted in Figure 04. Each of these layers plays a crucial role in the overall architecture of the cloud computing environment, and they will be described in detail in the following sections. (Zhang, Cheng, & Raouf, 2010)**.**

Figure 4: Cloud computing architecture.



Source: (Zhang, Cheng, & Raouf, 2010)**.**

- **The hardware layer**

In cloud computing is responsible for managing the physical resources of the cloud, such as physical servers, routers, switches, power and cooling systems, and is typically implemented in data centers. The hardware layer plays a critical role in ensuring efficient hardware configuration, fault-tolerance, traffic management, as well as power and cooling resource management (Zhang, Cheng, & Raouf, 2010).

- **The infrastructure layer**

Also referred to as the virtualization layer, creates a pool of storage and computing resources by partitioning the physical resources using virtualization technologies such as Xen, KVM, and VMware. This layer is an essential component of cloud computing, providing features such as dynamic resource assignment that would not be available without virtualization. (Zhang, Cheng, & Raouf, 2010)

- **The platform layer**

Built on top of the infrastructure layer, consists of operating systems and application frameworks. Its primary purpose is to reduce the burden of deploying applications directly into virtual machine containers. For instance, Google App Engine operates at the platform layer to provide API support for implementing storage, database and business logic of typical web applications. (Zhang, Cheng, & Raouf, 2010)

- **The application layer**

At the highest level of the cloud computing architecture, comprises the actual cloud applications. Cloud applications leverage automatic scaling to achieve better performance, availability, and lower operating costs. Compared to traditional service hosting environments like dedicated server farms, cloud computing architecture is more modular, with each layer loosely coupled to those above and below it. This allows each layer to evolve separately and supports a wide range of application requirements while reducing management and maintenance overhead. (Zhang, Cheng, & Raouf, 2010)

2-4 Types of the Cloud

Cloud computing has revolutionized the way businesses and organizations operate by providing flexible and scalable solutions that allow users to access data and applications remotely. Cloud computing is divided into three main categories: Software as a Service (SaaS), Infrastructure as a Service (IaaS), and Platform as a Service (PaaS). Each of these categories has its unique features and benefits, making them suitable for different types of businesses and organizations. By understanding the differences between these types of cloud computing, organizations can choose the most appropriate solution for their needs, improve efficiency, and reduce costs. (GRASSA, 2014)

2-4-1 SaaS (Software as a Service)

SaaS is a mode of using software solutions by accessing them remotely through the hosting services of the software vendor. This mode of service delivery is commonly used for software applications related to CRM or web marketing. Since the software solution is accessed through a simple internet browser, the company is relieved from the burden of installation, updates, or technical maintenance. This also enables employees to use the software solution in mobile

settings. Subscription-based or usage-based billing models may apply to the provision of SaaS solutions, and customization and service provision fees may also be added. In the web marketing domain, email campaign management platforms, web analytics tools, and ad servers are typically offered as SaaS solutions. The advantages of SaaS include no installation or update requirements, pay-as-you-go pricing, and easy software testing. On the other hand, SaaS limitations include being confined to the offered software, lack of control over data storage and security, and sometimes suboptimal performance of web application. (GRASSA, 2014)

2-4-2 Paas (Plateform as a Service)

Paas consists primarily of shared servers and their operating systems, forming a cloud-based platform. In addition to delivering software solutions in SaaS mode, PaaS offers specialized development environments that include languages, tools, and necessary modules. The benefit of PaaS is that these environments are hosted by an external service provider, allowing businesses to focus on development without requiring infrastructure or maintenance personnel. PaaS offers automated deployment, eliminating the need to purchase or install additional software. However, its limitations include being restricted to one or two technologies (e.g., Python or Java for Google AppEngine, .NET for Microsoft Azure, proprietary for force.com) and a lack of control over the underlying virtual machines. PaaS is only suitable for web applications and targets developers. Google App Engine is the primary provider of this type of infrastructure. (GRASSA, 2014; Jayachander & Chunming, 2019)

2-4-3 Iaas (Infrastructure as a Service)

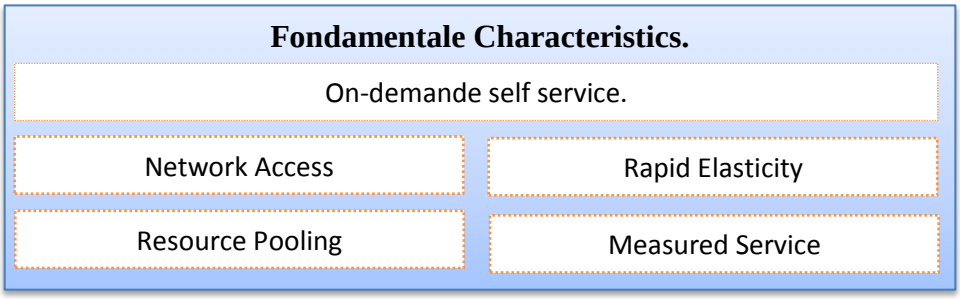
Iaas refers to the provision of infrastructure resources on-demand, whereby the majority of these resources are located remotely in data centers. IaaS provides administrators of a company with access to servers and their configurations. Clients have the option to rent clusters, memory, or data storage, with costs being directly proportional to the degree of resource utilization. The advantages of IaaS include great flexibility and complete system control, which enables the installation of any type of business software. However, IaaS requires system administrators, just like traditional on-premises server solutions. The target audience for IaaS is IT infrastructure managers. Amazon EC2 is the primary provider of this

type of infrastructure, while OpenStack serves as an example of such infrastructure. (GRASSA, 2014)

2-5 Characteristics of the Cloud

Cloud computing is a paradigm that provides access to massive computational power via the Internet, rather than through local machines. This approach allows organizations to efficiently allocate resources and move them to areas where they need more processing power, thus minimizing waste of unused resources. Traditionally, processing power was distributed across local machines, but cloud computing facilitates centralized processing in data centers, effectively treating computing as a commodity that can be traded over the Internet. Key characteristics of cloud computing include large scale, virtualization, low cost, geographic distribution, service orientation, resilient computing, and advanced security for services. (Jayachander & Chunming, 2019) In addition to these attributes, cloud computing should also exhibit fundamental characteristics as illustrated in Figure 05.

Figure 5: Characteristics of the Cloud.



Source: (Jayachander & Chunming, 2019)

- **On-demand self-service**

In an automated and user-friendly manner, end-users are enabled to access specific computing resources (such as CPU time, network storage, software, etc.) at their discretion, including the ability to initiate or terminate usage without requiring human intervention. (Jayachander & Chunming, 2019)

- **Network access**

Cloud computing provides a means of delivering computing resources over the internet, which can be accessed by diverse applications from a range of devices, including laptops, desktops,

and mobile devices, based on the requirements and availability of end-users. (Jayachander & Chunming, 2019)

- **Resource pooling**

Cloud service providers utilize a multi-tenancy model to consolidate their computing resources, serving various end-users with dynamically assigned physical and virtual resources based on consumer demand. This enables end-users to access computing resources regardless of their location, thus facilitating location-independent resource pooling. (Jayachander & Chunming, 2019)

- **Physical transparency or Rapid elasticity**

End-users are provided with the ability to dynamically adjust their resource allocation as needed, scaling up or down their usage of computing resources depending on demand. This allows for greater flexibility and cost efficiency, as resources can be scaled up during periods of high demand and scaled down when demand is lower. Furthermore, this scalability is easily configurable by end-users, ensuring that resources are available to meet peak demands at any time. (Jayachander & Chunming, 2019)

- **Pay peruse or Measured Service**

Despite sharing and pooling all resources among multiple tenants, cloud service providers must ensure that end-users are only charged for the services they have used. This requires an accurate mechanism for measuring the specific services used by each customer. (Jayachander & Chunming, 2019)

2-6 Cloud deployment models

Cloud computing is a solution that offers a virtual space for server or network infrastructures, development, and execution platforms. The deployment models of cloud computing are defined by the relationship between the cloud provider and the organization or company that is using the cloud services. Choosing the appropriate deployment model is crucial for companies seeking to address their cloud computing needs effectively.

There are four deployment models available in cloud computing: private, public, hybrid, and community cloud.

2-6-1 Public cloud

Rajkumar, James, & al propose definitions for public cloud as a “cloud made available in a pay-as you-go manner to the general public “, it’s a cloud service provider offers services to multiple businesses, academic institutions, government agencies, and other organizations with access via the Internet. (Buyya, Broberg, & Goscinski)

Cloud service providers offer a range of services that can be accessed by multiple organizations, including businesses, academic institutions, and government agencies, among others, over the Internet. These services are delivered through a shared computing infrastructure that is scalable and configurable and can be tailored to meet the specific needs of each customer. Cloud computing has become an increasingly popular model for delivering IT services due to its flexibility, cost-effectiveness, and ease of use. Cloud service providers employ various mechanisms and technologies to ensure the security, availability, and reliability of their services, such as data encryption, network monitoring, and disaster recovery planning. (Peter & Timothy).

For example the main "public" and professional services (such as Gmail, Google Apps, Amazon, Microsoft, etc.) provided in SaaS mode are mostly hosted on public clouds.

2-6-2 Private cloud

Cloud infrastructure is designed to be used by a single organization that comprises multiple tenants, and can be regarded as a shared computing environment that provides on-demand access to a pool of configurable computing resources. Private clouds, which are dedicated to a specific organization, can be operated either on-premises or off-premises and are protected by the organization's firewall to ensure the security and privacy of the data and applications hosted on them. The deployment of private clouds can offer benefits such as greater control, improved performance, and reduced costs, and is a popular choice for organizations that have strict data security and compliance requirements. (Peter & Timothy)

2-6-3 Hybrid cloud

Hybrid clouds are a type of cloud delivery model that combines two or more distinct cloud environments, such as private and public clouds, in a single infrastructure that is integrated using technology to enable seamless data and application portability. This hybrid approach

offers organizations the flexibility to leverage the benefits of each cloud type, while also mitigating some of their limitations. Cloud bursting, for instance, is a technique commonly used in hybrid cloud environments to address fluctuations in workload demand by automatically shifting computational tasks from a private to a public cloud, or vice versa, based on predefined thresholds. Hybrid clouds are gaining in popularity as they offer a scalable, secure, and cost-effective way for organizations to manage their computing needs, while also providing greater control and customization options compared to public clouds. (Peter & Timothy)

2-6-4 Community cloud

Cloud infrastructure can be designed to serve a specific community of user organizations that share similar computing requirements, including security, policy, and compliance considerations. This type of infrastructure is commonly referred to as a community cloud, and is typically provisioned for the exclusive use of the member organizations, who may have access to shared computing resources, storage, and networking capabilities. The community cloud model can offer several advantages over other cloud delivery models, such as greater control and customization options, improved security and privacy, and better compliance with industry-specific regulations. In order to ensure the smooth operation of a community cloud, it is essential to establish clear governance policies, service level agreements, and management frameworks that take into account the needs and expectations of the member organizations (Peter & Timothy).For instance, the online study platforms for universities are community cloud. (Ahmed & Asaf, 2021)

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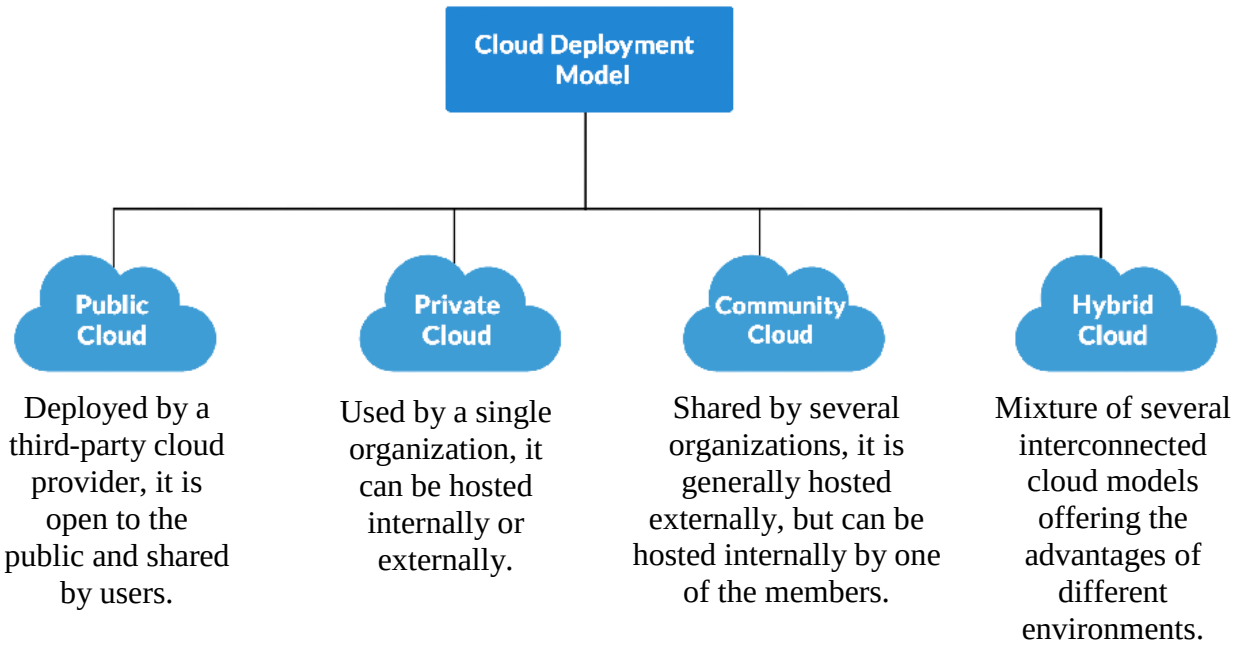
Figure 6: Cloud deployment models.



Source: (Peter & Timothy

2-7 The difference between cloud computing and virtualization

Cloud computing and virtualization are two distinct yet interrelated concepts. Virtualization involves the abstraction of compute resources, including storage and networking connectivity, through the creation of virtual machines. Cloud computing, on the other hand, involves the allocation, delivery, and presentation of virtualized resources through a centralized control system. Although virtualization is not a requirement for building a cloud environment, it facilitates the scaling of resources quickly and efficiently. (intel, July 2014)

Virtualization is the backbone of cloud computing, offering significant benefits in terms of resource utilization, security, privacy, and cost-effectiveness. Virtualization software enables a single computer to perform the functions of several other computers, allowing for the creation of virtual web servers or file servers that optimize the use of hardware resources while minimizing costs related to purchasing, maintenance, depreciation, energy consumption, and floor space. (Rashid & Amit, 2019)

The advantages of virtualization extend beyond cost savings, with benefits such as enhanced security, portability, trouble-free testing, simpler manageability, increased flexibility, fault isolation, and quick deployment. These advantages make virtualization a valuable tool in addressing some of the biggest challenges in the area of data security and privacy protection. (Rashid & Amit, 2019)

In conclusion, virtualization plays a critical role in cloud computing, providing a powerful tool for optimizing resource utilization, enhancing security, and reducing costs. The advantages of virtualization extend beyond the realm of cost savings, making it an essential component of any modern computing infrastructure.

3 Cloud migration for Organizations

Cloud migration is becoming increasingly popular for enterprises seeking to modernize their IT infrastructure and streamline their operations. Migrating legacy systems to the cloud can offer many benefits, including reduced maintenance costs, increased scalability, and improved agility. However, the migration process can be complex and challenging, requiring careful planning and execution to ensure a successful transition.

Various factors can impact the cloud migration process, including the organization's existing IT environment, the complexity of the legacy systems, the level of security and compliance requirements, and the available resources for the migration. It is crucial for organizations to identify these factors and develop a migration strategy that addresses each of them to minimize risks and ensure a seamless migration.

In this part we will provide an in-depth analysis of the cloud migration process for enterprise and legacy systems, including the various factors that can impact the migration and strategies for addressing them. Additionally, we will highlight best practices for managing the migration process and key considerations for ensuring a successful transition.

2 Legacy systems

Legacy systems are business-critical systems that hold the organization’s core business functions developed in a traditional way using monolith architecture and usually deployed on-premises. Through time, this system is exposed to improvement changes, increasing its size and number of functionalities, thus increasing its complexity, and maintaining it becomes a

disadvantage to the organization. Migration to the cloud environment becomes the primary option to improve legacy application agility, maintainability, and flexibility. However, to take advantage of the cloud environment, monolith legacy application needs to be rearchitected as microservice architecture to fully benefit from cloud advantages. (Fahmideh, Daneshgar, Rabhi, & &Beydoun, 2018)

3-1 Cloud Migration

Chauhan et al. characterize cloud migration as a reengineering process that enables organizations to interact with and utilize cloud services. (Chauhan & and Babar, 2012). Another definition describes cloud migration as a re-architecting process that involves modifying various components of legacy systems, including the business and data layers, to ensure compliance with cloud computing standards. A more encompassing definition of cloud migration considers socio-technical aspects and defines it as a set of migration activities aimed at supporting end-to-end migration. This definition takes into account the perspectives of stakeholders with diverse backgrounds and captures both business and technical concerns. (Fahmideh & al, 2017)

Cloud computing is distinguished by its elasticity, which is enabled by an abundance of resources, including CPU, memory, storage, and network bandwidth, that are available to service consumers. These resources can be obtained and released based on demand, allowing for optimal resource usage in the event of workload fluctuations. This feature sets cloud computing apart from other computing paradigms, such as cluster and grid computing.

3-1-1 **Migration Process**

This section outlines the primary stages involved in the migration process to cloud computing. Its objective is to offer a framework for transferring systems to cloud platforms, providing a set of guidelines for a successful transition.

- ✓ **Requirements Identification**

The initial step of the cloud migration process involves identifying the business requirements that serve as the driving force behind the migration. This step aims to establish the primary purpose and goals of the migration and to identify the necessary changes required for the system to operate effectively in a cloud computing environment. By breaking down the

business requirements into more specific functional and extra-functional requirements, they can be analyzed using qualitative or quantitative methods. This process lays the foundation for the subsequent steps of the migration process. (Chauhan & and Babar, 2012)

- ✓ **Identification of Potential Cloud Hosting Environments**

This activity involves the identification of a suitable set of cloud computing platforms that align with the nature of the project, data confidentiality and sensitivity requirements, budget constraints, and long-term organizational objectives. The selection process takes into account the organization's long-term commitment to specific cloud providers. Additionally, the features of potential cloud platforms are explored to ensure their compatibility with the organization's requirements. (Chauhan & and Babar, 2012)

- ✓ **Analyzing Applications Compatibility with Potential Cloud Environments**

Cloud computing provides various deployment models such as private, public, hybrid, and community clouds. In this activity, the most suitable deployment model for a particular system is identified based on various factors such as security, control, cost, and service-level agreements (SLAs). The organization's existing IT infrastructure and policies are also taken into account. Once the suitable deployment model is identified, the necessary changes are made to the system to align it with the chosen deployment model. (Chauhan & and Babar, 2012)

- ✓ **Identification of Potential Architecture Solutions**

Following the identification of requirements and the selection of potential cloud computing platforms, the next step involves analyzing the requirements in the context of each potential cloud environment. During this activity, the application components that are sensitive to different quality attributes, such as security and privacy, are identified. Proposed solutions are then evaluated to determine their advantages and disadvantages with respect to these quality attributes. Ultimately, a solution is chosen that best meets the functional and quality requirements. In cases where one solution cannot satisfy all requirements, a tradeoff analysis is conducted to identify the optimal solution that satisfies the most critical requirements. (Chauhan & and Babar, 2012)

- ✓ **Evaluation of Cloud Environments for Cloud Specific :-Quality Attributes -**

Cloud migration involves data migration from on-premises systems to the cloud. During this activity, the data is moved to the cloud while ensuring data integrity and security. The data migration strategy is selected based on the nature of data, business requirements, and the cloud platform being used. The data migration strategy can be offline, where data is first transferred to an intermediary storage device, and then uploaded to the cloud, or online, where data is transferred directly to the cloud in real-time. The data migration activity also involves identifying and resolving any potential compatibility issues with the cloud platform. (Chauhan & and Babar, 2012)

- ✓ **Evaluation of Proposed Solutions and Effected Components Against Target Platforms**

Cloud migration planning involves estimating the potential costs and risks associated with migrating a system to the cloud. This activity aims to identify the cost drivers that need to be considered in the cloud migration planning process, such as hardware and software licensing costs, data transfer costs, and ongoing maintenance and support costs. Additionally, the risks associated with migrating to the cloud, such as security risks and compliance risks, need to be identified and assessed. The goal of this activity is to ensure that the migration process is financially feasible and that the risks associated with the migration are manageable. (Chauhan & and Babar, 2012)

- ✓ **Implementation**

The concluding activity of the migration process endeavors to implement or refactor the proposed solutions that are intended for the purpose of migrating a system to be deployed on a selected cloud environment. (Chauhan & and Babar, 2012)

3-2 Factors affecting Cloud Migration

This section discusses the various challenges that organizations face while adopting cloud computing technology. Each of these factors has a significant impact on the successful implementation of cloud computing. The lack of standardization in SLAs and interoperability rules, for instance, creates compatibility issues when migrating to the cloud with multiple CSPs, leading to vendor-lock situations. Insufficient prior expertise in cloud computing and a

lack of appropriate cloud strategy and frameworks can also hinder successful implementation. Understanding these challenges is critical in devising effective cloud adoption strategies that can help organizations maximize the benefits of cloud computing while minimizing the associated risks.

- ✓ **Virtualization**

Virtualization is considered a fundamental technology for achieving efficient resource sharing in cloud computing. Despite its benefits, managing virtualization presents several challenges during cloud adoption and migration. Some of the challenges associated with virtualization management include server consolidation, resource sharing, and virtual machine security. Therefore, it is crucial to give more attention to virtualization management while adopting cloud computing. (Shuaib, samad, Alam, & Tabrez Siddiqui, 2019)

- ✓ **Security and Privacy**

Security and Privacy are primary considerations for organizations and individuals Contemplating the adoption of cloud computing. Extensive research has identified a range of security threats and concerns, including data loss/leakage, privacy violations, identity and access management issues, data security breaches, and malicious attacks within cloud computing environments. Addressing these challenges more efficiently is critical for enhancing the likelihood of cloud adoption among organizations. (Shuaib, samad, Alam, & Tabrez Siddiqui, 2019)

- ✓ **Interoperability**

One of the significant challenges in the adoption of cloud computing is the absence of a universal set of rules for all cloud service providers, leading to compatibility issues when migrating to the cloud with multiple CSPs. This can result in a vendor-lock situation, which further exacerbates the challenge of cloud migration. A more standardized approach to cloud adoption could alleviate these issues and increase the ease of migration. (Shuaib, samad, Alam, & Tabrez Siddiqui, 2019)

- ✓ **Service level Agreement SLA (service level agreement)**

Represents an important agreement between cloud service providers (CSPs) and organizations, stipulating the performance metrics, availability, data backup, updates, billing management, and legal provisions of cloud services. However, the lack of standardization across CSPs in SLAs leads to compatibility issues and hinders cloud adoption. (Shuaib, samad, Alam, & Tabrez Siddiqui, 2019)

- ✓ **Organizational context At the organizational level**

The adoption of cloud computing is a complex and multifaceted process that poses numerous challenges for organizations. Several factors, including the existing business environment, organizational support and size, and the level of knowledge and willingness to embrace cloud computing, can hamper the successful implementation of cloud computing. To effectively manage cloud resources and achieve organizational goals, management commitment and the development of a clear cloud adoption strategy are critical. However, inadequate cloud strategy development, limited domain knowledge, and insufficient preparedness can result in failed cloud migration, leading to an inability to realize desired business objectives. Furthermore, organizations must consider which services they require and how external challenges can impact these services. The lack of prior expertise in cloud computing and a dearth of appropriate cloud strategy and frameworks can further impede successful implementation. (Shuaib, samad, Alam, & Tabrez Siddiqui, 2019)

2-3 Advantages of Cloud Computing migration for Organizations

Cloud computing is a strategic solution that efficiently distributes shared computing resources to applications, thereby maximizing performance while reducing maintenance costs and providing economic benefits. Its superior reliability in a clustered environment also makes it a more advantageous option compared to traditional computing methods, allowing businesses to streamline their operations while ensuring smooth and uninterrupted processes (Ayob, January 2016).The following are some of the advantages that organizations can derive from cloud computing migration:

- ✓ **Automation**

Cloud providers assume the responsibility of keeping applications up to date, relieving the organization's IT staff of this task. They recognize the importance of timely updates to retain customers and prevent attrition. This shift allows the IT staff to rely on the diligence of cloud providers in maintaining and upgrading applications. (Bhopale, 2013)

- ✓ **Agility**

A key benefit of cloud computing, emphasizes the importance of efficiently integrating new capabilities into the IT infrastructure based on business requirements. Organizations are interested in determining the service's elasticity, portability, adaptability, and flexibility. (Alkhalil, Sahandi, & John, 2014)

- ✓ **Reduced cost**

Cloud migration offers organizations a cost-saving opportunity by reducing both capital expenses (CAPEX) and operating expenses (OPEX). This is made possible through on-demand resource acquisition, eliminating the need for significant upfront investments. Additionally, cloud computing outsourcing resource management, maintenance, and upgrades to third-party providers alleviate organizations of associated responsibilities and costs.(Bhopale, 2013)

- ✓ **Security and privacy**

Security and privacy are significant concerns for the majority of organizations, encompassing various attributes such as confidentiality, privacy protection, data integrity, and availability. The final steps involve selecting the most suitable cloud provider and proceeding with implementation. This includes training staff on the new system, communicating relevant information to stakeholders, and documenting the process. (Alkhalil, Sahandi, & John, 2014)

With adequate planning and implementation of effective security measures, cloud computing can provide enhanced security and help reduce the level of associated risks. (Ayob, January 2016)

- ✓ **Strategic value**

The strategic value of cloud computing lies in its ability to streamline work processes, allowing organizations to focus on their core competencies, such as application development. Cloud service providers manage the underlying infrastructure, reducing the burden on organizations to maintain it themselves. Additionally, CSPs regularly update their offerings, ensuring users have access to the latest technology. This allows organizations to remain competitive and move nimbly in the marketplace. Cloud computing also facilitates collaboration among teams, regardless of their geographic location, further enhancing the organization's agility and competitiveness[1].

2-4 Security on the Cloud

The emergence of cloud computing has led to the evolution of cloud security, which has become increasingly critical as more users adopt cloud services. The widespread use of these services means that inadequate protection of cloud infrastructure can leave vast amounts of customer data vulnerable to attackers from around the world. To ensure the protection of cloud-based resources, a range of security measures can be employed, including network attack prevention, software attack prevention, intrusion detection, access control, abnormal behavior analysis, virus analysis, malware analysis and others. The Cloud, with its vast storage and traffic capacity, is particularly vulnerable to security issues. In order to implement a durable and effective security policy, it is essential to identify potential risks and critical areas of vulnerability.

- ✓ **Data security**

When it comes to ensuring data security, encryption solutions offer a natural solution. Specifically, a commonly used method involves generating a public/private key pair, where only the intended recipient possesses the private key required to decrypt data. It is important to note that the Cloud provider does not hold the private key, thus ensuring secure data protection (depending on the key size). Furthermore, this approach allows clients to selectively encrypt specific portions of their data. However, implementing this method can present certain

[1] (https://www.ibm.com/topics/cloud-computing-benefits, (consulted 30/04/2023))

challenges, particularly when it is necessary to manipulate decrypted data during processes such as backup or indexing. (David, Farid, Jérôme, Loïc, Mickaël, & Thomas, mai 2012)

- ✓ **Identifying Security Risks**

SYNTEC Numérique presents nine risks that are linked to cloud computing. These risks include loss of data control, deficiencies in interfaces and APIs, compliance and maintenance of legal aspects of data, data relocation, isolation of data environments, monopolization of resources, data loss, recovery, impersonation, and malicious use. These risks demonstrate the importance of implementing a comprehensive and resilient security policy to safeguard data in the cloud. (David, Farid, Jérôme, Loïc, Mickaël, & Thomas, mai 2012)

- ✓ **Physical security**

The physical security measures those are necessary for data centers to ensure the safety and availability of data. These measures include access control, traceability, protection of certain areas against environmental risks, and implementation of hardware redundancies. The use of different equipment and the replication of configurations are also important to prevent potential problems. Finally, a geographically remote backup system can be implemented to enable a business continuity plan in case of infrastructure loss. These measures highlight the importance of maintaining the integrity and availability of data, which is critical for the continuity of business operations. (David, Farid, Jérôme, Loïc, Mickaël, & Thomas, mai 2012)

- ✓ **Logical security**

The crucial security considerations that are required to be taken into account while integrating security measures into virtualized platforms. It accentuates the significance of adhering to the same security policies as those in physical architecture while also tackling the specific security challenges of the cloud, such as co-location and infrastructure sharing. (David, Farid, Jérôme, Loïc, Mickaël, & Thomas, mai 2012) The passage underscores the use of filtering equipment and antivirus solutions for securing network segmentation and regulating incoming requests. Additionally, it emphasizes the importance of an authentication process and highlights two good logical security practices, namely configuring the virtual machine operating system and isolating network traffic appropriately during the design of the virtual network.

To anticipate all risks, it is important to establish supervision of these infrastructures. It is essential to ensure the implementation of clustering systems for servers in case of failure. Finally, security management must be carried out rigorously.

3-5 Issues and threats to Cloud Computing enfolding in the Enterprise

Before embarking on cloud computing adoption, it is imperative to comprehend the associated risks. It is recommended to perform a comprehensive risk assessment prior to handing over control to a third-party provider. Despite the initial success and popularity of cloud computing and the wide availability of suppliers and tools, this new model of computing inherently presents a significant number of challenges and risks. Suppliers, developers, and end-users alike must consider these challenges and risks to make the most of cloud computing. There exist several obstacles to cloud computing adoption, which can impede an organization's migration to cloud-based business operations (Khan, 2019).The following section summarizes these challenges:

- ✓ **Security, Privacy and Trust**

Cloud computing poses significant challenges to achieving security at all levels, which has consistently been the primary concern of information officers. The effectiveness of cloud computing in meeting security regulations is a subject of uncertainty, as organizations must ensure that the protection of individuals' data is not compromised. The reliance on third-party companies and structures to host critical data or perform essential activities makes trust in suppliers vital for optimal protection of cloud-based applications (Zhang, Cheng, & Boutaba, 2010) .Legal and regulatory issues also require attention, as the physical location of data centers determines the applicable laws for managing data, and sending data over publicly available communication systems carries the risk of cyber-attacks. Small businesses must address cloud security issues such as legal compliance and loss of control over data to mitigate risks associated with cloud computing. (Khan, 2019)

- ✓ **Lack of Time and Sufficient Resources**

The dearth of time, insufficient training, and expertise pose formidable impediments to the expeditious adoption of cloud computing in small enterprises. Owing to their limited resources, small businesses are typically understaffed and preoccupied with multiple tasks,

leaving them with inadequate time to embark on new projects. Despite the potential gains associated with cloud computing, small business leaders are often unable to commit the necessary time to weigh the benefits of cloud computing. Furthermore, inadequate training and expertise present another challenge to the adoption of cloud computing (Khan, 2019) .Business owners often lack the guidance of proficient IT professionals, which is necessary to make informed decisions about cloud adoption. With limited financial resources, small businesses find it challenging to recruit and retain competent IT professionals in-house, thus exacerbating the issue.

- ✓ **Network and Open Access**

The potential of cloud computing to provide widespread access to computing resources, similar to the availability of electricity, creates new opportunities for industry and a wide range of consumer products. The availability of network and open access to computing power and data through the cloud facilitates a new era of industrialization and the need for increasingly sophisticated consumer products. (Khan, 2019)

- ✓ **Interoperability**

Interoperability is a crucial factor in the widespread adoption of cloud computing by enterprises, as it enables the seamless transfer and utilization of data between public and private clouds. Many organizations have made significant strides in standardizing their processes, data, and systems through the implementation of enterprise resource planning (ERP) systems (Shaqrah, 2016) .This process has been facilitated by flexible infrastructures that allow for the creation of single instances or highly integrated connections between instances to manage the consistency of master and transactional data and generate robust aggregated information. However, even with these improved platforms, the rate at which companies change may still outpace the ability of IT organizations to respond to these changes. Software-as-a-Service (SaaS) applications delivered through the cloud provide a low-capital, fast deployment option. Depending on the application, it is crucial to integrate with traditional applications that may be resident in a separate cloud or on conventional technology. The ability for interoperability is either an enabler or a barrier to the integrity and consistency of an organization's data and processes. (Zhang, Cheng, & Boutaba, 2010)

- ✓ **Integrity**

(Shaqrah, 2016)"*Integrity related with the check framework against any sort of information misfortune, alteration, as well as harm which caused purposeful or unexpected reasons, for example, harming activities of programmers or unapproved individual both inside or remotely enterprise"*.

The web security framework plays a crucial role in ensuring that data is transmitted accurately and reaches its intended destination without any alteration. Any compromise in the integrity of data transmission can severely impact the effectiveness of a web security system. Furthermore, the authenticity of data is directly linked to the security system's processes, which work to establish the source of the data and verify its sender. Enterprise-level operations involve complex protocols, which may encounter various security issues, thus hindering the efficacy of the security system. (Khan, 2019)

In conclusion, the conceptual framework presented in this chapter explores the main concepts of virtualization, cloud computing, and migration to the cloud for organizations. Virtualization serves as the underlying technology for cloud computing, and is based on the principle of creating virtual versions of hardware or software elements, offering various advantages such as server consolidation and increased flexibility. Cloud computing is emerging as a model for delivering IT services over the Internet, and offering different types of deployment. Organizations can migrate to the cloud to gain benefits such as cost reduction and flexibility, but this requires careful consideration of security and system compatibility issues. Security in the cloud is therefore a crucial aspect to consider when migrating. In sum, virtualization underpins cloud computing, and migrating to the cloud enables organizations to take advantage of this service model while requiring proper advanced planning and management to ensure a successful transition.

Chapter II: Methodology and hosting company

Following the presentation of the theoretical foundations of our research, it is pertinent to elucidate the methodology used to conduct the study.

This section will provide an overview of the research methods, data collection techniques, and analytical approaches utilized to analyze the results.

Section 1: Organizational context

The purpose of this section is to give an overview of the internship host organization, with a presentation of its objectives, vision, missions and organizational chart, as well as the missions of our host structure and its importance within the organization.

1 Company Presentation

Algeria's leading multimedia mobile operator, Nedjma which became Ooredoo on

November 21, 2013, is the Algerian subsidiary of the Ooredoo Group. Present in Algeria since December 23, 2003, the date of obtaining the license to provide cell phone services in Algeria, the Nedjma brand was commercially launched on August 24, 2004, offering Algerians, whether they are individual or corporate customers, a range of innovative offers and services, which adhere to international standards.

History and objectives

- WTA was set up by Kuwait's Wataniya Telecom and joined by United Gulf Bank (UGB). With a 15-year license, WTA has adopted an accelerated investment program with projects worth US$1 billion over three years.
- Wataniya Telecom was founded in 1999 in Kuwait. It is one of the companies of Kuwait Projects Company (KIPCO), the largest private company in Kuwait with assets of more than 10 billion USD.
- In March 2007, Qtel became the majority shareholder (51%) of Wataniya Telecom Kuwait and consequently owns 80% of Nedjma.
- It was during a press conference held, on November 12, 2013 at the Sheraton Hotel in Club des Pins that the CEO of Nedjma, Joseph Ged announced the official change of its commercial and visual identity by adopting the new name Ooredoo (The brandname translated from Arabic means "I want-أُريد")

- On December 15, 2013 in conjunction with the commercial launch of the 3G++, network, Nedjma becomes Ooredoo Algeria. The company's visual identity in Figure 07

Figure 7: Ooredoo Algeria's visual identity evolution

Source: Internal document

The general organizational chart of Ooredoo Algeria At the central level there are 13 departments in the company:

1. Deputy Department

2. ERM & Quality Department

3. Project Management Office Department

4. Strategy Department

5. Corporate Affairs Department

6. Operational of Information and Security Department

7. Procurement & Supply Chain Department

8. Legal & Regulatory Affairs Department

9. Financial Department

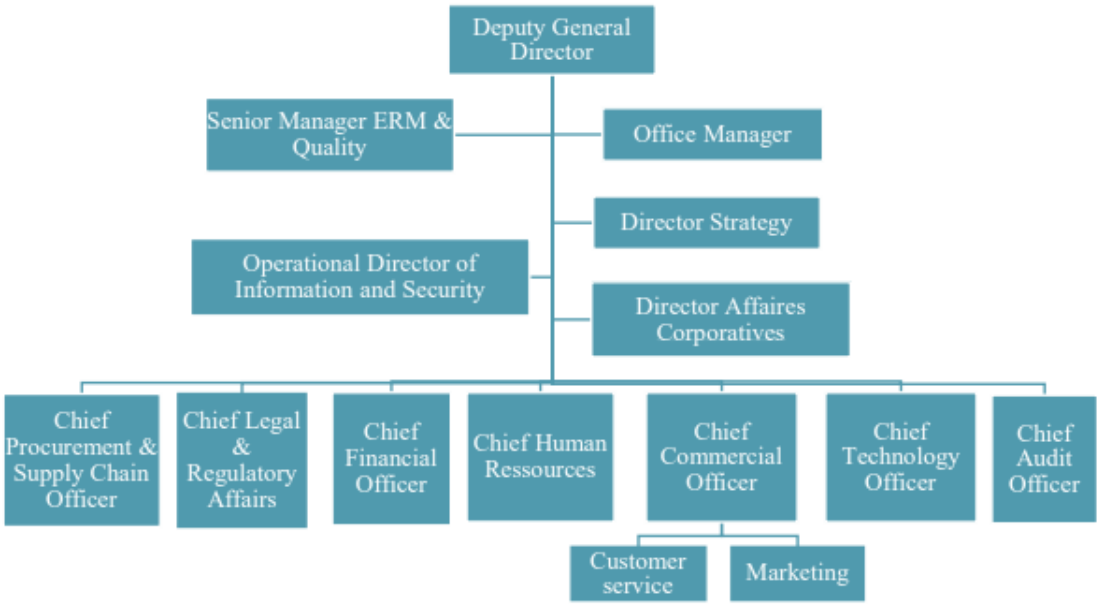
10. Human Resources Department

11. Commercial Department, Customer Service Department, Marketing Department

12. Technology Department

13. Audit Department.

Figure 8: The general organizational chart of the Ooredoo Company.

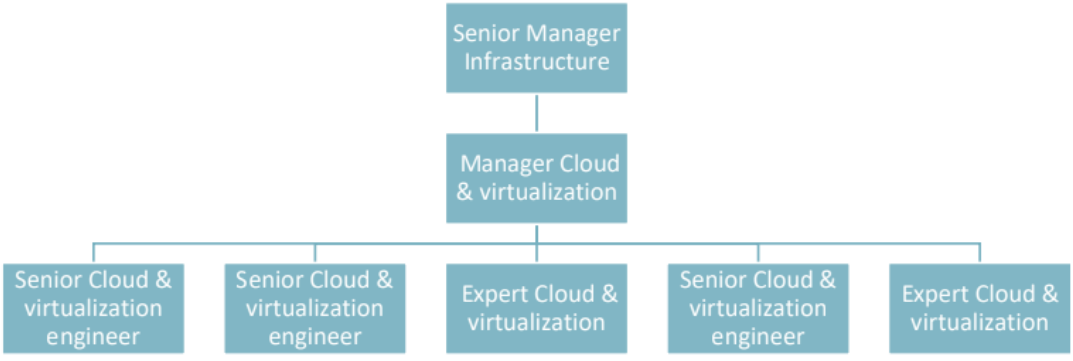


Source: internal document.

3 Cloud team presentation

Cloud team Organization Chart

Figure 9: The Cloud team Organization Chart



Source: internal document.

About the cloud team

- ✓ Management of Cloud platforms.
- ✓ Management converged and hyper converged platform.
- ✓ Study and elaborate the upgrade, extension and migration action plan for our platforms.
- ✓ Life cycle management of all cloud platforms and equipments.
- ✓ Virtual platforms.
- ✓ Converged and hyper-converged platform.

Section02: Methodological framework

1. Choice topic:

By exploring this topic, we can uncover how cloud computing migration can contribute to the growth and modernization of businesses in Algeria. The adoption of cloud technologies has the potential to revolutionize the way organizations operate. The findings of this research can help businesses in Algeria make informed decisions about adopting cloud computing solutions and drive their digital transformation initiatives forward.

2. Choice company:

By studying Ooredoo's journey, initiatives, and cloud-related services, one can gain valuable insights into the company's unique contributions to the Algerian market. Ooredoo's early adoption of cloud computing has made them a leader in the industry, and their specialized expertise, robust infrastructure, extensive connectivity, and dedicated support have made them a valuable resource for organizations seeking to migrate to the cloud. By examining Ooredoo's experiences, it is possible to understand their role in driving the adoption and transformation of cloud computing in Algeria, and to gain a localized and practical perspective on the benefits of cloud migration for organizations in the region.

3 Research methodology

During the course of our research, we aimed to highlight the contribution of cloud computing migration for organizations in general and at OOREDOO particularly.

Given the novelty of cloud computing as an emerging field and the complexity of the factors influencing it, we will utilize the qualitative approach for this study.

Qualitative research is better suited for exploring issues in which the extent of research is not well-established and the research topic is an area of significant interest that has been identified as a gap in the existing literature. When addressing content marketing subjects, the qualitative methodology is more suitable in comparison to the quantitative approach due to the lack of clear definition within the field.

We employed a qualitative methodology that entailed an inductive approach in a natural setting. This method involved conducting an in-depth examination or generating hypotheses by collecting data through purposeful sampling and iteratively interpreting and analyzing the data.

"Qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them. Qualitative research involves the studied use and collection of a variety of empirical materials – case study, personal experience, introspective, life story, interview, observational, historical, interactional, and visual texts – that describe routine and problematic moments and meanings in individuals' lives." (Aspers & Ugo, 2019).

3. Data collection method

4-1 Documentary Research

Throughout our research, we made sure to collect as much relevant information as possible. To this end, we conducted a review of various internal documents and data belonging to the host organization. This process proved invaluable in enabling us to present a comprehensive and accurate portrayal of the company.

4-2 Interviews

To gather the information required to answer our research questions, we employed a qualitative research design in the form of interviews.

Interviews are a form of conversation between researchers and study participants that center on questions relevant to the research study. Typically, these questions focus on the

participant's thoughts, opinions, perspectives, and experiences related to the research topic. Through this method, we were able to gain a rich and detailed understanding of the participants' perspectives and insights, which were instrumental in shaping our findings and conclusions.

An interview could also be defined as “an interchange of views between two or more people on a topic of mutual interest, sees the centrality of human interaction for knowledge production, and emphasizes the social situatedness of research data.” (Kvale, 1996)

To carry out our study, we opted for a series of semi-structured interviews, noting that this method is often used in management science research. It should be noted that data collection through interviews is considered as "a data collection technique that contributes to the development of knowledge favouring qualitative and interpretative approaches, particularly those based on constructivist paradigms". (Lincoln, 1995)

a- Semi-Structured interviews

A semi-structured interview is a method of qualitative data collection in which an interviewer asks a set of predetermined key questions while also allowing for flexibility and exploration of new topics. This open-ended approach encourages participants to elaborate on their responses, leading to the discovery of unexpected insights and ideas (Bazeley, 2007).

Semi-structured interviews have been used in a variety of research studies across different disciplines, including health sciences, psychology, and education (Hesse-Biber & Leavy, 2006).Overall, they are a valuable tool for collecting rich and detailed data in qualitative research.

b- Interview Guide Construction

Given that our theme is vast and our study is part of a qualitative research approach, we used semi-structured interviews to allow the interviewees to express their ideas freely, based on a guide (presented in APPENDIX).

This guide helps us identify relationships, impacts, and defects, leading to a more accurate assessment of the situation. It enables us to propose effective solutions and recommendations based on a thorough analysis of the situation.

c- **Interviewees**

To add an empirical aspect to our research, we conducted semi-structured interviews with a selective group of Ooredoo employees.

The selection process was based on their job positions and their relevance to our research topic. We ensured that they were capable of answering the questions listed in our interview guide.

We interviewed 2 kind of informants:

-2 deputy directors.

-and all the cloud team.

Tableau 3: List of interviewees

Interviewee	Position	Years of experience	Interview duration
1	Deputy director IT	19	2h
2	Deputy franchise director	9	45min
3	cloud systems and virtualization manager	10	1h30min
4	senior cloud engineer and infrastructures	8	1h30
5	virtual desktop infrastructure administrator	9	1h
6	cloud administrator	19	2h
7	Senior cloud engineer	8	1h15
8	Expert cloud and virtualization	7	1h45
9	Expert cloud and virtualization	9	30min

Source: elaborated by us.

4. Data Processing

Content Analysis

Our selection of this specific data processing approach is based on its aim to capture the interviewees' statements in an objective manner**.**

The data from the interviews were analysed using the content analysis method, focusing on keywords and ideas related to the research topic.

Each interview has been transcribed in a verbatim before being analysed according to the mentioned methodology. The results of the analysis were integrated into the dissertation using the Statement Quotation Comment (SQC) approach, proposed by Weaver Hightower in 2019. This approach involves introducing the topic with a background statement, quoting a direct citation as data, and providing researcher remarks as comments to build the discourse

Chapter III: RESULTS ANALYSIS AND DISSCUSION

Section 1: Results presentation and analysis

1 Situation Analysis

In this section of the situation analysis, we provide an overview of the company's state both before and after the migration to the cloud, based on insights from interviews and obtained documents.

Process before Cloud

Before the widespread adoption of cloud computing, OOREDOO relied predominantly on on-premise infrastructure for hosting their data, applications, and IT resources. This infrastructure comprised physical servers, storage devices, and networking equipment, typically located within data centres or server rooms on the organization's premises. To meet their business requirements, OOREDOO followed a multi-step process involving various stakeholders.

The process began by analyzing the requirements and business objectives of software vendors, which were then translated into technical specifications and a sizing plan. The sizing plan aimed to determine the necessary computing resources, including servers, storage capacity, and network bandwidth, to support the application. Acquiring these resources involved a lengthy procurement process, often taking six months or longer.

Multiple teams, such as technical, purchasing, legal, and others involved in the procurement process, contributed significant effort during this period. After the acquisition, the resources had to be installed and configured, which was typically a time-consuming and intricate task. Completion of this process could take several weeks or even months and required a substantial allocation of human resources.

- ✓ **Technical aspect**

In the traditional architecture before the advent of cloud technology, Ooredoo typically relied on a traditional architecture where they would purchase a dedicated physical machine to run a single application. This approach resulted in the deployment of multiple servers to accommodate various applications, leading to increased complexity and resource consumption. Additionally, maintaining these physical machines required significant

environmental costs, including space for housing the hardware, power consumption for running and cooling the equipment, and on-going maintenance efforts.

Process after cloud

Following the widespread integration of cloud computing, OOREDOO experienced a significant transformation by moving away from its traditional on-premise infrastructure and towards adopting a private cloud-based solution. This pivotal change resulted in an overhaul of the procurement and management procedures for computing resources, ultimately leading to improved operational efficiency and a more efficient operational framework.

In the new cloud-based model, OOREDOO no longer needed to go through the lengthy procurement process for physical servers, storage devices, and networking equipment. Instead, they established their private cloud infrastructure, which provided dedicated virtualized resources within their own data centers. This allowed OOREDOO to have greater control and security over their data and applications while still leveraging the benefits of cloud technology.

With the adoption of a private cloud, OOREDOO's process for acquiring computing resources became more agile and scalable. They could provision virtual servers, storage, and network resources on-demand, reducing the lead time for resource acquisition. This agility enabled them to respond quickly to changing business requirements and scale their resources up or down based on demand.

Moreover, the move to private cloud architecture enabled OOREDOO to consolidate their applications and services onto a centralized platform. Instead of deploying multiple physical servers for different applications, they could now leverage virtualization to run multiple applications on shared resources within their private cloud. This consolidation reduced complexity, improved resource utilization, and lowered maintenance costs.

In terms of environmental considerations, transitioning to a private cloud architecture also brought about significant benefits. OOREDOO could optimize power consumption and cooling requirements within their data centers, as virtualized resources are more efficient compared to dedicated physical servers. This resulted in reduced energy consumption, lower environmental impact, and cost savings in the long run.

In summary, the adoption of a private cloud architecture transformed OOREDOO's process from a lengthy and resource-intensive approach to a more agile, scalable, and environmentally conscious one. The move to a private cloud allowed them to maintain control over their infrastructure, streamline resource allocation, and optimize their operations based on business needs.

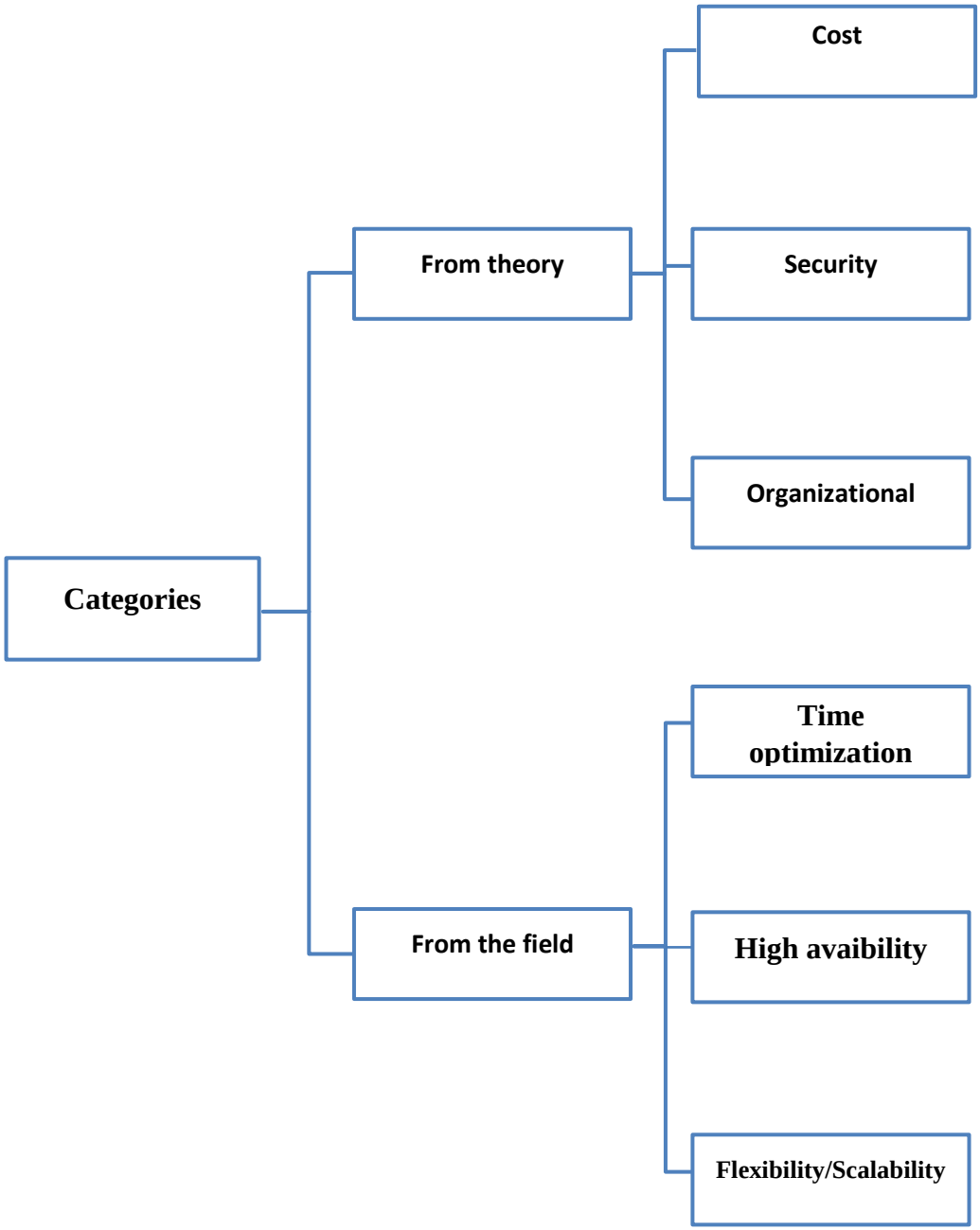
2 Categories justification

In our study, we focused on six categories that contribute to cloud migration for organizations: cost, security, organizational, time optimization, high availability, flexibility and scalability. The first three categories were based on existing theories and findings from relevant articles. According to The article by (Ahmed & Asaf, 2021)Ahmed Abdlrazaq and Asaf Varole that found in their study that The cost-benefit is the primary concern by enterprises to migrate into cloud computing as it reduces the cost of hardware, staff, maintenance, operation, and data center, as for the security is the biggest concern, has inspired our approach to the cost and security categories. For the organizational category, we drew insights from the article by Amara Toumi and Maza, (Toumi Amara & Maza, 2022)where they stated "By leveraging cloud computing technologies, businesses can enhance their information access, communication, and collaboration, as well as their customer and supplier relationships." (Toumi Amara & Maza, 2022).

The cost category is crucial as it helps us understand the financial implications of cloud migration. The security category addresses concerns and challenges related to data and system protection in traditional methods. The organizational category focuses on understanding the impact of cloud computing on an organization's structure and functioning, including changes in roles, responsibilities, and workflows during adoption.

However, field interviews revealed insights that led us to add time optimization, high availability together with both flexibility and scalability alongside the theoretical categories. These categories emerged from discussions with the different Ooredoo interviewees, providing real-world perspectives on the benefits and challenges related to these aspects in cloud computing migration. By using field insights, our aim was to bridge the gap between theory and practice and gain a comprehensive understanding of the practical implications of these categories have on cloud adoption.

Figure 10: Categories.



Source: Elaborated by us

3 Interview analysis

The analysis results of respondents' opinions are presented in six categories of cost, security, organizational, time optimization, high availability, and flexibility/scalability. They presented in six tables:

Tableau 4: The results of the verbatim regarding the cost category

	Before	After
Cost	Before the cloud, high expenses were spent due to multiple physical infrastructure, maintenance and management team's costs, and upfront investments in hardware, which would slow down business projects. *"…Before migrating to the cloud, in terms of cost, we incurred significant expenses for hardware procurement, maintenance, and infrastructure management… "* *"…The traditional data center required substantial financial investments for maintenance, space, energy, and hardware equipment…"* *"…Traditional physical infrastructure necessitates substantial initial investments in hardware, networking equipment, and data centers, resulting in high setup and maintenance costs…"* *"…The need to constantly purchase new physical servers was expensive and difficult to manage, leading to underutilization of resources and increased costs…"*	Ooredoo experienced significant cost reductions after moving to the cloud. As it provided them with the ability to scale resources according to their needs, and the cost efficiency of cloud-based infrastructure. Also, the cloud's ready-to-use solutions allowed for budget savings and better control over operating expenses (OPEX) and capital expenses (CAPEX). *"…The biggest challenge is the speed of meeting business needs. With a private cloud, we save money because the faster we can deliver, the quicker we can bring a solution to market and generate revenue…"* *"…Expenses related to IT can be easily reduced by tenfold after adopting the cloud…"* *«…Ooredoo have been able to significantly reduce the human effort and physical resources required for IT resource management…»* *"…The cloud directly impacts OPEX and CAPEX, not only reducing them but also providing better control over them…"*

Source: By us according to interviews

The statements provided by the employees all highlight the cost-saving benefits of migrating to the cloud. They all agreed that the expenses associated with maintaining a large number of physical machines had a negative impact on the company's revenue, such as significant investments in physical infrastructure and in-house maintenance (space, energy, and hardware equipment…).

After migration to the cloud, all the employees acknowledged that there was a huge reduction in expenses related to hardware equipment and improved financial efficiency. It also allowed for budget savings and better control over (OPEX) and (CAPEX). All the employees recognized that OOREDOO experienced cost reduction after moving to the cloud.

Tableau 5: The results of the verbatim regarding the Security category

	Before	After
Security	Before the cloud, OOREDOO relied on in-house security measures, which were secure but had limitations in terms of capabilities. As they encountered challenges such as server sprawls and complex infrastructure. *"…they encountered challenges such as server sprawls and complex infrastructure…"* *"…before the cloud, we had to invest in robust security measures and constantly update and patch our on-premise infrastructure…"*	Virtualization can provide better security than traditional technologies used before, especially by providing better isolation between applications and services running on the same physical server. This reduces the risk of compromise and interference between different applications and increases overall system security. *« … Virtualization can offer better security compared to traditional technologies used before it in some ways, such as providing better isolation between applications and services running on the same physical server… »* *"…The cloud reduces the complexity and vulnerabilities of security compared to the pre-cloud era. Security is centralized in the cloud, allowing for easier securing of all virtual machines simultaneously…"*

Source: By us according to interviews

As for security, the statements from the interviewees indicate that before implementing cloud technology, OOOREDOO relied on its security measures, which were considered secure but had limitations in terms of what it could achieve. The company encountered difficulties managing its infrastructure due to server sprawls and complex systems. As a result, they had to make substantial investments to maintain strong security measures and constantly update and patch their on-premise infrastructure. However, after migrating to the cloud, security is now centralized, making it much easier and more efficient to manage the security of all virtual machines simultaneously. This is possible because the cloud provides better isolation between applications and services running on the same physical server, reducing the risk of compromise and interference between different applications.

Tableau 6: The results of the verbatim regarding Organizational category

	Before	**After**
Organizational	Before the advent of cloud technology, the organizational aspect of IT physical infrastructure was handled separately by different teams. The Unix team was responsible for both hardware and operating systems, while the IT team solely focused on maintaining and managing the infrastructure. This division of labor resulted in a significant amount of effort and energy loss to meet demands. Moreover, routine maintenance tasks tied up valuable resources that could have been better utilized for strategic initiatives and innovation. *« …Previously, only the Unix team handled hardware and OS, resulting in a lot of effort and energy loss to meet demands…"* *"…To manage the traditional solution, dedicated teams and even departments were required, impacting staff…"*	In an effort to centralize hardware and software management, OOREDOO opted for a migration to the cloud. The implementation of cloud technology aimed to improve operational efficiency, reduce costs, and establish a flexible and scalable IT infrastructure. *« … With virtualization, it brought the creation of a new service, a new team, and new profiles, responsibilities, and skills… »* *"…Optimization of costs and expertise, as having a dedicated IT department managing data in the cloud is more efficient than multiple teams handling data storage…"*

Source: By us according to interviews

The employees at OOREDOO emphasize the organizational limitations of the traditional infrastructure model before the cloud era. Before virtualization, OOREDOO faced challenges with its IT infrastructure management. To address these issues, OOREDOO made the strategic decision to migrate to the cloud. This transition allowed for the centralization of hardware and software management. The organization experienced improved operational efficiency, reduced costs, and the ability to focus on strategic initiatives and innovation. The migration to the cloud necessitated the creation of a new team with specialized skills, leading to enhanced expertise in managing cloud-based systems.

Tableau 7: The results of the verbatim regarding the High availability category.

	Before	**After**
High availability	Before the cloud, Ooredoo faced significant challenges in maintaining a highly available infrastructure. Managing the physical architecture was a daunting task that often fell short of the organization's needs and proved time consuming and expensive. Accessing critical information was slow, and sharing available resources was impossible, resulting in productivity delays at times. Achieving high availability requires implementing redundant infrastructure and complex failover mechanisms, which increases technical complexity and associated costs. *"...before, the physical architecture was not highly available as it is with the Cloud, it was hard to manage and it took a long time to meet the needs..." "…before access to information was slow and not at all available all the time when needed…"*	After migrating to the cloud, OOREDOO gains access to a multitude of high availability functionalities such as automatic backups, data replication, and load balancing. The incorporation of these features ensures that OOREDOO can maintain uninterrupted access to data and services, which perfectly aligns with the company's core values and enables optimal operations. Moreover, the cloud's built-in redundancy, failover mechanisms, and load balancing capabilities efficiently distribute workloads resulting in fast and non-stop access to information. Thanks to its advanced architecture, OOREDOO can now enjoy an unprecedented level of high availability that was previously unachievable. *"…After migrating to the cloud, we can leverage the cloud provider's built-in high availability features, such as automatic backups, data replication, and load balancing, to achieve improved uptime and reliability…"* *"…high availability makes access to information fast something that was not*

		possible before…"

Source: By us according to interviews

The employees of OOREDOO encountered notable challenges due to the lack of high availability in its physical infrastructure prior to adopting cloud technology. Managing and fulfilling organizational needs was difficult and slow information access, along with the complexity and cost of achieving high availability, added to the struggle.

Even so, after migrating to the cloud, the benefits were clear. The utilization of built-in high availability features such as automatic backups, data replication, and load balancing greatly improved uptime, reliability, and access speed. These advantages are well-articulated and demonstrate how cloud technology can overcome previous obstacles faced by businesses.

Tableau 8: The results of the verbatim regarding the Time optimization category.

	Before	**After**
Time Optimization	Before the cloud era, manual processes and time-consuming tasks were prevalent in managing and provisioning IT resources. The tasks such as server provisioning and resource allocation required significant effort and time due to the need for manual intervention and traditional procurement and installation processes. This resulted in delays and inefficiencies in meeting the organization's IT needs. *"…before the cloud you had to do everything manually and it took a lot of time…"* *"…Regarding time optimization, before the cloud, provisioning new servers or resources took a considerable amount of time due to the procurement and installation processes…"*	Migrating to the cloud offers organizations significant time optimization benefits. It enables faster platform delivery, accelerated project timelines, and efficient provisioning of resources. This reduces setup and scaling time compared to traditional methods. The resulting time optimization enhances operational efficiency, streamlines processes, and enables faster response to business needs. *"…the cloud gives a gain in the time of delivery of the platform which will help to accelerate projects…"* *"…after migrating to the cloud, we can provision resources on-demand, significantly reducing the time required to set up and scale our infrastructure…"*

Source: By us according to interviews

The employees' statements highlight the contrast between the time-consuming manual processes of the pre-cloud era and the time optimization benefits brought by migrating to the cloud. Before the cloud, managing and provisioning IT resources required extensive manual intervention and traditional procurement and installation procedures, resulting in delays and inefficiencies. In comparison, the cloud enables faster platform delivery and accelerated project timelines, along with on-demand resource provisioning, reducing setup and scaling time. This time optimization translates into enhanced operational efficiency, streamlined processes, and improved responsiveness to business needs. The time optimization offered by the cloud empowers organizations to streamline operations, enhance efficiency, and swiftly adapt to changing business demands.

Tableau 9: The results of the verbatim regarding the flexibility and scalability category.

	Before	**After**
Flexibility and Scalability	During the pre-cloud era, the resolution of machine malfunctions necessitated the acquisition of new hardware components due to the inherent inflexibility of physical servers in autonomously mitigating issues. To accommodate expanding demands, the process of scaling the infrastructure entailed substantial undertakings in terms of meticulous planning, procurement, and implementation. The conventional model exhibited limitations in terms of flexibility, as it relied on specific hardware manufacturers and software developers, thereby constraining adaptability. Furthermore, the available solutions were not inherently scalable, impeding the organization's capacity to effectively accommodate burgeoning workloads. *"…there is no flexibility in the classic model, because you depend on the hardware*	The decision to migrate to the cloud was primarily driven by the desire for enhanced flexibility in platform delivery and resource management. The ability to swiftly provision resources without complications emerged as a prominent factor in favor of cloud adoption. Following the migration, the organization gained the capability to efficiently scale resources up or down in response to fluctuating demands, thereby enabling prompt adaptation to evolving business requirements. Moreover, the cloud-based infrastructure facilitated remote accessibility to inventory, allowing for increased dependence on hardware and ensuring greater work flexibility across various devices. *"...The flexibility of being able to deliver a platform quickly and add resources without the hassle is one of the main reasons that pushed us to migrate to the cloud..."*

	producer and software editor…" *"…before the cloud, scaling our infrastructure to meet growing demands involved significant planning, procurement, and implementation efforts…"*	*"…after migrating to the cloud, we can easily scale our resources up or down based on demand, enabling us to quickly respond to changing business needs…"* *"...The flexibility of being able to deliver a platform quickly and add resources without the hassle is one of the main reasons that pushed us to migrate to the cloud..."* *"…after migrating to the cloud, we can easily scale our resources up or down based on demand, enabling us to quickly respond to changing business needs…"*

Source: By us according to interviews

The statements provided by OOREDOO employees shed light on the challenges faced in the pre-cloud era, particularly concerning the inflexibility and limitations of the traditional infrastructure model. In the traditional model, resolving machine malfunctions required acquiring new hardware components, while scaling infrastructure involved extensive planning and implementation efforts. This model relied on specific hardware producers and software editors, limiting adaptability. On the other hand, migrating to the cloud offers enhanced flexibility and scalability, enabling organizations to swiftly provision resources and respond to changing business needs. The cloud-based infrastructure facilitates remote accessibility and provides the flexibility to deliver platforms quickly.

4 Discussion

Cloud computing migration has brought about significant changes in how organizations handle their IT infrastructure and deliver services. In this section, we will be discussing the contribution of cloud computing migration to organizations, with particular emphasis on several key categories including operational efficiency, cost savings, security, organizational aspects, flexibility and scalability, high availability, and time optimization. By comparing our findings with existing literature and analyzing the case study of Ooredoo, we aim to provide a

comprehensive understanding of the challenges organizations faced prior to migrating to the cloud and the benefits they experienced with cloud adoption**.**

According to the literature, the organizations faced different challenges and problems with physical infrastructure IT on several levels, we including six: Security, Cost, Flexibility and scalability, Time Optimization, High Availability and last but not least Organizational Level.

Firstly, the costs associated with traditional infrastructure, including hardware acquisition, space requirements, power consumption, cooling, and ongoing maintenance, posed significant financial burdens (Rashmi, Gadadhar, & Mehfuz, 2015).Secondly, robust security measures were necessary to safeguard data, applications, and IT resources, addressing concerns related to data privacy, confidentiality, and unauthorized access (Fatemeh & al, 2022).Moreover, effective coordination and collaboration among technical, purchasing, legal, and other teams were essential to navigate the complexities of the procurement process. Additionally, ensuring high availability of applications was a concern due to potential single points of failure and limited redundancy in individual physical machines. Finally, scaling resources to meet changing demands proved to be time-consuming and inefficient, characterized by lengthy procurement processes and the installation of additional physical machines, thereby impacting resource allocation and responsiveness to business requirements. (Rashmi, Gadadhar, & Mehfuz, 2015)

The current research aligns with previous studies, highlighting the significant challenges faced by OOREDOO in managing their on-premise infrastructure before transitioning to cloud-based solutions. Specifically, robust security measures were required to protect their data, applications, and IT resources. However, implementing comprehensive security protocols for multiple physical servers and storage devices proved complex and resource-intensive. Additionally, the traditional architecture of purchasing dedicated physical machines for individual applications resulted in increased costs related to equipment, space, power consumption, and maintenance. Furthermore, scaling resources to meet changing demands was a time-consuming process, leading to delays and inefficiencies. Moreover, achieving high availability for applications was challenging due to single points of failure and limited redundancy. Lastly, coordinating multiple teams involved in the procurement process added complexity and resource allocation issues within the organization. These challenges

underscore the importance of carefully considering security, cost, flexibility, resource allocation, availability, and coordination when managing traditional infrastructure before transitioning to cloud-based solutions.

After migrating to the cloud and conducting an extensive analysis of their pre-cloud issues, it is clear that all six categories have significantly benefited OOREDOO. These factors also played a critical role in motivating their decision to move to the cloud.

Cost savings have been one of the most significant benefits observed after the cloud migration at Ooredoo. By adopting a cloud-based model, OOREDOO eliminated the need to go through a lengthy procurement process to acquire physical servers, storage devices, and networking equipment. This approach also brought significant environmental benefits, such as reduced energy consumption, lower environmental impact, and long-term cost savings. These findings align with the literature review conducted by Maina Lawan, Oduoza, and Buckley (Lawan, Oduoza, & Buckley, 2021) .Which highlighted the role of cost reduction in the decision-making process for cloud adoption.

In terms of security, the centralization of security measures provided by the cloud has strengthened data protection and mitigated potential threats. OOREDOO was able to maintain greater control and security over their data and applications while still leveraging the benefits of cloud technology, as highlighted by the literature review conducted by Fatemeh, Chandni, Seema, Hadiseh, and B (Fatemeh & al, 2022).

The cloud migration positively impacted organizational aspects, such as streamlined operations and improved resource utilization. The consolidation of hardware and software management within the cloud environment resulted in better coordination and efficiency within the organization, reducing human effort. According to the cloud team, only they are responsible for acquiring and managing the hardware, ensuring that it does not affect other teams' efficiency and productivity. These findings align with the literature review conducted by Wafa Bouaynaya and Marc Bidan (2017), (Bouaynaya & Bidan, 2017) which highlighted the organizational benefits of migrating to cloud computing solutions.

All OOREDOO employees interviewed agreed that the ability to provision resources on-demand and eliminate manual processes has resulted in faster platform delivery and improved

responsiveness to business needs, resulting in time optimization. High availability has also been a key benefit observed at Ooredoo after the cloud migration. The built-in redundancy, failover mechanisms, and scalability options provided by the cloud have ensured uninterrupted access to data and services, ensuring continuous service availability and minimizing potential disruptions. Furthermore, the organization gained increased flexibility and scalability, enabling them to adapt to changing demands and effectively scale resources to support business growth.

Although the last three categories were based on field interviews, literature by Luqman Abdulnabi and Rajab Asaad (2022) supports our findings on the high availability and flexibility benefits of cloud computing. However, our study contradicts their claims that scalability is not significant for organizations, as our research at OOREDOO highlights the benefits of scalability. This discrepancy may result from contextual differences and varying organizational needs. (Luqman Abdulnabi & Rajab Asaad, 2022)

Our analysis of the six categories shows that there is an interconnectedness and interdependency between them. The cost reductions from cloud computing positively impact organizational efficiency, while enhanced security measures contribute to improved availability. The flexibility and scalability offered by the cloud support time optimization, allowing for rapid resource allocation and efficient business needs. These findings highlight the synergistic impact of cloud computing migration across various dimensions, resulting in overall organizational improvement.

In conclusion, OOREDOO's migration to the cloud has brought about significant improvements and benefits across various aspects of their operations. The analysis of their pre-cloud challenges and the synthesis of existing literature have highlighted the interconnected nature of six critical categories: cost savings, security, organizational efficiency, time optimization, high availability, and flexibility/scalability. By adopting cloud technology, OOREDOO has achieved substantial cost savings by eliminating the need for traditional infrastructure procurement, leading to streamlined processes and long-term financial gains. The centralization of security measures within the cloud has enhanced data protection, providing Ooredoo with greater control and security while leveraging the inherent

advantages of cloud technology. The consolidation of hardware and software management within the cloud has improved organizational efficiency, resulting in streamlined operations and resource utilization. Time optimization has been achieved through on-demand resource provisioning and automation, enabling faster platform delivery and increased responsiveness to business needs. The cloud's redundancy, failover mechanisms, and scalability options have ensured high availability and continuous service availability. Despite legal restrictions and limited cloud service provider availability in Algeria, Ooredoo has successfully optimized its operations by maintaining a private cloud, realizing cost savings and meeting specific requirements. Overall, OOREDOO's migration to the cloud serves as a valuable example for organizations considering similar transitions, emphasizing the need for a comprehensive approach to cloud adoption.

CONCLUSION

Our research has examined the contribution of cloud computing migration for organizations, uncovering a range of significant benefits that arise from such migration.

Cloud computing, although relatively new, offers numerous benefits to users, despite its limited development in Algeria. When organizations migrate to cloud technology, it affects various aspects, both directly and indirectly. We focused on six key categories: cost, security, organizational impact, time optimization, flexibility/scalability, and high availability.

The literature review aligns with our study findings, confirming that cloud migration has a profound influence on organizations. It enables them to optimize operations, reduce costs, improve flexibility, enhance data security, and achieve scalability. Notably, some researchers argue that scalability may not be a significant factor for organizations. However, our study at Ooredoo found that scalability provides flexibility and facilitates resource provisioning, contributing to organizational efficiency.

Our qualitative study revealed that cloud computing has a substantial impact on organizations across multiple levels, bringing various benefits. Moreover, globally, migrating to the cloud is generally beneficial for organizations, with some exceptions. Every system or technology has its flaws, but in the case of cloud technology, the benefits outweigh the drawbacks, especially when migration is well-planned and maintained while ensuring the necessary conditions for optimal functioning.

The primary reasons that prompted OOREDOO to migrate to the cloud and operate efficiently were the challenges they faced with their on-premise infrastructure and the benefits they gained after the migration. Continuously advancing our understanding of cloud computing empowers organizations to make informed decisions and harness this technology to drive innovation, efficiency, and success in the digital era.

Speaking of the conditions necessary for the smooth functioning of cloud technology in Algeria, they are less available compared to other parts of the world. Consequently, the downsides of this technology in Algeria are more significant, considering factors such as the legal status and. The legal position remains unclear, and lawmakers do not show immediate interest in regulating it. Nevertheless, we still believe that migrating to the cloud would be a

favourable decision for Algerian organizations. Despite the greater downsides compared to other regions, the overall benefits outweigh them.

Looking ahead, our research paves the way for further exploration. Future studies could delve deeper into the specific challenges organizations face during the cloud migration process and propose effective strategies to overcome these obstacles. Furthermore, investigating the long-term impacts of cloud migration on organizational performance, innovation, and customer satisfaction would provide valuable insights. Exploring the integration of emerging technologies, such as

- Edge computing

- Artificial intelligence

In conjunction with cloud adoption, could also be a fruitful area for future research.

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Appendices

Appendices 1: Interview guide.

Interview questions

My name is Benyoucef Meriem, and I am currently pursuing my Master's degree in strategic management and information system at ENSM. I am working on my final research project with my colleague and partner, Salem Hydaia.

We have titled our project "The Contribution of Cloud Computing Migration for Organizations." In order to support our research efforts and ensure a successful conclusion to our project, we have created an interview guide to gather insights and perspectives from professionals with expertise in cloud computing and related fields**.**

General questions:

1-please introduce yourself

2-how many years of experience do you have with cloud?

3-what is your role in the cloud team?

Section 1: Drivers for adopting the cloud

4-can you describe to us the process used before the cloud computing including the technologies used?

5-what are the problems that you faced before migrating to the cloud?

7-what were the main drivers for your organization’s decision to migrate to the cloud?

Section 2: process of migrating to the cloud

9-what are the phases of implementation of your cloud solution?

10-have there been any challenges or drawbacks associated with cloud computing migration in your organisation?

Section 3: cloud computing contribution on the security level

12-is cloud more secure than technologies used before?

13-have you ever faced a dysfunctions or crush on your private cloud? , and did it affect the service quality?

14-How has the cloud affected your organization's security?

15-What are the security benefits for your organization to go for cloud computing?

Section 4: cloud computing contribution on the cost level

17-how has cloud computing migration impacted your organization's IT budget and spending priorities?

Section 5: cloud computing contribution on the organisational level

19-how has the cloud migration impacted the way your organisation operates?

20-what benefits has your organisation realized from migrating to the cloud?

21-how has cloud computing migration affected the roles and responsibilities of the IT staff in your organisation?