Politécnico
de Viseu

Escola Superior
de Tecnologia
e Gestão de Viseu

A contribution to the improvement of the Bodum Data Center

Luca Gil Lopes

Trabalho de Projeto
Mestrado em Engenharia Informática - Sistemas de Informação

Trabalho efetuado sob a orientação de

Prof.Doutor Filipe Manuel Simões Caldeira
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Declaration

I, Luca Gil, of the Department of Computer Science, of Computer science, school of Technology and Management Polytechnic of Viseu, confirm that this is my own work and the figures, tables, equations, code snippets, artwork and illustrations in this report are original and have not been taken from any other person's work, except where the work of others has been explicitly acknowledged, quoted and referenced. I understand that failing to do so will be considered plagiarism, a form of academic misconduct, and will be penalised accordingly.

Luca Gil Lopes

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I want to express my gratitude to everyone who somehow was involved in this project and supported, boosted, and encouraged me. And I wish to express my gratitude:

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I am very grateful to my family, especially my wife Sara and my daughter Heidi for their constant and unconditional love and support that keep me focused and motivated during the project, they are the reason of my success and achievements and without them, this project would not be possible. I also want to thank my parents for the support they gave me during this journey, but in particular my father he was without a doubt the person who pushed me the most to embrace this master's degree and pushed me to succeed in it and for that I leave here my thanks to him.

A special thanks to some students of this master's degree, for their support and companionship throughout the entire master's degree. Because this project is a very important step to close this chapter, but the path that brought me here is also very important and that's why I would like to express my particular appreciations to my friends, namely Luis Nina, Miguel Ferreira, and Pedro Baptista, who helped me get here.

ABSTRACT

This work was developed to support an internal project at Bodum Portuguesa, Produção de Artigos Metálicos, SA. Bodum is a multinational company offering customers coffee, tea, and home accessories solutions according to Bodum's values. Bodum is a company that creates products with excellent design at affordable prices, based on the principle that "form follows functionality," keeping sustainability, environmental responsibility, and the well-being of its employees and the planet in mind. Bodum's current CEO, Peter Bodum, has said, "Good design does not have to be expensive".

This project aims to solve the problem of obsolete servers, the lack of resources, and the waste of processing power on Bodum's servers. Today they have servers with OS Windows 2008 R2, which is quite old. Insufficient resources slow the servers regarding performance, processing, and communication.

With this project, the company will gain more efficient servers. It will also be possible to have current services and applications with greater capacity and performance, which is an immediate need.

The project involves migrating six physical servers in Switzerland, Denmark, Australia, the United States of America, Japan, and China. This project aims to improve the performance of those servers while migrating to new servers with the latest operating systems version and more advanced hardware. There is a need to do this migration to ensure better performance of the servers and better control. The new servers are already purchased and placed in their respective locations, and some are already in use, making this migration more complicated than usual.

Simply, it is necessary to migrate the old servers to the new ones. After analyzing the scenario, an improvement proposal was made since the servers are not virtualized. A request was made to the company administration proposing to virtualize the new servers before migration. This request is still awaiting a response. If this request is accepted, the new servers will become virtual machines, and the old servers will migrate to the new ones. If the request to virtualize the servers is refused, the migration will still be made to the new servers without virtualizing them.

Furthermore, after performing the mentioned migration, a proposal will be made to migrate the information system infrastructure to a cloud. This proposal includes an analysis of the company's current system and a comparison with an identical scenario hosted on a cloud providing the company with all the necessary information about the processes and

procedures of migration to the cloud. If the company plans to move services to the cloud, it will already have all the information it needs.

The implementation of the Cloud infrastructure and the respective migration of the whole system is left for future work if the company's board of directors agrees. This thesis will undoubtedly serve as a basis for its implementation.

ABSTRACT (PORTUGUESE)

Atualmente existe um projeto interno na empresa Bodum Portuguesa, Produção de Artigos Metálicos, SA. A Bodum é uma empresa multinacional que oferece soluções de café, chá e acessórios para casa para todos os tipos de clientes de acordo com os valores da Bodum. A Bodum é uma empresa que cria produtos com excelente design a preços acessíveis, com base no princípio de que "a forma segue a funcionalidade", mantendo a sustentabilidade, a responsabilidade ambiental e o bem-estar de seus colaboradores e o planeta em mente. Como o atual CEO da Bodum, Peter Bodum, disse "Bom design não tem de ser caro".

Este projeto visa solucionar o problema de os servidores serem obsoletos, a falta de recursos e também o desperdicio da capacidade de processamento. Atualmente os servidores da Bodum ainda possuem Windows server 2008 R2, que é bastante antigo e a falta de recursos resulta em fraco desempenho dos servidores e até falhas.

Com o desenvolvimento deste projeto, a empresa vai ficar com servidores mais atuais e por consequência mais eficientes, também vai ser possível usufruir de serviços com mais funcionalidades isto com uma maior capacidade de processamento e armazenamento, o que no imediato é uma necessidade da empresa.

O projeto consiste na migração de seis servidores físicos, localizados na Suíça, Dinamarca, Austrália, Estados Unidos da América, Japão e China. Este projeto visa melhorar a desempenho de servidores da empresa, pois a migração irá ser feita para novos servidores com versões mais atuais do sistema operativo e também com hardware mais recente e avançado. Esta migração é necessária no sentido de garantir melhor desempenho dos servidores e controlo. Neste momento, os novos servidores já foram adquiridos e colocados nos respetivos locais e alguns dos servidores até já estão a ser utilizados, o que tornará essa migração um pouco mais complexa do que o normal.

Na perspetiva da empresa o objetivo principal deste projeto é migrar tudo o que está nos servidores antigos para os novos. Depois de uma breve análise ao sistema da Bodum, foi feita uma proposta de melhoria, uma vez que os servidores não são virtualizados. Com o propósito de melhorar o sistema existente, foi feita uma proposta de virtualização dos novos servidores antes de se realizar a migração, caso a proposta de virtualização dos servidores seja aceite, primeiro os servidores serão virtualizados e só depois é que será feita a migração dos servidores antigos para os novos já virtualizados. Caso o pedido para a virtualização dos servidores acima mencionados seja recusado, a migração será realizada de forma direta de servidor físico para servidor físico.

Após realizar a migração mencionada, vai ser feita uma proposta para migrar as infraestruturas do sistema de informação da Bodum para uma nuvem. Será feito uma análise do sistema atual e uma comparação com um cenário idêntico na nuvem. Com isto, a empresa vai ter em sua posse todas as informações necessárias sobre os processos e procedimentos de migração para a nuvem. No futuro, se a empresa pretender migrar os serviços para a nuvem, já terá o conhecimento para o fazer.

No que diz respeito a uma migração para a nuvem de toda a infraestrutura da empresa, essa etapa será para realizar como trabalho futuro caso a empresa assim o entenda. Este projeto vai servir, sem dúvida, de base para a sua implementação.

KEYWORDS

Virtualization
Hypervisors
Migration
Cloud Migration
VMware
AWS

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List of Abbreviations

AD DS	Active Directory Domain Services
AWS	Amazon Web Services
CPU	Central Processing Unit
CMD	Command Prompt
DC	Domain Controller
DNS	Domain Name System
DHCP	Dynamic Host Configuration Protocol
EC2	Elastic Compute Cloud
IT	Information technologies
IasS	Infrastructure as a Service
iDRAC	Integrated Dell Remote Access Controller
IP	Internet Protocol
OS	Operating System
OU	Organizational Unit
PasS	Platform as a service
QoS	Quality of Service
RAM	Random Access Memory
RDP	Remote Desktop Protocol
SMB1	Server Message Block
SaaS	Software as a service
TCO	Total cost of ownership
USD	United States Dollar
VM	Virtual Machine
VMM	Virtual Machine Monitor
VPC	Virtual Private Cloud

Chapter 1

INTRODUCTION

This chapter will address the motivations and objectives of the project and describe the methodologies used to support it. This work aims to demonstrate an implementation of a real case study, supported by a thorough literature review on server virtualization aiming to improve a company's infrastructure.

This project was developed within the scope of the master's degree in Computer Engineering - Information Systems for Bodum Portuguesa, Production of Metallic Articles, SA. The main objective is migrating the existing servers to newer and faster ones.

Since there was a need for the company to migrate, we proposed to analyze the existing scenario, perform the complete migration to the new servers and, as an improvement, virtualize the new servers to obtain more scalability and availability. As this is an actual case study, the proposals for improvements always depend on Bodum management's approval. Regardless of the consent for implementing the improvement suggestions, another recommendation is made for a potential migration to the cloud, allowing the company to follow a step-by-step migration of the existing information system to the cloud.

1.1 Motivation

Due to the lack of resources, waste of processing capacity, and the use of old server operating systems versions, Bodum has been suffering some technical problems related to the use of its servers. To avoid more severe issues, migrating to new servers is imperative. Identifying this problem led to the current project's development as an immediate need for migration exists, as the servers still have Windows server 2008 R2. This old version consequently hinders the use of the servers, and as Microsoft communicated, the support for this operating system came to an end in 2020 (https://learn.microsoft.com/pt-br/troubleshoot/windows-server/windows-server-eos-faq/end-of-support-windows-server-2008-2008r2).

Server virtualization is not a relatively recent idea. On the contrary, it has been around for many years [24]. However, it has shown significantly increased benefits over time, particularly in large organizations, in terms of saving energy and costs, increasing the availability and scalability of the company's services and applications [21], and improving recovery in case of disaster. The suggestion of this theme was a great opportunity because it would be possible to move from theory to practice in a real case study. Furthermore, it was with great pleasure that this work was accomplished, as it fosters the

transition from older to more recent technology.

Given the project's significance, a second improvement proposal will be made after the migration, focusing on migrating the company's infrastructure to a Cloud.

1.2 Migration Scenarios

At this project's start, six servers were running Windows server 2008 R2 that needed to be migrated to a newer version. These servers belong to Bodum and are located in Switzerland, Denmark, Australia, the United States of America, Japan, and China. The company acquired and installed new servers with a Windows Server 2019 version. These servers already belong to Bodum's domain with their IP and name defined. Some are already being used partially, as explained throughout the document.

Bodum intends to increase performance and storage capacity, for which the new servers have a greater capacity for both storage and processing. The project presented by Bodum would be to make a direct migration from a current physical server to a new physical server without virtualization.

The proposal for improvement presented to the company was: before making the much-needed migration of the new servers mentioned above, we would virtualize the servers and perform the migration. The main objective of this proposal is to make the infrastructure more efficient and reliable [20].

In an ideal scenario, the improvement proposal would be entirely accepted, meaning that the servers would be virtualized first, and then the migration would take place. After all data and services are migrated, a general analysis of the infrastructure for migration to a public Cloud would be made.

1.3 General Objectives

In this project, there are two primary goals. For the company, the goal is to migrate the old servers to the new ones, keeping everything as it is. For the author of the project, the plans are more ambitious - the migration from the old servers to the new ones with the benefit of the new servers being virtualized before the migration, intending to monitor the processing of servers and all the benefits that virtualization would provide. In addition, the author wants to simulate a migration to the Cloud to understand its benefits better and reduce costs and processing waste.

1.4 Document Structure

This document is composed of seven chapters. Chapter one intends to introduce the topic by presenting the project framework, motivation, current scenario, and objectives. The second chapter discusses state of the art, focusing on virtualization and aiming to give the justification for this project. The third chapter outlines the methodology planned and used in this project. In the fourth chapter, an analysis of all physical hardware is made, and the entire migration process carried out for the company is described. The fifth chapter intends to describe the company's infrastructure improvement. This improvement aims

to simulate an identical scenario to the current one in Amazon Web Services. The sixth chapter is summarized as a step-by-step that shows how the creation and configuration of the components are done to simulate the improvement proposal. In the seventh chapter, a discussion and a conclusion are presented.

Chapter 2

STATE OF THE ART

In this chapter the study carried out for the execution of this project will be shown, firstly a study on virtualization was carried out where it is possible to understand the concept and types of visualization as well as some definitions and how virtualization works. Although the company chose not to virtualize the servers because they think is not necessary, the study was carried out anyway to understand the purpose of virtualization and how it works. This chapter also addresses the topic of Cloud Migration, since we are going to simulate a migration of the company's services to the Cloud, it makes sense to study this matter to better understand what Cloud Migration is, what services and types of Cloud exist, to be able to make a better decision on this subject if this is the way to go in the future. In this chapter, will also be identified and explained the components used in this project and a comparison will be made between Cloud and On-Premises.

2.1 Virtualization

It is essential to study Virtualization before implementing it to verify that it meets all the project requirements, raising awareness of the advantages and disadvantages, which will be discussed in this section. Some definitions related to Virtualization and the essential virtualization techniques are presented.

2.1.1 Virtualization definitions and concepts

Virtualization is a technique that allows several different applications, services, and operations to run on a single device. Routers, switches, and servers can also be virtualized [29]. In short, Virtualization is a way to camouflage the hardware from the end-users, where the goal is to replicate several computational environments isolated from each other [14].

Virtualization can be understood as creating a virtual environment that simulates a physical environment. More technically, Virtualization is the abstraction of a physical layer in several logical divisions.

The behavior of a physical system is completely changed due to Virtualization. The physical server operates as the host, where the hypervisor is installed and where the necessary virtual machines will be installed [8].

How does it work?

All the necessary resources are virtualized (CPU, memory, among others). The hypervisor translates and maps all requests from virtual resources to physical resources, as shown in figure 1. For example, a VM is called VM-X access memory cell 323, and the hypervisor maps cell 323 to the physical memory cell 123, where it can be computed with the translation table of figure 1.

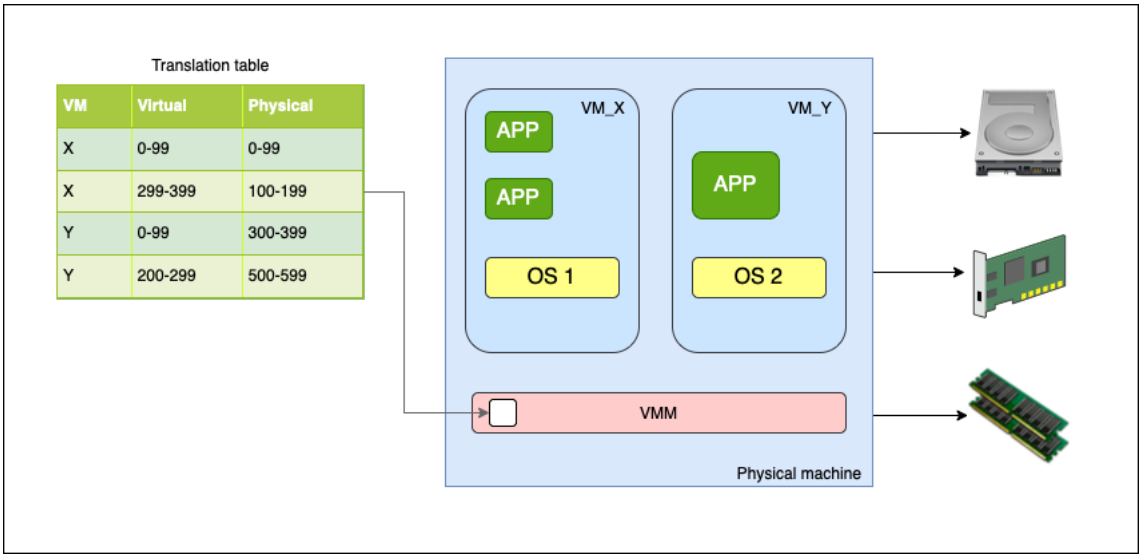


Figure 1: Hypervisor translation process

Virtual machine (VM)

A VM is an emulated computer that runs inside a physical computer. A real computer with its OS runs a VM with its own OS. Machine virtualization is the activity of running one OS inside another. Several virtual machines can run on the same host (real computer), usually, a server, to take full advantage of the server's resources. Each virtual machine runs its OS separately from the other. This means that a user can run different operating systems within a single physical machine, allowing access to other existing software that can be installed within the virtual machine itself. In the computing domain, a VM is the virtualization of a computer system. A VM is based on computer hardware and provides the user with the functionality of a real computer. [27, 28].

Virtual machine monitor (VMM)

A VMM creates, monitors, and runs VMs (virtual machines); sometimes, it can be called a hypervisor. VMM has an exceptional skill that allows sharing of a physical machine's resources, and the Hypervisor manages these resources. The Hypervisor is isolated in a layer where the physical resources and VMs are managed. VMM is also where the VMs are stored. The primary functions of a VMM are to ensure that VMs have virtual hardware available and to manage interaction requests made by VMs to the virtual hardware. A VMM can authorize more than one OS instance to act on isolated VMs simultaneously [20].

The hypervisor can be implemented in two ways. The first can be embedded in hardware to create, run, and monitor VM. This can be called Type-1 hypervisor, and sometimes bare-metal, which describes the hypervisor installation directly on the computing hardware, which means the hypervisor works now on top of native hardware. The second way is to use it as an application installed on an existing OS called a hosted hypervisor, or Type-2 hypervisor, the hypervisor runs as a typical application on top of an operating system, and the VMs are executed on top of the hypervisor application [20, 40, 1]. In short, when the hypervisor runs directly on top of native hardware (bare-metal installation), it is called a Type-1 hypervisor. When the hypervisor runs as a standard application on top of a host OS, just like another computer program, it is called Type 2 Hypervisor [1, 25]. The abovementioned types can be seen in figure 2.

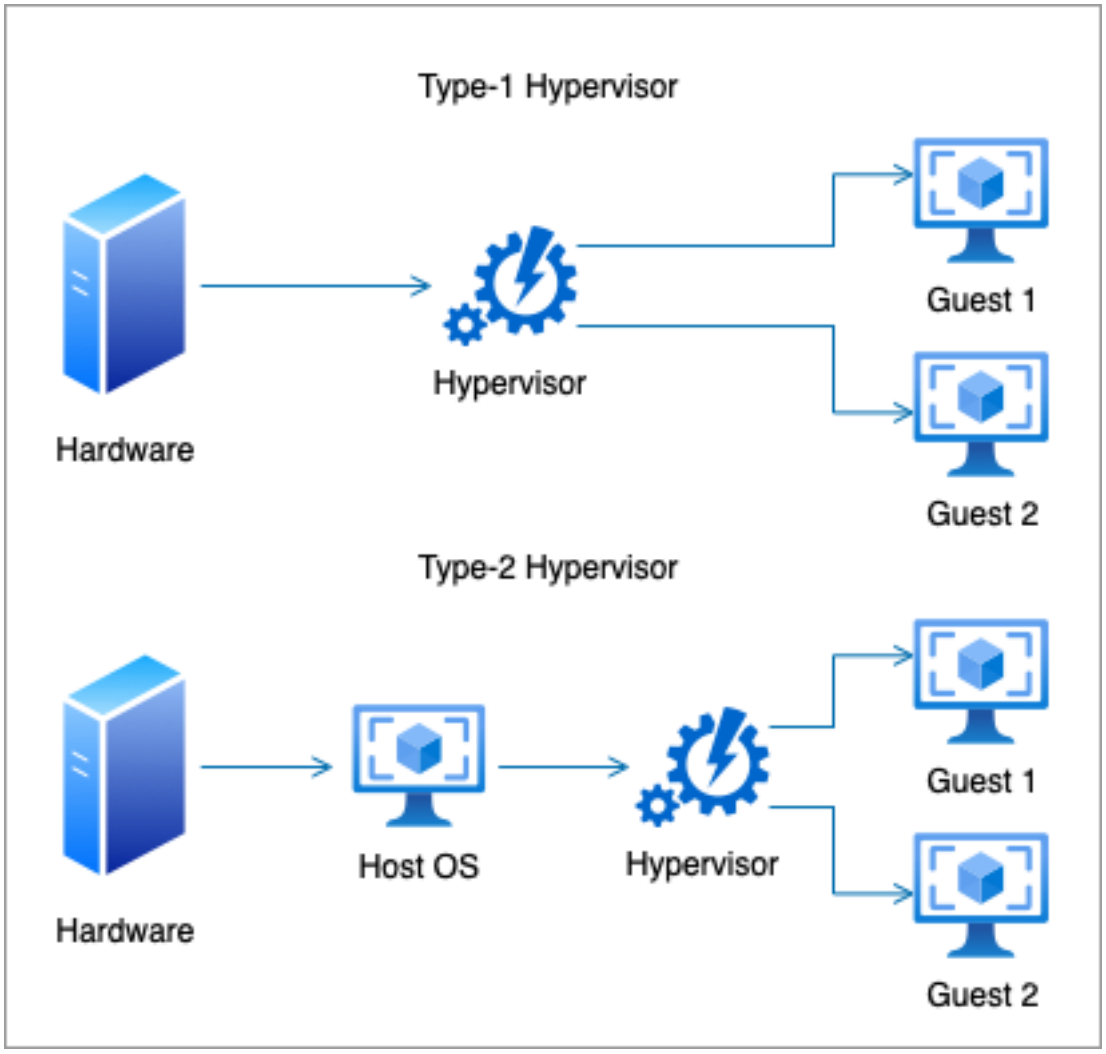


Figure 2: Hypervisor Types

Types of hardware virtualization

Hardware virtualization can be implemented in several ways [20]. The three most common methods are the following:

- Full Virtualization: In this approach, the virtualization completely emulates the essential hardware to run a VM, and the guest OS is completely isolated from the VM.
- Paravirtualization: The hardware is not properly emulated in this approach. The guest OS must be changed before installing the VM, allowing the OS to share resources. This approach improves host performance by decreasing the number of requests made to the VMM.
- Hardware-assisted virtualization: This approach uses available resources of the host computer to build the VMs. This approach can also be called Native Virtualization, Accelerated Virtualization, or Hardware VM.

2.2 Virtualization Techniques

2.2.1 General view

Virtualization is not new. It first came into use in the 60s, as confirmed by Goldberg's publication in 1974 [13], and it has become more common in Information Technology (IT). Virtualization has brought many benefits over time, particularly in large organizations, allowing companies to reduce energy consumption, purchase less equipment, such as servers and desktops, increase service availability, and improve recovery from disasters.

Thus, virtualization quickly became a revolutionary solution for IT management due to its crucial characteristic of providing resources that in physical infrastructure would be impractical or even impossible. Costs are reduced since virtualization allows several applications to be allocated on a single physical server. Therefore, this is an excellent benefit for managers of organizations [21].

We are increasingly aware that virtualized systems are essential for IT infrastructures worldwide, as virtualization results in a lower total cost of ownership (TCO) and greater control of the system by IT teams [17].

Due to the pandemic caused by COVID-19, which we are still overcoming, sound financial management is essential for decision-making in organizations. Any decision must consider the economic impact it will have [21]. With server virtualization, we create more investment opportunities within the organization, saving on physical space, maintenance, energy, and hardware. This way, organizations can have more control, more resources available, and greater security with fewer financial resources. Virtualization responds to the organization's needs in a more personalized form at a lower cost and substantially faster. It is unnecessary to buy and configure new servers every time a new application or service is needed for the organization [21].

2.2.2 Server virtualization

Server virtualization consists of a physical server and virtualization software (in this case, we will use VMware ESXI, which we discuss later) and splitting it, transforming a phys-

ical server into several virtual servers, each able to perform different tasks without any interference between them. This way, we can avoid having a server for each service or application the organization needs.

When a server is virtualized, it can be transformed into as many servers as are needed, and the components permit, where each one can run a different OS. Thus, applications or services can run in isolated environments without interference. This implies a reduction in processing waste [21, 14]. See the right-hand side of figure 3 for a graphical view of server virtualization.

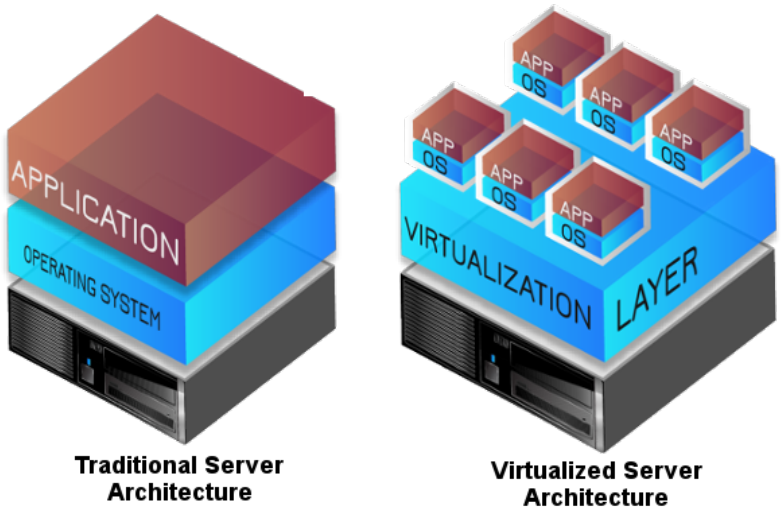


Figure 3: Comparison between Traditional Server and Virtualized Server [26].

2.2.3 Network virtualization

Network virtualization is the process of transforming a hardware-dependent network into a software-dependent network. The primary objective of a virtualized network is to insert a layer between the physical hardware and the services that are using that same hardware. This allows network functionality, hardware, and software to be available independently of the hardware [12, 27]. Simplistically, network virtualization refers to the absence of resources traditionally delivered in hardware to software. Network virtualization allows you to create and manage networks through the software while using the underlying physical network as a backplane for packet forwarding. All resources on a physical network (routers, firewall, etc.) are delivered via software and only need the IP of the underlying physical network for packet forwarding.

Network virtualization separates network resources, typically available in hardware or software. A virtual network can join multiple physical networks into a single, software-based network. The opposite can also happen, dividing a single physical network into several independent virtual networks [12, 27, 41]. For instance, VLAN is an example of network virtualization; this is like a subsection from a local area network (LAN) generated by the software and embeds network devices in one group, regardless of location. Busy networks will benefit from more performance and speed, and easy changes.

2.2.4 Storage virtualization

Storage virtualization combines physical storage from several network storage devices, conveying the idea of a single storage device. The main objective of storage virtualization is to relate to the physical storage through logical images to avoid confusion [9, 24]. This process has been increasingly used to solve the problems generated by the exponential growth of data that today in companies is increasing more and more [3].

2.2.5 Virtualization tools

For some years, the demand for new technologies in organizations has increased, making the market increasingly competitive. As mentioned above, virtualization is not a recent technology. On the contrary, this technology has become almost standard for organizations over time. There are several tools named hypervisors for this process, including VMware ESXi, XenServer, and the Microsoft Hyper-V Hypervisor. According to [14, 10], the most suitable tool among those mentioned above is VMware ESXi because, in most of the tests performed, it was the tool that had the best results, as can be seen in figures 4, 5, and 6. For this reason, it was the tool chosen for this project.

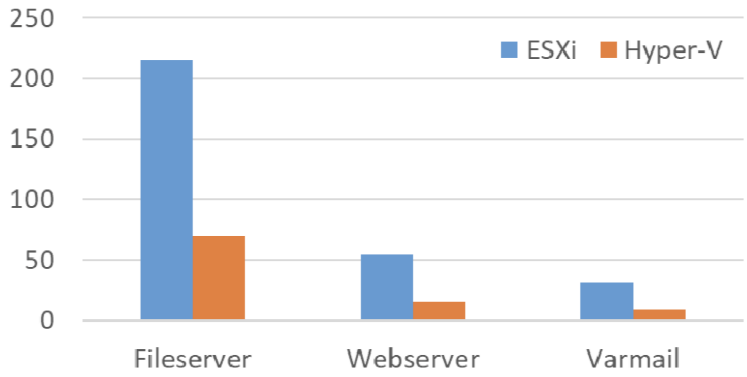


Figure 4: Performance comparison for one VM[10].

As can be seen, the VMware ESXi has a much better performance than the Microsoft Hyper-V Hypervisor when used for one Virtual Machine. (Figure 4).

When using two and especially three VMs simultaneously, there is a reduction in the performance of both hypervisors compared to the results of the tests obtained with a single Virtual Machine, figures 5 and 6.

As a result, VMware ESXi is generally superior in tests performed, as shown in [10].

2.3 Cloud Computing

In order to plan a Migration to the Cloud it is necessary to study Cloud Computing. Migration to the cloud is a process that needs to be carefully studied to understand its feasibility, as specific requirements will need to be met. Definitions and concepts related to Cloud Computing and an explanation of its potential contribution to this project are described below.

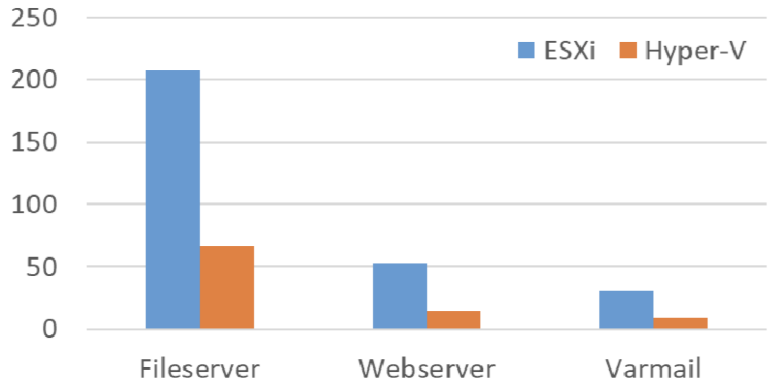


Figure 5: Performance comparison for two VM[10].

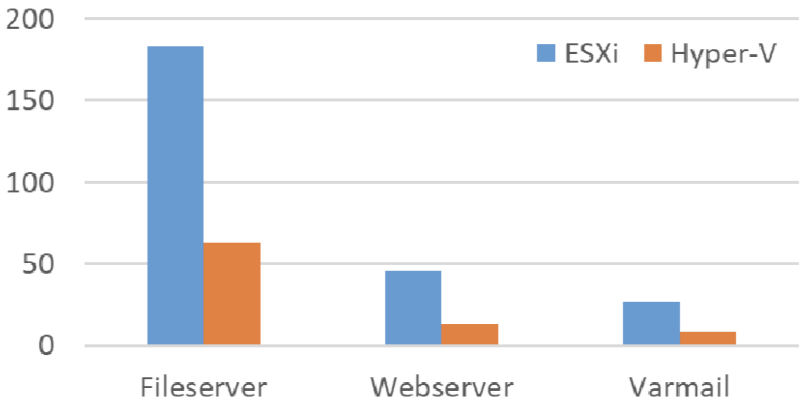


Figure 6: Performance comparison for three VM[10].

2.3.1 General view

Cloud computing is a term used for resource availability that facilitates and grants on-demand access to an extensive repository of computing resources, including servers, applications, and services, which can easily be made available without the service provider's intervention [23]. The concept of Cloud computing can be summarized as the availability of different services on the internet. These resources can be applications, tools such as storage, servers, etc. [7, 2]. Moreover, data storage is performed through services that are accessed remotely and can be done anywhere, at any time, avoiding the installation of software and data storage. Software, files, and services are accessed remotely. Hence the association with the name cloud [19].

Cloud computing is a significant IT advance; these services allow companies to save costs, facilitate IT infrastructure and increase productivity. The process of migrating to the cloud is somewhat complex as it should be an efficient, secure system that adapts to the company's needs [30].

2.3.2 Costs

The costs of services can be paid monthly, and only the services used are charged. In other words, it is pay-per-use, thus avoiding the unnecessary acquisition of resources and, at the same time, avoiding the excess and waste of hardware. Compared to conventional physical systems, cloud services are cheaper [30].

2.3.3 Productivity

Cloud services are an asset to the productivity of the IT team, as it is possible to manage services anywhere remotely, with quick access to information and applications. Cloud services are agile and can guarantee safe and reliable backups, which means there is a lower risk of data and information loss. With cloud services, the IT team will have access to the latest, most advanced technology, with greater processing capacity and speed, with the advantage that the services are easy to use and to set up [30].

2.3.4 Common cloud types

Public cloud

A public cloud is a model where all computing services are managed by a third-party provider and can be shared with other organizations. Public cloud providers provide services such as infrastructure (IaaS), platforms (PaaS), and even software (SaaS) to users, charging a monthly fee or a pay-per-use fee to avoid hosting these services in a data center. The public cloud is typically used in less critical applications [5, 6, 19, 22].

Private cloud

A private cloud is built specifically for an organization to have complete control over the cloud they own. Compared to other types of cloud, a private cloud offers greater security and privacy through the organization's firewalls and hosting. In this case, critical data is not accessible to third-party providers. The counterpart of the private cloud is that it requires the same maintenance and management costs as a data center, so the company's IT department has to be responsible for managing the private cloud [5, 6, 19, 22].

Hybrid cloud

A hybrid cloud is a model that combines a private cloud with some services of a public cloud, which communicates through software between the services. This model offers flexibility by forwarding work requests between clouds depending on the needs and costs. A hybrid cloud allows greater control over critical data because confidential information can be stored in a private cloud and, at the same time, benefit from the computational resources of a public cloud [5, 6, 19, 22].

2.3.5 Cloud services

As stated in [15], there are three main different types of cloud services:

Infrastructure as a Service (IaaS)

The infrastructure is provided to customers; the provider is responsible for controlling, maintaining, and operating costs. The user does not have control over the infrastructure but controls other things like storage, OS, and limited control of network components. In short, the user has full control except has physical hardware resources. In this case, the cloud provides the user with raw computing resources. The user will pay the SaaS provider for the service, and the SaaS provider pays the cloud for the resources, such as Amazon Web Services, Google Cloud Infrastructure, or Digital Ocean.

Platform as a service (PaaS)

It is a cloud environment for development and implementation, with features that allow the delivery of everything from the most complex applications to the simplest. The user does not have control over the infrastructure but controls the application deployment and sometimes the hosting environment setup. For instance, Windows Azure or Red Hat OpenShift, and in this case, the customer will pay the SaaS for the service, and SaaS pays the cloud provider for the infrastructure.

Software as a service (SaaS)

Software as a Service (SaaS) could provide the entire application, which allows users to connect to cloud-based applications remotely over the Internet, such as Microsoft Office 365. In SaaS, customers pay the cloud provider. The user does not have any control of the could infrastructure.

The main advantage of IaaS, PaaS, and SaaS services or other cloud solutions designated as a service is economical. Still, this advantage is directly dependent on the number of services purchased. The more services purchased, the more expensive the solution will be. With these services, it is possible to access and scale the necessary IT resources with a calculated cost and without purchase and maintenance expenses [15, 6, 23]. To make the most of these services, whether economically or in terms of performance, availability, and scalability, it is necessary to understand very well the needs and requirements of the company or the project because, depending on the number of services needed, this can be expensive.

With IaaS, it is possible to create redundancy between servers in different geographical areas to guarantee high availability. Usually, IaaS providers use data centers around the world, which allows IaaS users to obtain lower latency and more performance as services and applications can be chosen by the customer by proximity. The fact that there is significant competition between cloud providers means that customers are provided with the latest technology on the market with competitive features and costs [6, 15, 19].

2.3.6 Cloud computing characteristics

Cloud computing is a new way of computing. It has some unique characteristics, for example, agility, maintenance reduction, low cost, services in the pay-per-use mode, high scalability, and rapid elasticity. This means it allows faster operations, sharing of resources between users, and cost reduction, as installing applications on each computer is

unnecessary, making maintenance more manageable and easier to access. The client only pays for the resources it consumes and nothing else, the cost of the services provided is calculated according to the use of each one of them and allows to request more resources on a large scale without human intervention, and this makes ease and speed in increasing and decreasing resource consumption [23, 19].

2.4 Architecture and Components of the Cloud Adopted in this Project

This section describes the components used in this project to simulate a scenario in AWS Cloud, an architecture very similar to the one used for the developed simulation. The information present in this section was obtained through research and reading of documents published by AWS that can be found at: https://docs.aws.amazon.com.

2.4.1 VPC Architecture

AWS splits into several regions with different availability zones. For this work, EU-WEST -2 Europe (London) was used due to regional proximity to reduce latency; within this region, there are three availability zones. Within the availability zone, a VPC will be created. A VPC is designed within the region and covers all availability zones, and subnets will be created within the availability zone. Subnets can be either public or private [34].

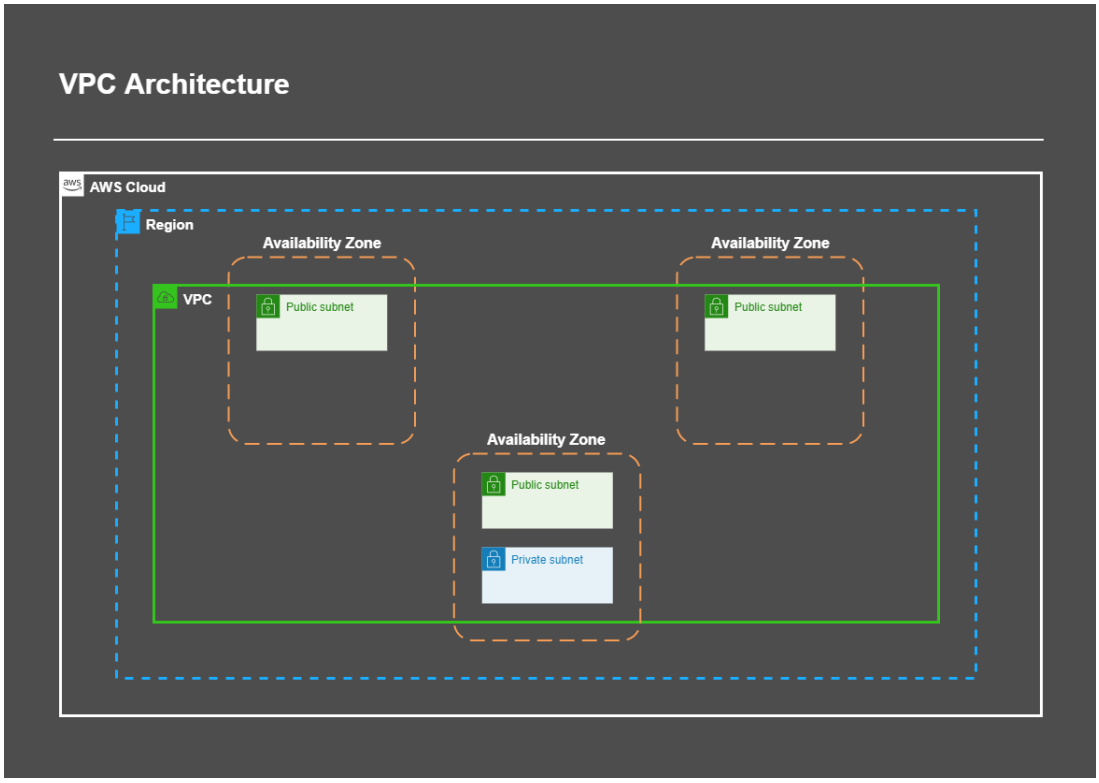


Figure 7: VPC Architecture

As shown in figure 7, there are three availability zones. Two comprise a public subnet, and one includes a public subnet and a private subnet. Availability zones with a public subnet have internet access, and those with a private subnet do not have internet access.

2.4.2 Components of a VPC

A VPC comprises several components, most of which will be described in this section.

Routing table and Router

The components represented in figure 8 are directly related. The router's operation always involves consulting the information in the routing table, which is the component that contains information on where communications should go. When there is communication between two IPs, the details on how they will communicate are in the routing table, so the router consults the routing table to know where to send the communication requests. If there is no information about where a particular communication should be sent, that communication will not be made [34, 37].

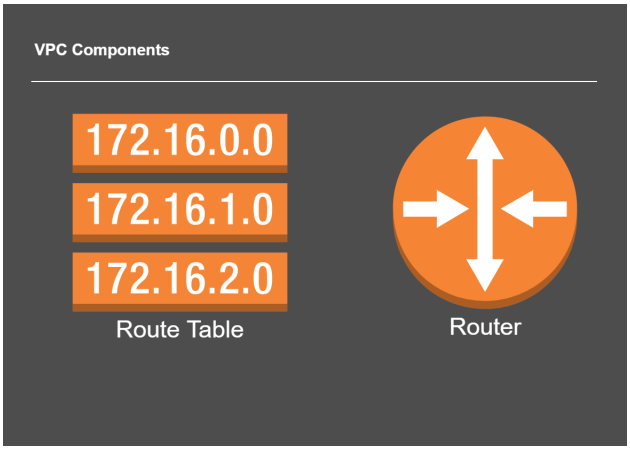


Figure 8: Routing Table and Router

Elastic IP and Elastic Network Interface (ENI)

In figure 9, two components are represented. The first is Elastic IP, essentially a static public IP. The second component is the ENI, which works as a virtual network card, a network port for EC2 instances. EC2 instances will be described later. With an Elastic IP, it´s possible to hide the failure of an instance by remapping the address quickly to another one. The Elastic Network Interface (ENI) works as a virtual network card, and it´s possible to configure a network interface and then attach it to an instance. A practical example, if an EC2 stops working, and it will take some time for the problem to be solved, it is possible to quickly create a new EC2 and reattach the ENI using the same configuration [34, 32].

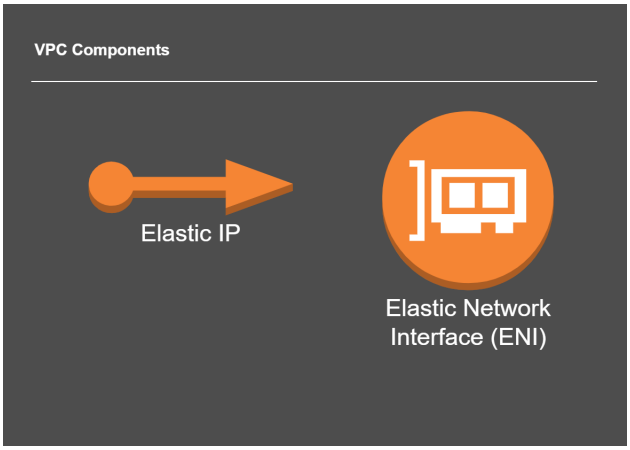


Figure 9: Routing Table and Router

Customer Gateway, VPN Connection, and VPN Gateway

The components shown below in figure 10 are necessary to establish a VPN Connection. The Customer Gateway is a simple router outside of AWS aiming to communicate with a router on an on-premises site. On the AWS side, a Virtual Private Gateway will establish communication between the Customer Gateway (on-premises) and AWS (Virtual Private Gateway). This will establish an IPSec connection between these two endpoints [34, 36].

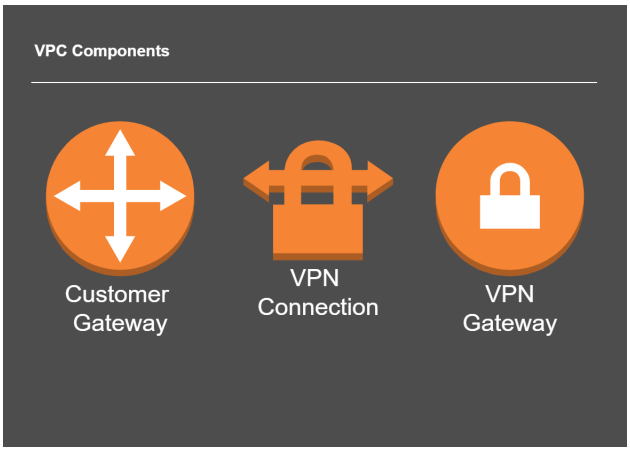


Figure 10: Routing Table and Router

VPC Peering

VPC peering is when there are two VPCs connected. Their communication works by request. For example, VPC A sends a request, and VPC B accepts this request or not, depending on the configuration [35, 34]. See figure 11.

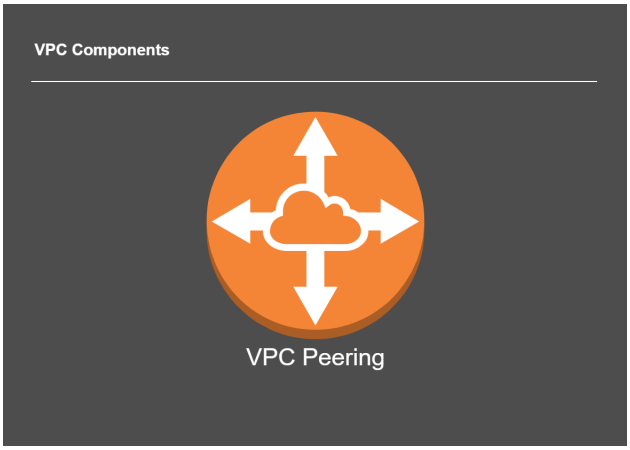


Figure 11: VPC Peering

VPC Endpoints

As figure 12 shows, VPC Endpoints allow maintaining private communication with some AWS services. For example, in the communication between an EC2 instance and an S3 service, the S3 service only uses public endpoints, which means that when it is necessary to communicate with this service, it is required to use the internet, making the communication between an EC2 instance and a service S3 public. The VPC Endpoint is like a middleman between the communication of an EC2 with an S3. That is to say, the EC2 communicates directly and privately with the VPC Endpoint and then communicates with the S3, keeping private communication [34]

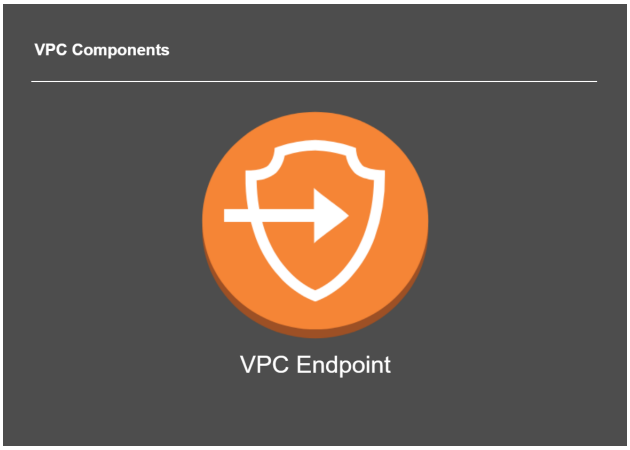


Figure 12: VPC Endpoints

2.4.3 NAT Gateway

Figure 13 shows the NAT Gateway server used by the private subnets to access the internet. For example, a database server located in a private subnet will, logically, not allow access from the outside world. However, database servers need updates and patches, and for that, they must access a repository that is on the internet. That is what NAT Gateway is for. It is configured on a public subnet and allows the database server on a private

subnet to communicate with it, forwarding the communication to the outside world. NAT Gateway allows instances that are in a private subnet to be able to connect to services outside the VPC, however external services cannot initiate a connection with those same instances [34].

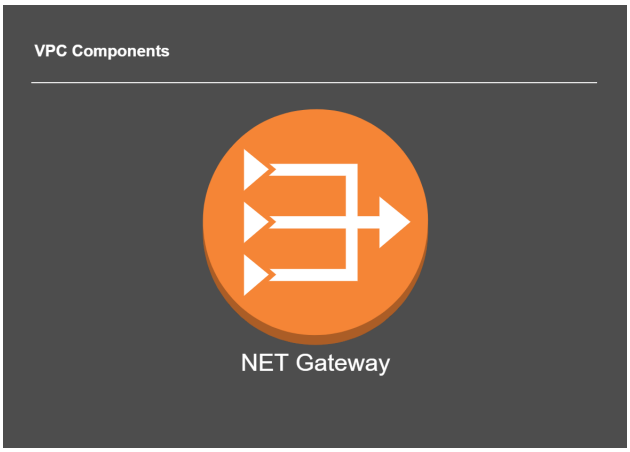


Figure 13: NAT Gateway

Subnets

Figure 14 shows an example of a VPC with three availability zones, each with two subnets, making a total of six subnets, three private and three public. The subnets work as subnetworks of the main VPC, so they must be within the range of IPs of the VPC. The subnets will be created with specific different IPs to be easily identified by zone in the future.

As mentioned above, each availability zone will have two subnets, one private and one public. Private subnets do not allow access from outside, but public subnets do. For example, a database usually does not need access from the outside world. However, a web server needs to be accessed from the external world [34].

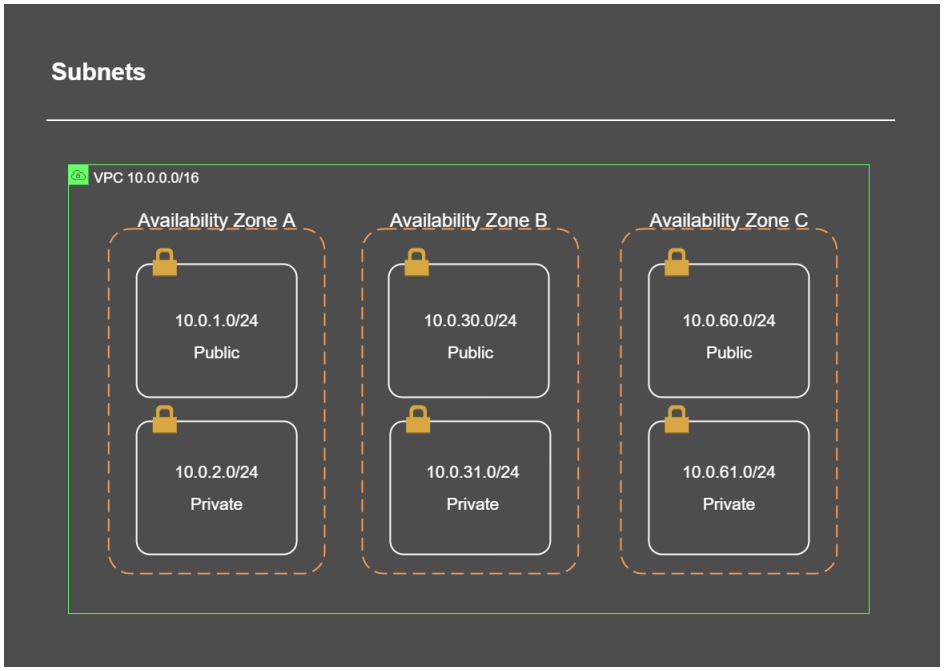


Figure 14: subnets

EC2

As figure 15 shows, EC2 is a service that provides secure and scalable computing capacity in the Cloud and offers several options for creating and running applications virtually, eradicating the need to purchase hardware. EC2 allows starting the servers needed for each purpose, setting security configurations, optimizing storage, and managing the network. EC2 is exceptional because it can scale up or down according to requirements or peak requests, which helps ensure that the application demands are met. Hence, instance auto-scaling allows you to define some metrics to increase or decrease the number of instances running; it´s possible to choose standard metrics like network bandwidth or CPU usage or custom metrics based on what you think is essential. This guarantees that you meet your application's demands without manual intervention and pay for what is needed and nothing else [33].

Figure 15: EC2 instance

2.4.4 How components work together

To better understand the behavior between the components, this section shows how the components interact and communicate with each other through charts and images.

Routing

The scenario in figure 16 consists of a VPC, two subnets, both with an EC2 with an elastic network interface attached, a router, an internet gateway, and a routing table.

Imagine the first EC2 wants to communicate with the second EC2, as shown in figure 16, if IP 10.0.1.10 intends to communicate with IP 10.0.3.10. The flow of this communication would be, when the router receives the communication request, he will look at the information in the routing table to see where to send the received request. The routing table contains information about where requests should be forwarded. As shown in figure 16, requests have a source and a destination. In this case, the routing table indicates that if the request source is within the 10.0.0.0/16 range, the route to forward the request is always local, which means that any request within the VPC IP range will always be local communication.

In another case, if an EC2 instance wants to communicate with a device outside the VPC, the router will see that any request where the source is outside the range of the VPC (10.0.0.0/ 16) will be sent to the gateway and forward to the internet. In other words, the routing table has information about where requests are sent to. When it receives a request, the router consults the routing table and follows the information it has. Suppose a request is made without information in the routing table. In that case, this communication will be discarded because there needs to be more information about where it should be forwarded [34].

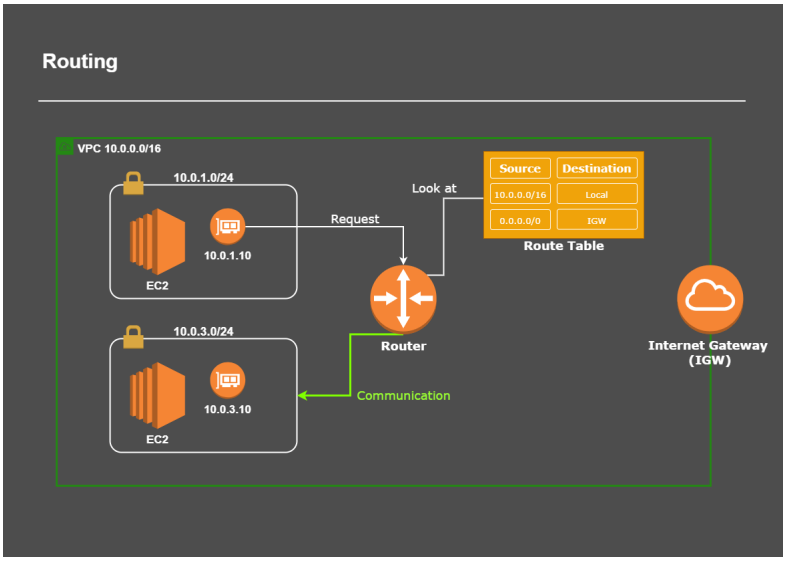


Figure 16: Routing

As shown in figure 17, there are now two routing tables, one public and one private. When we look more closely at figure 17 it is possible to see that in the private routing table, only one entry allows local communication. Therefore, any request made will only be accepted if it is to communicate internally. If not, the request will be denied.

The above is how we define whether a subnet is private or public; being public or private is not a characteristic or configuration of a subnet. What defines it is the configuration of the routing table associated with the subnet [34], as shown in figure 17.

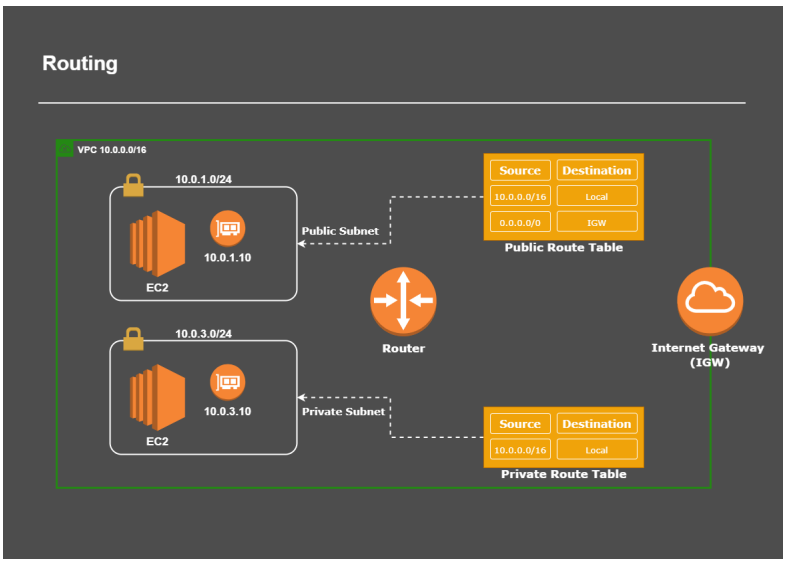


Figure 17: Routing (private and public)

Aside from routing and routing tables, a public IP is required if communication to the internet is needed. Therefore, in addition to associating the routing table, the EC2 instance that will carry out a public communication needs a public IP address.

Even if the EC2 instance is in the private subnet and has an elastic IP, it will not be able to communicate to the internet because the routing table associated with it does not have this information, as shown in figure 18. However, the EC2 in the Public subnet needs a public IP to communicate and receive information from the internet, as it is also possible to see in figure 18.

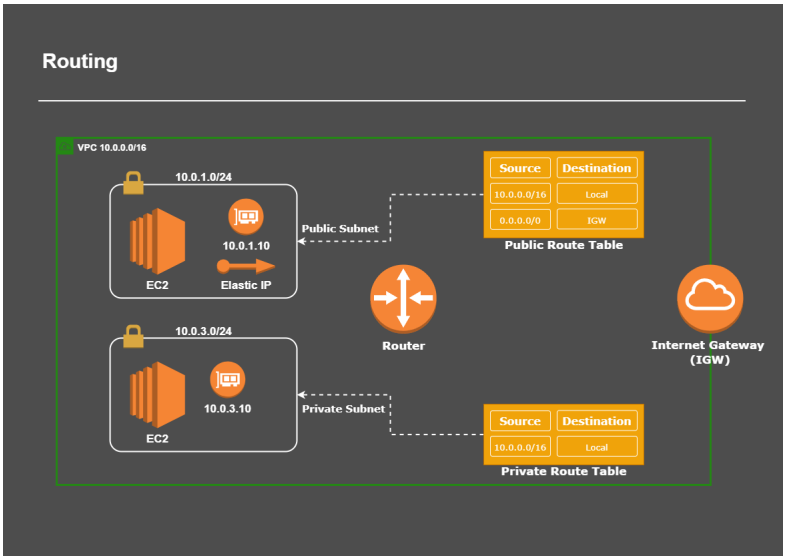


Figure 18: Routing (Elastic IP)

NAT Gateway

The NAT Gateway is a managed service provided by AWS that allows communications from the subnet to the outside world but does not allow communications from the outside world to the subnet. This component is used with some frequency to make updates in instances that do not need to communicate outside the system or instances that are in a private subnet.

Figure 19 shows a scenario similar to the previous one but with the difference that in the private routing table, there is a new route that will forward requests to the NAT Gateway [34, 38]

To summarise figure 19, if within the private subnet, any instance needs to communicate with an IP outside the range of the VPC, the request is sent to the router. The router will see that in the routing table, there is an entry for any IP in the 0.0.0.0/0 range, and the request will be forwarded to the NAT Gateway. Since the NAT Gateway is a managed service, it does not need additional configurations as it already knows what to do with the requests it receives. Now the NAT Gateway will send the request to the outside world.

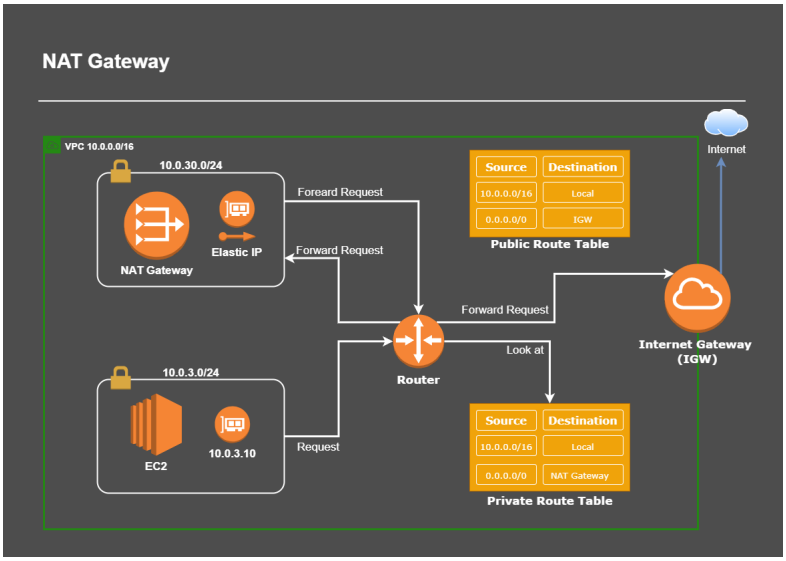


Figure 19: NAT Gateway

VPC Endpoint

For some endpoints in AWS, for example, Amazon S3, to communicate with an instance, it is necessary to go out to the internet through the internet gateway. This solution is not exactly good practice since the instances will communicate with the endpoints publicly, as shown in figure 20. Usually, this is not the desired scenario because, in this way, the data will be public, companies do not like to have their data public, and Bodum is no exception. The VPC endpoint is a kind of internet gateway because all instances will communicate directly with the VPC endpoint, and it will communicate with other endpoints. In this case, we are talking about Amazon S3, as shown in figure 21. The communication between the VPC endpoint and the Amazon S3 is private, thus making the communication more secure [34, 31].

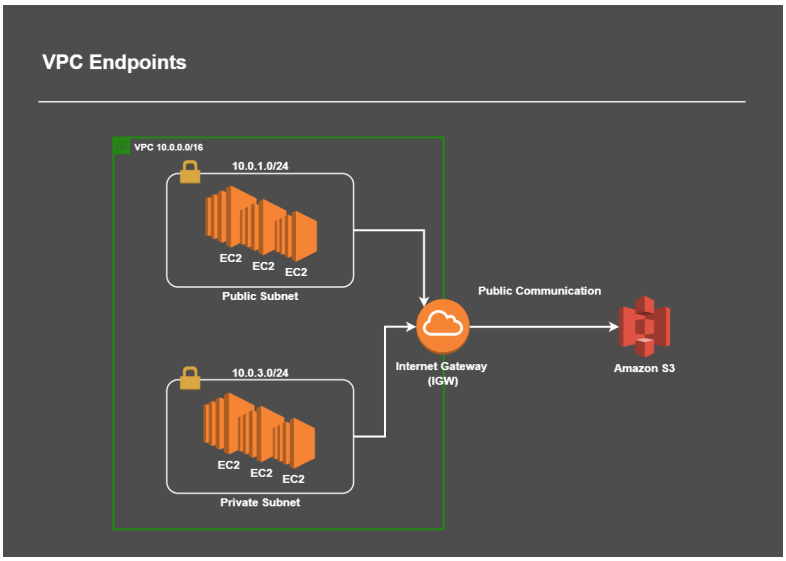


Figure 20: VPC Endpoint public communications

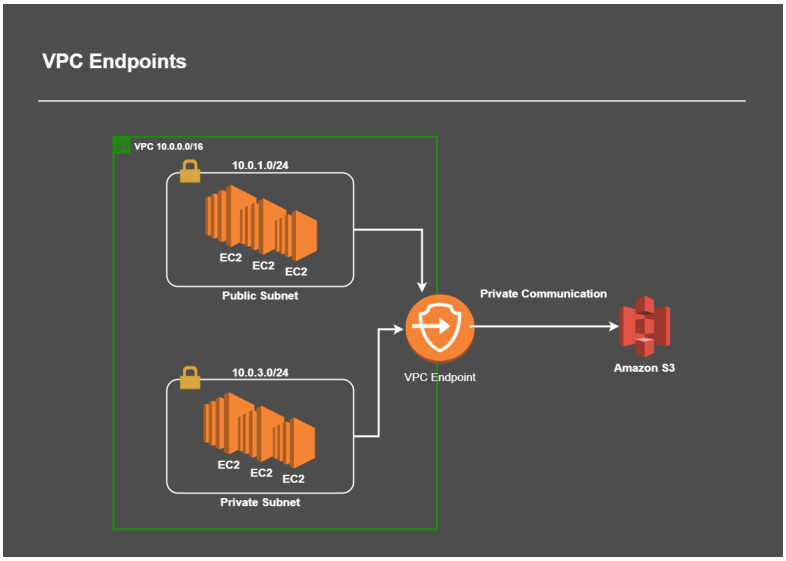


Figure 21: VPC Endpoint private communications

Important things to keep in mind

VPC is assigned and limited to a particular region and spans all Availability Zones in that region. In a VPC, there are five IPs, and they are always reserved. Figure 22 shows what these IPs are reserved for.

IP	Reserved for?
10.0.0.0	Network Adrress
10.0.0.1	Reserved by AWS for VPC router
10.0.0.2	Reserved by AWS. IP for DNS serve
10.0.0.3	Reserved by AWS for future use
10.0.0.255	Network broadcast address. Broadcast is not supported in a VPC, therefore this address is reserved

Figure 22: Reserved IP Addresses

Subnets can be public or private and are restricted to a single availability zone. That is, a subnet can only be assigned to one availability zone. The subnets must be linked to a routing table. Otherwise, there will be no forwarding of information.

Internet Gateway must be added to the routing table to have inbound and outbound internet. Therefore, it is only possible to communicate with the outside world with an Internet Gateway.

NET Gateway simulates a kind of DMZ, where external access is blocked, but internet access is allowed. This is the basis we should keep regarding a VPC in AWS Cloud.

2.5 Cloud Vs On-Premises

The choice between a Cloud or On-premises system must be made according to the needs of each company or client. Each option has advantages and disadvantages that should be considered when deciding between one or the other depending on the purpose; therefore, we can see some differences between these two systems that can help in decision making,

but they have one thing in common both systems are two different ways of delivering and consuming IT services.

On-premises computing is when a company has full control over its own IT infrastructure. That means that the company manages all the things by itself like data centers, hardware, storage, and software and all of these are physically on the company´s premises. This approach means the company needs to buy every piece of equipment that needs someone in the company infrastructure to manage this equipment and software, and this means that it will be very difficult to scale up or down as the company needs.

On the other hand, Cloud Computing is a way to deliver IT services over the internet, these services are the responsibility of the Cloud provider. Cloud computing allows entities to consume IT resources as a service on a pay-as-you-use basis. Cloud computing allows you to easily add or remove resources as needed, which makes the system scalable.

Both approaches have advantages and disadvantages. Cloud Computing can be more flexible and more cost-effective but at the same time there is an increase on security risks and raise issues around data sovereignt and compliance. On-Premises computing the organization has more control and customization but with a higher cost. On-Premises computing is also much more difficult, and very expensive to scale.

Nowadays, most companies are doing Hybrid Cloud which allows them to have the infrastructure both on-premises and on cloud to take the best advantage of both. There are also some companies preferring a multi-cloud approach in the sense that they use different cloud services providers for different workload and services.

As already mentioned above, when we have to choose between one of these systems, it is of great importance to take into account the needs and requirements of the organization, such as data sensitivity, regulatory requirements, and scalability, and we must understand what is important for the company concerning cost, performance, security, and control.

Chapter 3

METHODOLOGY

Before implementing this project, some research was conducted on the various areas covering this project, including virtualization techniques and tools and cloud migration. Since this project is a real case study for Bodum Portuguesa, Produção de Artigos Metálicos, SA, it must respect some internal rules, such as the timeline, the organization's requirements, and costs.

Project management is a critical component of any project. This chapter will outline how the tasks and methodologies of this project were organized. During a project, there are some elements to consider to decide what methods should be applied and what tools to use to help in decision support. Since this is an IT project, the best thing to do is follow agile methodologies, which are considered helpful for this project and a trend. This project was developed based on the Scrum Framework. Although this project belongs to the IT area, it will be implemented in an industrial environment, so it is essential to refer to the "Waterfall Model" which is the basis of the Scrum framework.

3.1 Waterfall Model

The Waterfall Model came from the industrial world and was the first of its kind. Sometimes this model may also be referred to as the linear life cycle model. In other words, each phase of this model must be completed before starting the next phase, with no overlapping phases [4]. For example, in large-scale projects, redrawing something during the project requires high costs. Therefore, each task must be completed in the waterfall model before moving on to the next task. This process is highlighted in figure 23. The Analysis phase is intended to understand the concept of the business, and the next phase, Design, intends to transform this vision into something concrete. In these two phases, a sample of what the system will be is created, then, in the Development phase, as the name implies, it will be developed. The testing phase ensures that the functionalities of what is being developed follow the requirements. These functionalities pass to the Implementation phase and are implemented in a production environment. Then it goes into Maintenance, which is the last phase of this model to deal with possible changes [4, 16].

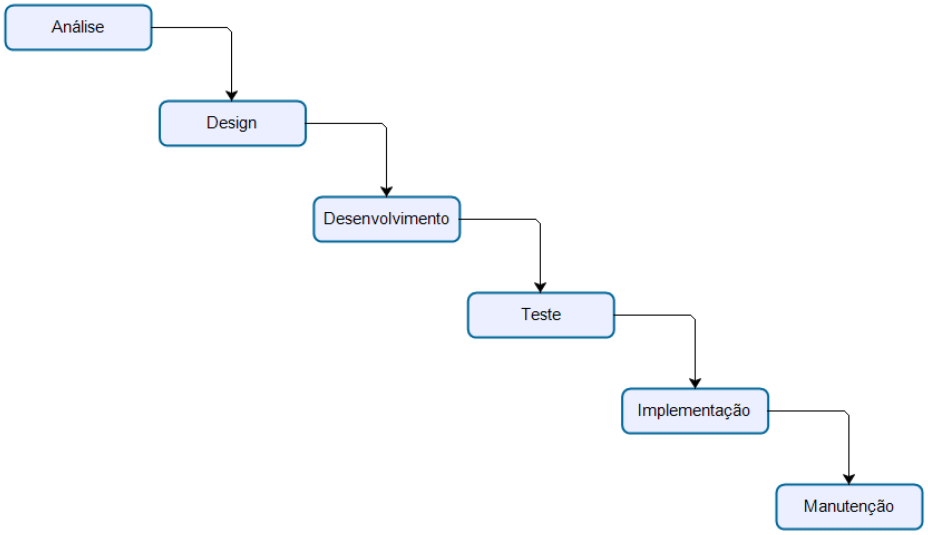


Figure 23: Waterfall Model [16]

3.2 Scrum Framework

Scrum is a framework for project management. Initially, this methodology focuses on software development, but it is also used in other areas such as sales, marketing, high technology, etc. This methodology is designed to divide the work into goals, which must be completed within a specific timeline; this particularity we call a sprint that ideally must be completed within a maximum period of one month, ideally in two weeks [11, 39].

A Scrum project comprises three fundamental parts, the Product Owner, Scrum Master, and Developer Team. These three parts include a relatively small team, self-manageable, cross-functional, and always focused on a single objective sequentially. Figure 24 represents the Scrum flow that is based on different types of meetings, and it is in these meetings that planning and monitoring measures are developed.

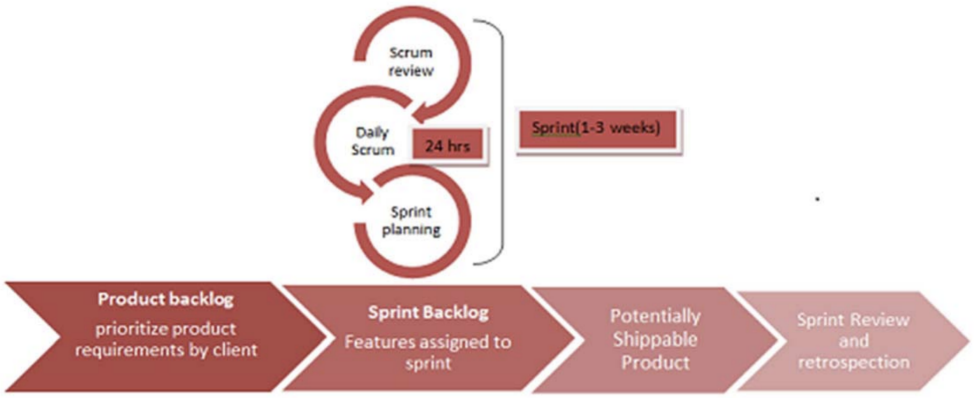


Figure 24: Scrum flow [39]

The Product Owner, with the project team at the beginning of each sprint, establishes

a set of requirements to be developed during this phase. Based on the previous sprint, the team will determine the amount of work possible to complete in the next sprint. When a sprint is completed, the team will demonstrate the work done to the product owner and other stakeholders, if applicable. This phase is of great importance as the team receives feedback on the work that has been completed, and the requirements for the next sprint are decided. A retrospective meeting is held to evaluate the work done, point out strengths and weaknesses, and recommend improvements [4, 16].

As mentioned above, this project was developed based on the agile Scrum methodology not only because it is a trend but because it is more functional in projects where some details are unknown and subject to changes. We can better understand the differences between Waterfall and agile methodologies in figure 25.

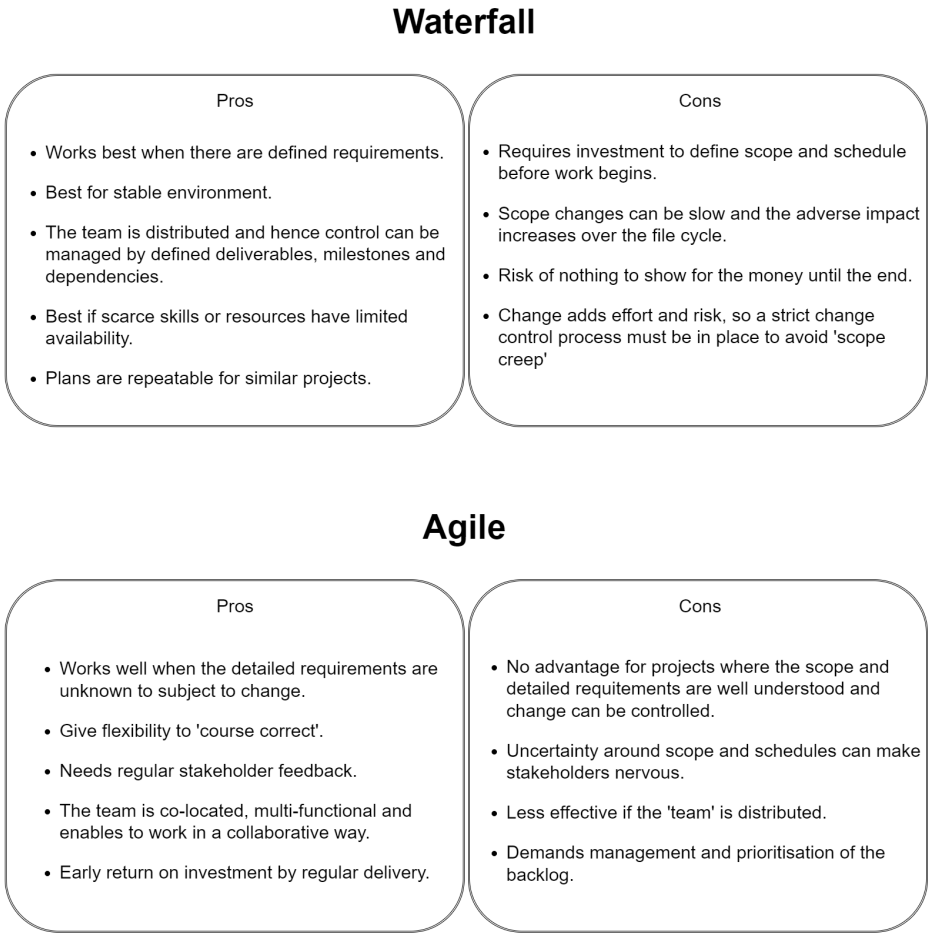


Figure 25: Difference between Waterfall and agile methodologies [4]

3.3 Work Plan

3.3.1 Guidance on work

The work plan comprises the following aspects:

- Analysis of the company's existing systems:
  How many servers exist;
  What services are present on each server;
  What is the criticality of each server;
  What accesses are allowed.

- Migration compatibility from 2008 R2 servers to windows server 2019:
  For compatibility, it is necessary to migrate the domain from File Replication Service (FRS) to DFS (Distributed File System).

- Migration Test:
  Install VirtualBox with a Windows Server 2019 VM and run migration tests to understand the system behavior and to avoid potential failures during the process.

- Scheduling dates for server migration:
  Schedule a date and time adequate for the server migration process according to the person responsible for each site.

- Virtualize physical servers (if approved by the company):
  Through iDrac [1] install the ISO VMware-VMvisor-Installer-6.7.0.update01.and install windows server 2019.

- Migration from Physical Servers to New Virtual Servers:
  Migrate all services from the old servers and copy all the files with their access to the new servers.

- System improvement proposal:
  It can be considered if the company accepts the proposal for the virtualization of new servers. If accepted, the migration will be implemented using server virtualization.

- SI to Cloud migration proposal:
  Analyze the best way and destination for migration to Cloud (Hybrid/private or public cloud) and the costs/benefits the migration entails.

- Requirements and needs for Cloud migration:
  Understand which services to make available and their criticality, need for redundancy, backup, etc.

[1] iDRAC was created to manage local and remote servers securely and helps IT administrators deploy, update, and monitor Dell EMC PowerEdge servers.

- Presentation of results and comparison:
  Present the obtained results and, if possible, perform some tests, and compare the costs and benefits of a physical SI on-premises or in the Cloud

3.3.2 Gantt calendar

To better understand the development of this project regarding the existent stages and the chronological order for development, the main steps of the work plan are presented using a Gantt chart. The Gantt chart is shown in figures 26, 27, and 28 and divided into three phases for a more general and understandable view.

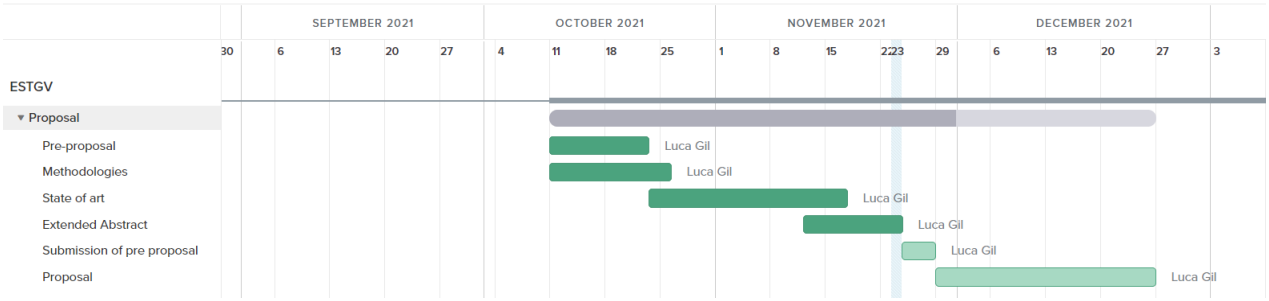


Figure 26: First phase (Proposal)

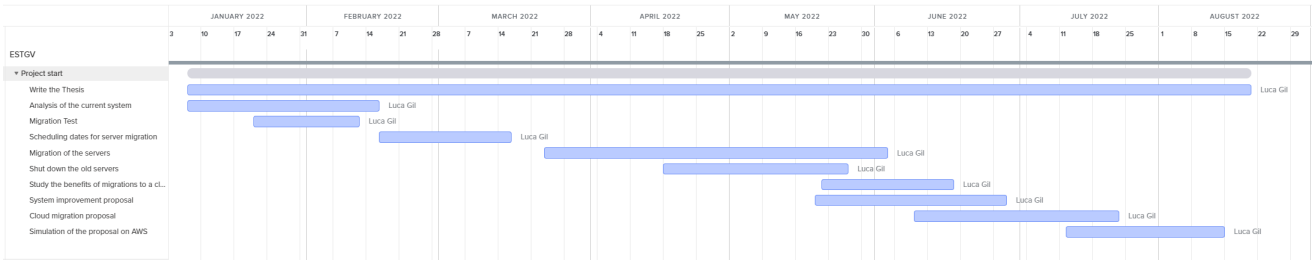


Figure 27: Second phase (Project Start)

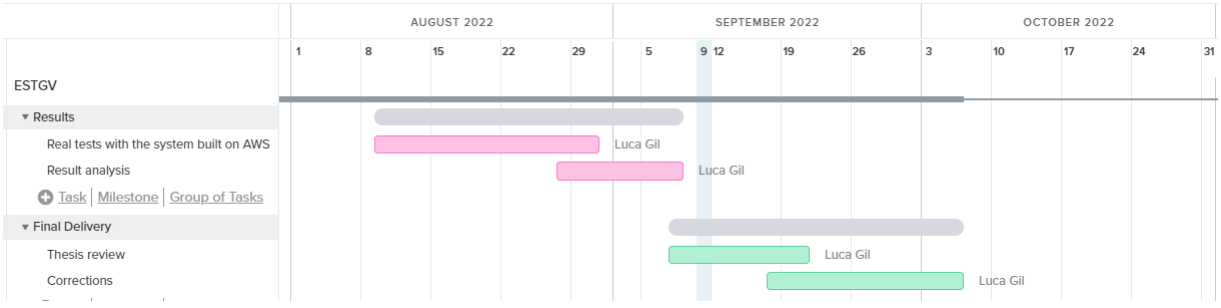


Figure 28: Third and fourth phases (Results and final delivery)

Chapter 4

MIGRATION TO THE NEW SERVERS

This chapter describes detailed information regarding the migration process executed in Bodum Portuguesa SA. Since the company decided that, for the moment, there was no interest in virtualizing the servers, the migration process was carried out directly from the existing physical servers to the new ones without virtualization. The following description will not disclose sensitive or confidential information about the company's IT systems.

4.1 Analysis of the Legacy and new servers

To execute the project, the company acquired new servers that will support the infrastructure after migration from the existing old server. Following, the main characteristics of the old and new servers are discussed.

Legacy servers

Figure 29 describes the main characteristics of the legacy servers. These characteristics are identical on all six servers except the storage capacity, which, on some servers, can be slightly different. In this case, it will not significantly impact because it's a slight difference.

By analyzing figure 29, it is possible to understand from the OS version that these servers are old, and from other components, the RAM, for instance, lacks resources. The above is corroborated by figure 30. At the same time, we see there is a waste of CPU usage since the CPU usage is only 4%. This is a subject that will be discussed later in another chapter. These servers have AD DS, DNS, DHCP, file and storage services, print server, and Web server running as main server roles. They also have features such as .NET framework 3.5.1, group policy management, and remote server administration tools. These roles and features will be replicated on the new servers.

Physical/Virtual	Physical
OS Name	Microsoft Windows Server 2008 R2 Standard
OS Version	6.0.600. Service Pack 2 Build 6003
Processor	Intel(R) Xeon(R) CPU E5506 @ 2.13GHz, 2133 Mhz
Core	4 Cores
Installed Physical Memory (RAM)	6GB
Physical Disks	3 Hard Drives PERC H700
Physical drive 1	136.12 GB (RAID-1)
Physical drive 2	5.025.38 GB (RAID-6)
Physical drive 3	1.862.50 GB (RAID-0)
IP	Confidential
Subnet Mask	Confidential
Default Gateway	Confidential
Mac Address	Confidential
Network details	Confidential
Brand	Dell
Model	PowerEdge T410
Serial	Confidential
Service Tag	Confidential

Figure 29: Characteristics of legacy servers

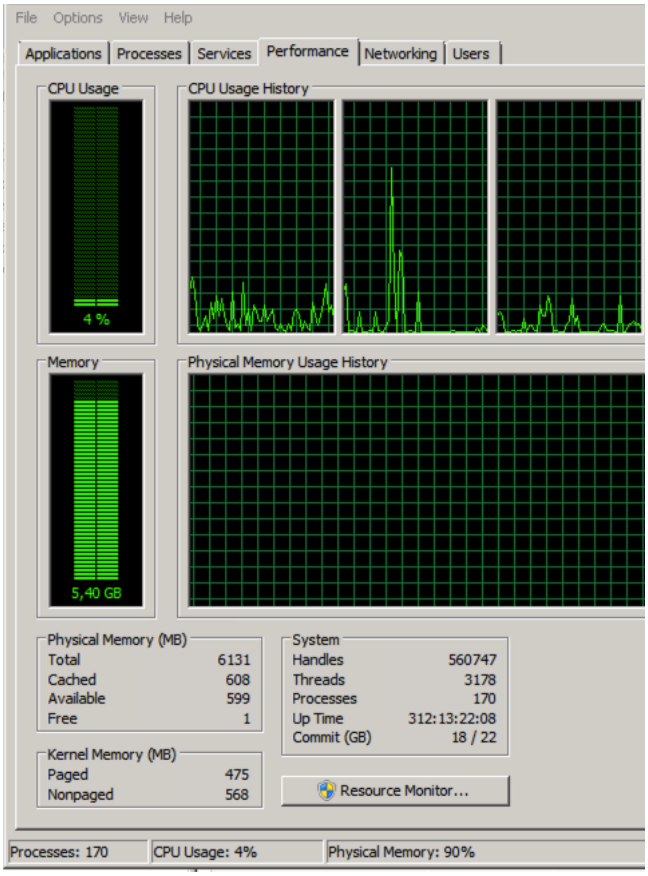


Figure 30: Performance of legacy servers

New servers

As shown in figure 31, the new servers have a recent version of the OS and improved processing capacity and RAM. Regarding storage, the servers were purchased with the configuration shown in 31.

The old servers should serve as a base for configuring the new ones. The existing configuration was replicated on each server in each country.

With these new servers, there is no longer a lack of resources, especially regarding memory RAM, as shown in figure 32. However, the problem of wasted processing capacity will increase as the processor of the new servers is newer and more powerful than the old servers. This is also one of the problems that the author will try to solve with the improvement proposal.

Physical/Virtual	Physical
OS Name	Microsoft Windows server 2019 Standard
OS Version	10.0.177.63 Build 17763
Processor	Intel(R) Xeon(R) Gold 5218 CPU @ 2.30GHz, 2295 Mhz,
Core	32 Cores
Installed Physical Memory (RAM)	42GB
Physical Disks	9 Physical Disks PERC H730P Adapter
Solid State Disk 0:1:0	446.63 GB (RAID-1)
Solid State Disk 0:1:1	446.63 GB (RAID-1)
Solid State Disk 0:1:2	893.75 GB (RAID-6)
Solid State Disk 0:1:3	893.75 GB (RAID-6)
Solid State Disk 0:1:4	893.75 GB (RAID-6)
Solid State Disk 0:1:5	893.75 GB (RAID-6)
Solid State Disk 0:1:6	893.75 GB (RAID-6)
Solid State Disk 0:1:7	893.75 GB (RAID-6)
Solid State Disk 0:1:8	893.75 GB (RAID-6)
IP	Confidential
Subnet Mask	Confidential
Default Gateway	Confidential
Mac Address	Confidential
Network details	Confidential
Brand	Dell
Model	PowerEdge T640
Serial	Confidential
Service Tag	Confidential

Figure 31: Characteristics of new servers

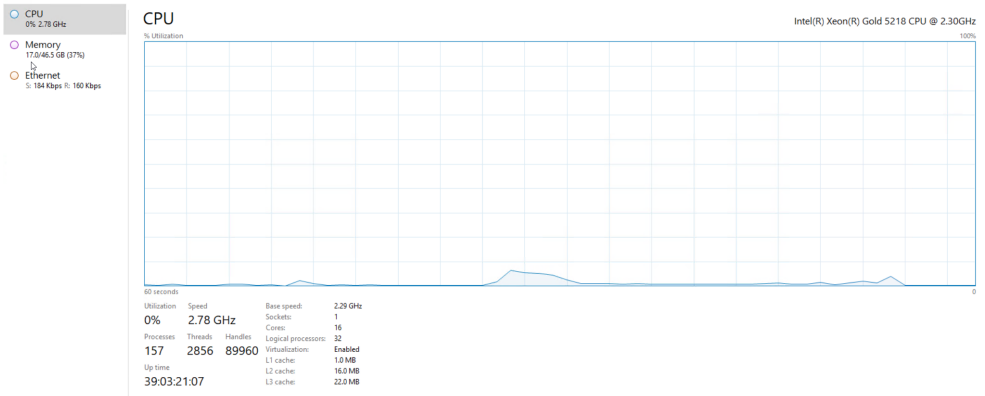


Figure 32: Performance new servers

4.2 Access to Servers

Since the company servers are located in different countries, it is challenging to have physical access. Thus, the first connection was made through iDRAC to add the servers to the Bodum domain and to activate the remote desktop service enabling us to have direct remote access to them. As mentioned earlier as a footnote in Chapter 3, iDrac allows help to manage local and remote servers and to deploy, update and monitor servers. In figure 33 it is possible to see what iDrac looks like. Although iDRAC was only used to access

the servers' virtual console, it is a complete and handy platform. The iDRAC is further described in appendix B.

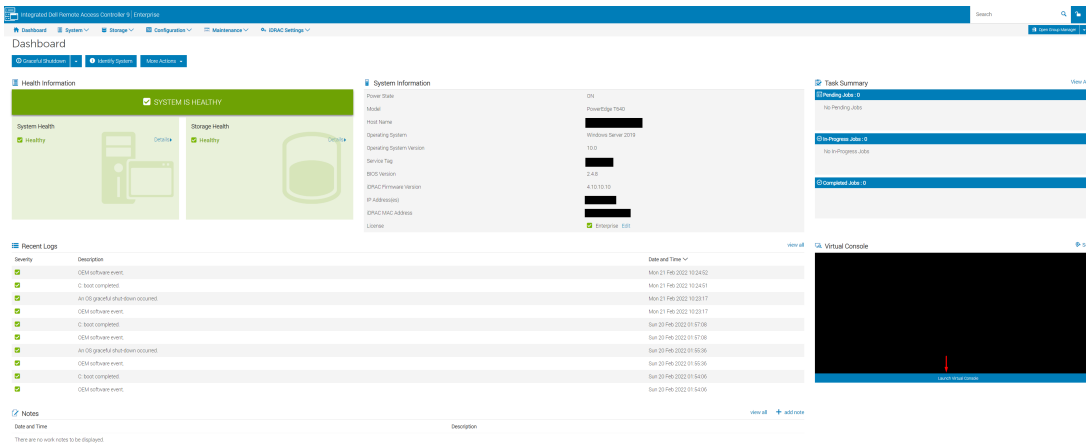


Figure 33: iDRAC overview

4.2.1 Enabling Remote Desktop Connection

Accessing the servers through iDRAC makes it possible to activate the remote desktop protocol (RDP), allowing to access the servers. It would also be possible to continue using iDRAC for remote server access, but RDP is already a well-known and straightforward native Windows tool. The steps that were taken to activate the RDP protocol are represented in figures 34, 35, and 36.

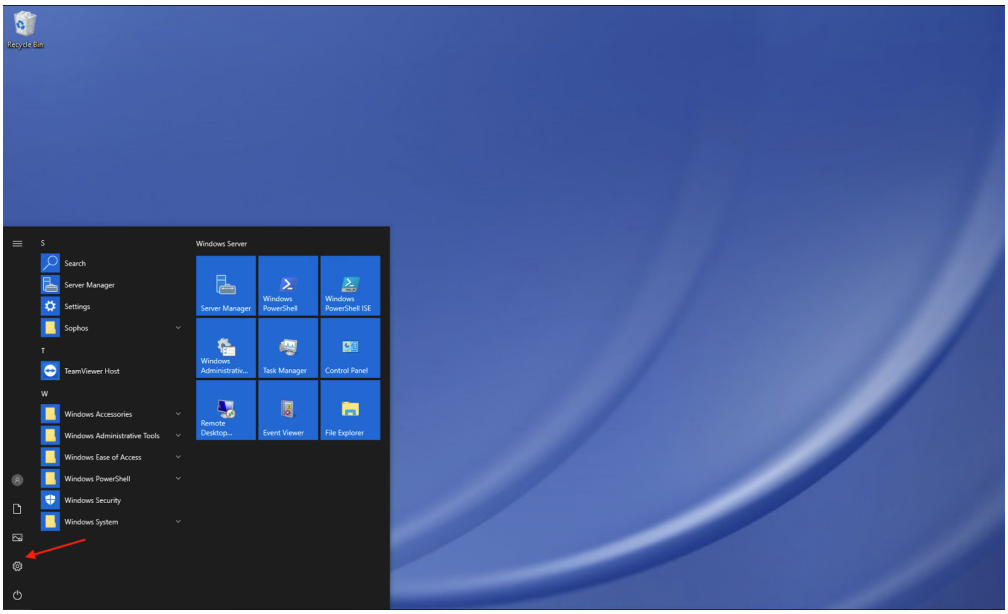


Figure 34: Activate RDP - Step1

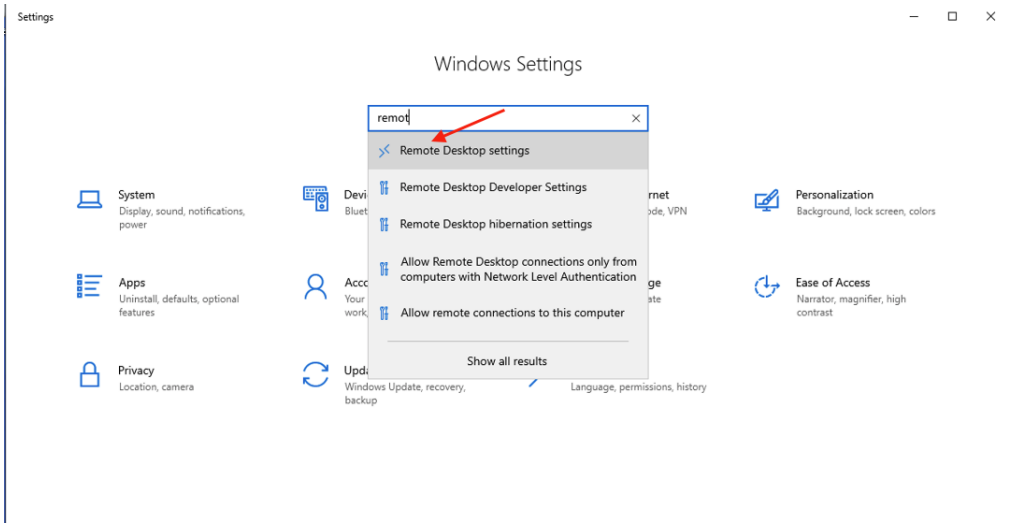


Figure 35: Activate RDP - Step2

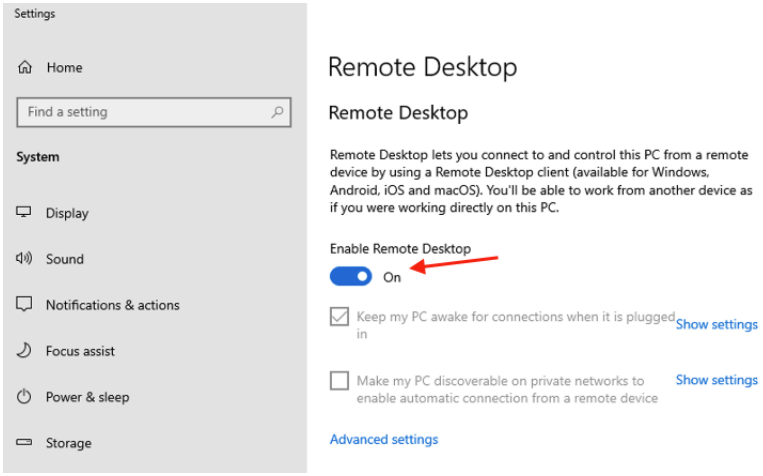


Figure 36: Activate RDP - Step3

4.2.2 Add Server to Bodum's Domain

After RDP is activated, as mentioned above, and used to access the servers to make the necessary changes and installations, it is possible to continue using iDRAC. However, for this purpose, RDP will always be used by default. Figure 37 shows the necessary steps to add the server to the Bodum domain. After following these steps, the server must reboot to join the Bodum domain. Once in the domain, the server was moved to a specific organizational unit (OU) to apply the Bodum policies regarding the "Domain Controllers" OU, as shown in figure 38.

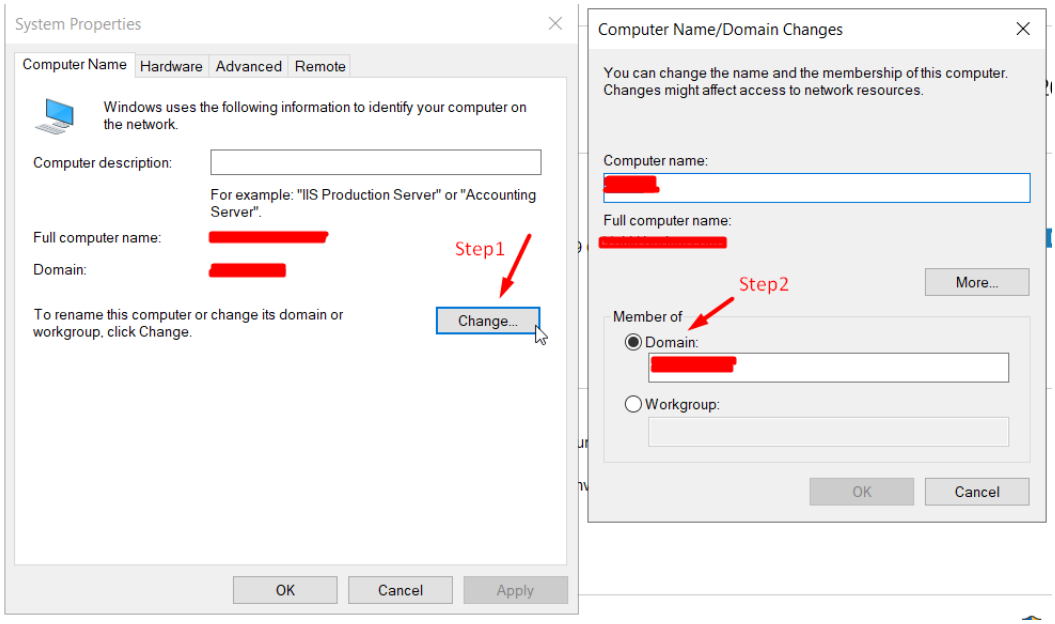


Figure 37: Add server to Bodum domain

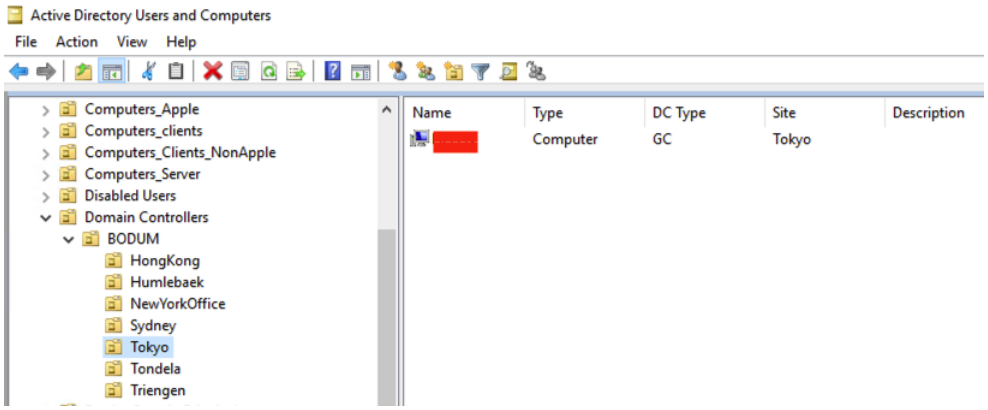


Figure 38: Add server to Bodum domain

4.3 Instal Roles, Services, and Server Features on new Servers

Now that the server is in the Bodum domain, RDP can access it. The roles that need to be installed and how to install them will be described. As already referred, all the configurations carried out on the new servers are based on the configurations present on the old servers.

4.3.1 Install Active Directory Domain Service (AD DS)

It is necessary to perform the steps described in figures 39 to figure 44 to install Active Directory Domain Service, DNS, and other roles.

1

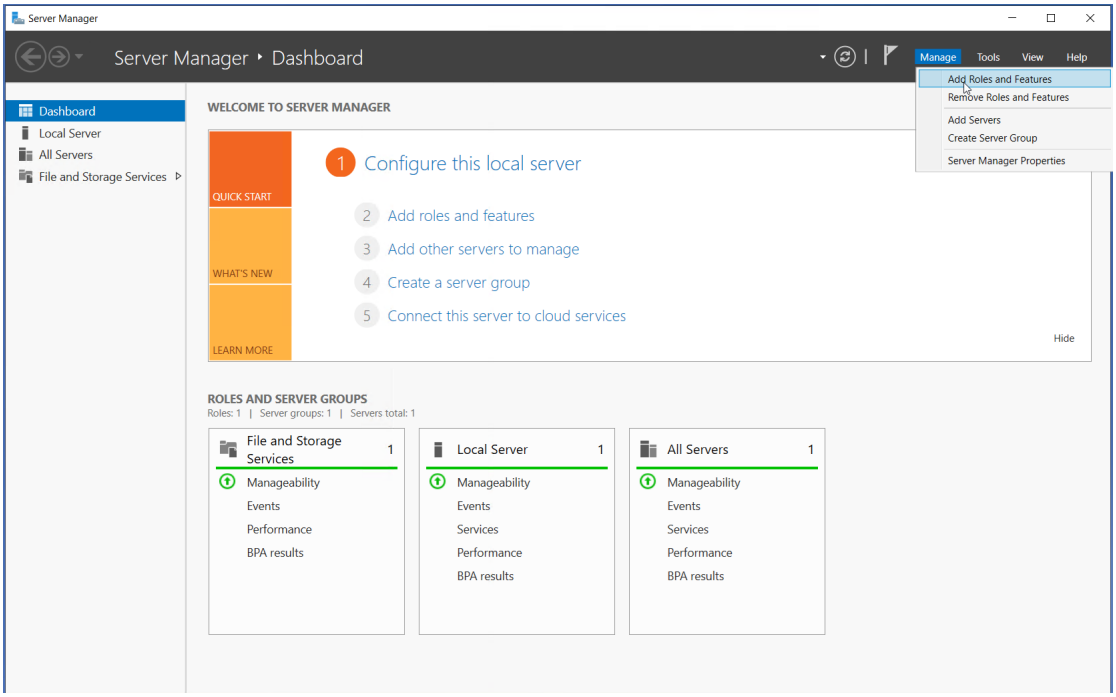


Figure 39: Add Roles to the server

[1] "Provide a central network directory that is the basis for the user and computer authentication and environment management via Group Policy. AD DS is used in almost every organization and is usually referred to as AD." [18].

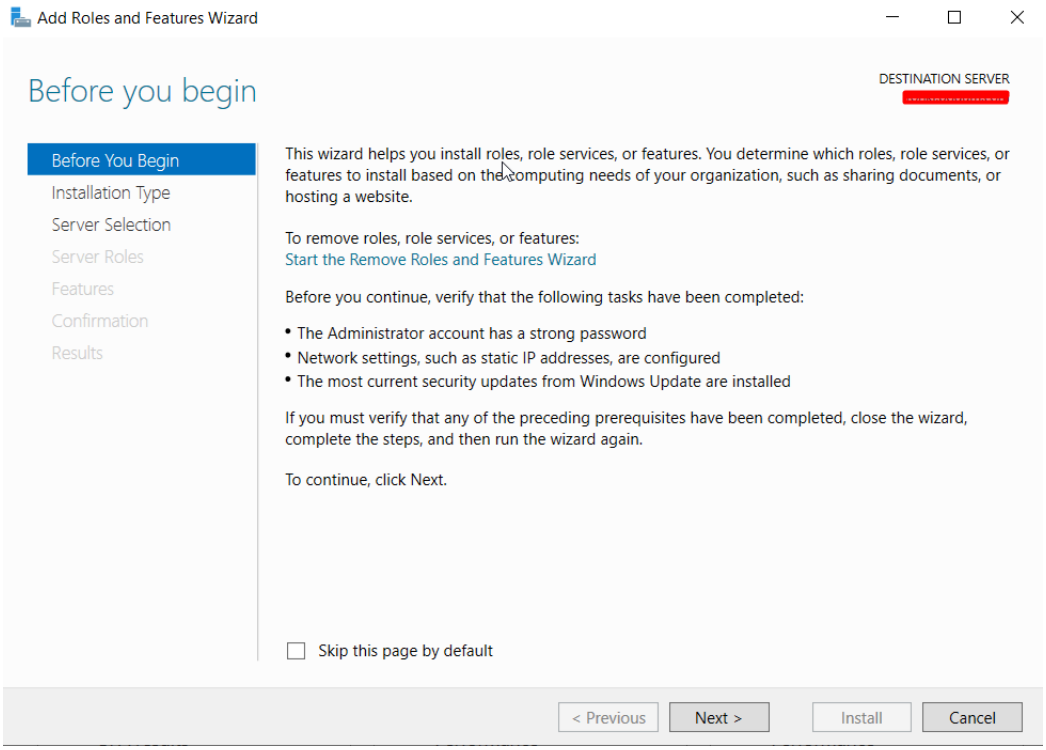


Figure 40: Before starting the installation

Before proceeding to the installation, it is suggested by the installation wizard that some tasks must be checked (figure 40).

Select installation type

Now it is time to choose the installation type, as shown in figure 41. There are two installation options. For this specific scenario, the first option, "Role-based or feature-based installation", will be chosen, which means configuring a single server and adding roles, role services, and features.

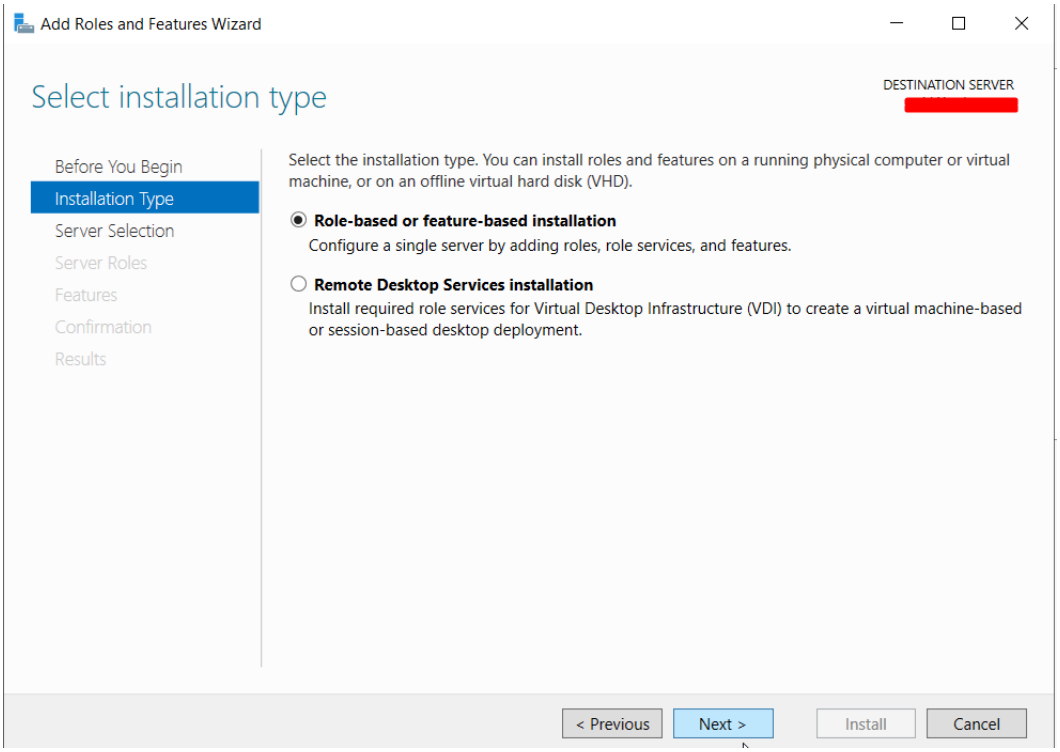


Figure 41: Select installation type

Select destination server

It is necessary to choose the destination server where the installation will occur. Figure 42 shows two options. One is to install it on a server from the server pool, and the other is on a virtual disk. Following the same line of thought as in the previous point, we will choose the first option. As shown in figure 42, when the first option is selected, the server's name is shown immediately below in the server pool, which in this case is blanked out in red because it is considered confidential company information.

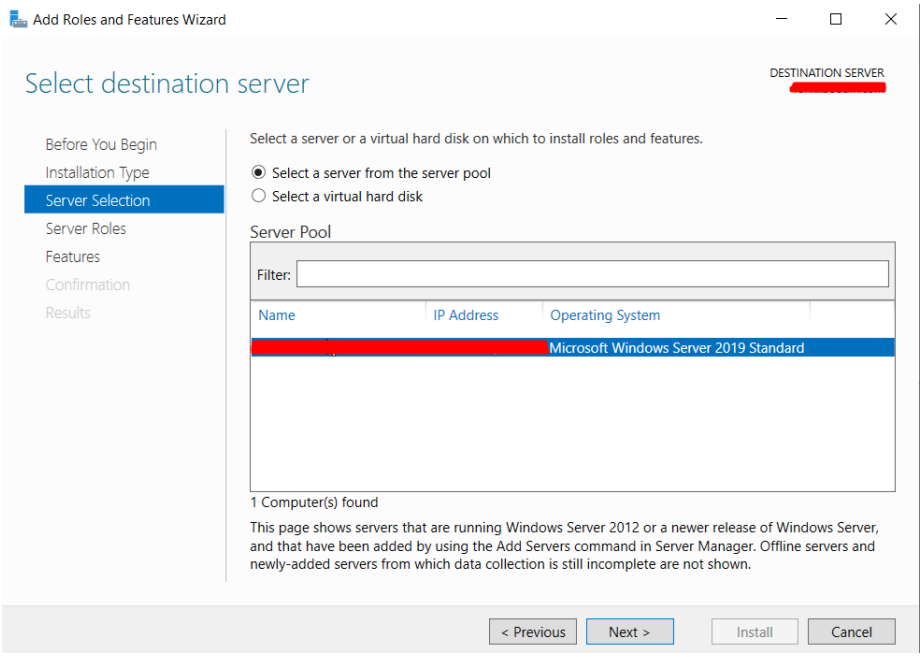


Figure 42: Select destination server

Select server roles

Now it is necessary to choose the roles to install on the server. The role we want is "Active Directory Domain Services". To install, select from the list shown in figure 43, click on the next button, and a new window is pictured with some mandatory features for installing AD DS. These features are shown in figure 44.

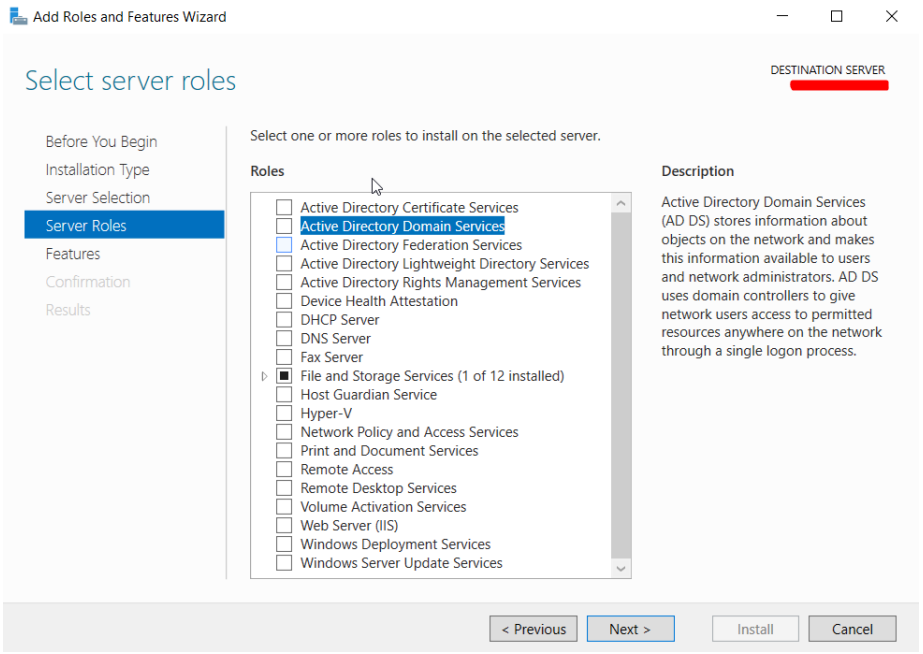


Figure 43: Select server roles AD DS

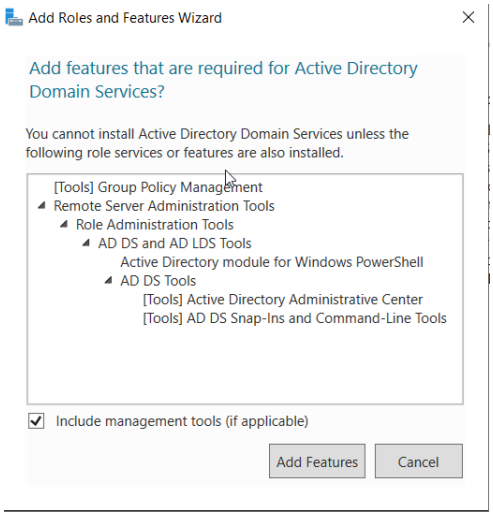


Figure 44: Features required to install AD DS

4.3.2 Install Domain Name System (DNS)

Regarding the DNS service, the next role that will be selected is the Domain Name System (DNS) represented in figure 45. The procedure is identical to the one above. Figure 46 shows some mandatory features for DNS installation.

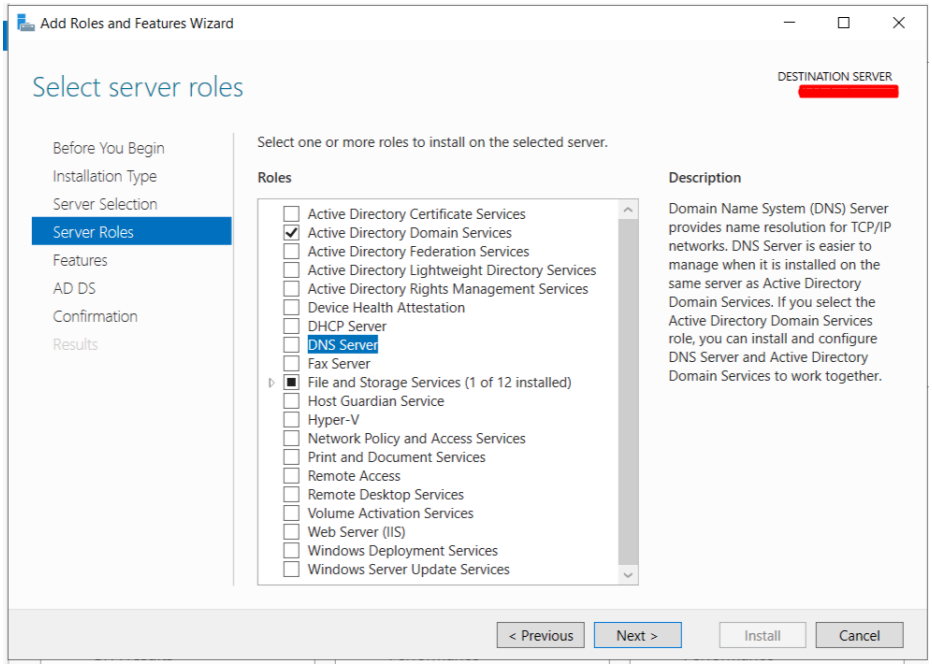


Figure 45: Select server roles DNS

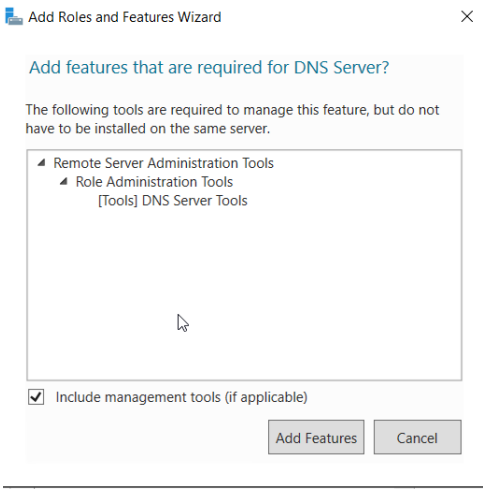


Figure 46: Features required to install DNS

4.3.3 Install Web Server (IIS)

To install a Web Server (IIS), the procedure is identical to the one above, as is shown in figures 47 and 48.

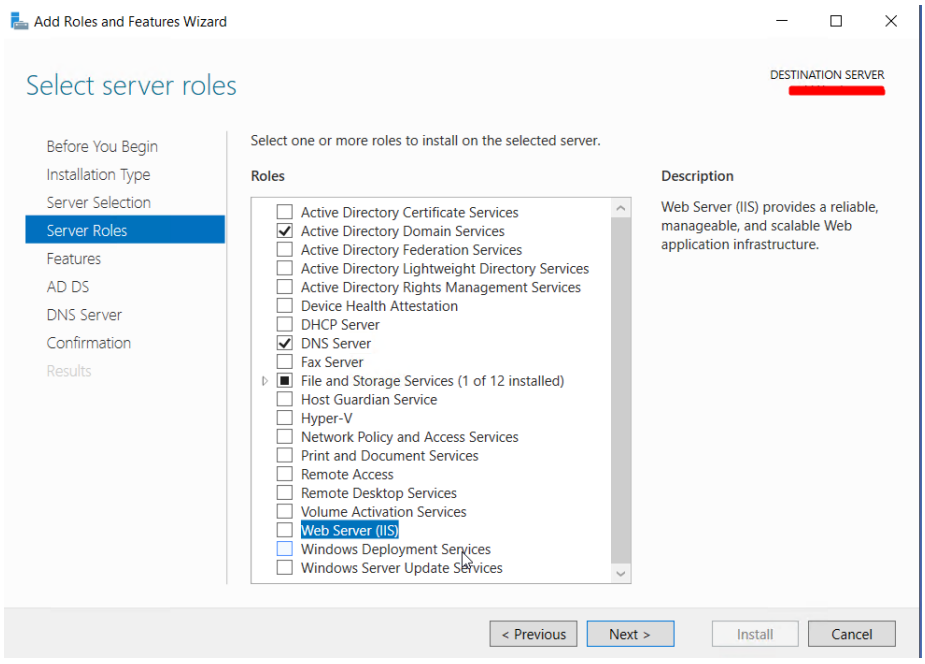


Figure 47: Select server roles Web Server

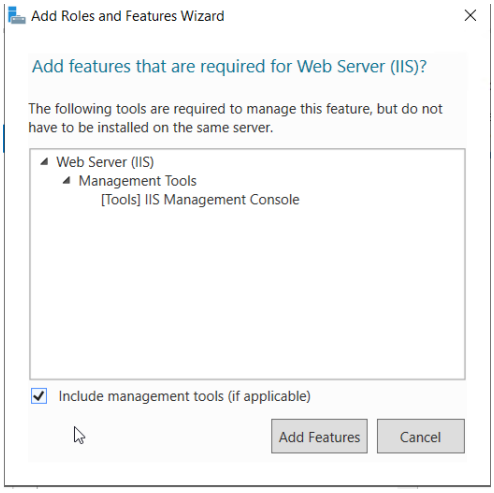


Figure 48: Features required to install Web Server

4.3.4 Install Dynamic Host Configuration Protocol (DHCP)

The DHCP is also to be installed, though this one has a particularity, and it is necessary to be careful when configuring this role, as explained below.

This process starts the same way as the previous, so the steps described above will be repeated from figure 39 to figure 42. After completing these steps, selecting the DHCP role for installation will be necessary, as shown in figure 49.

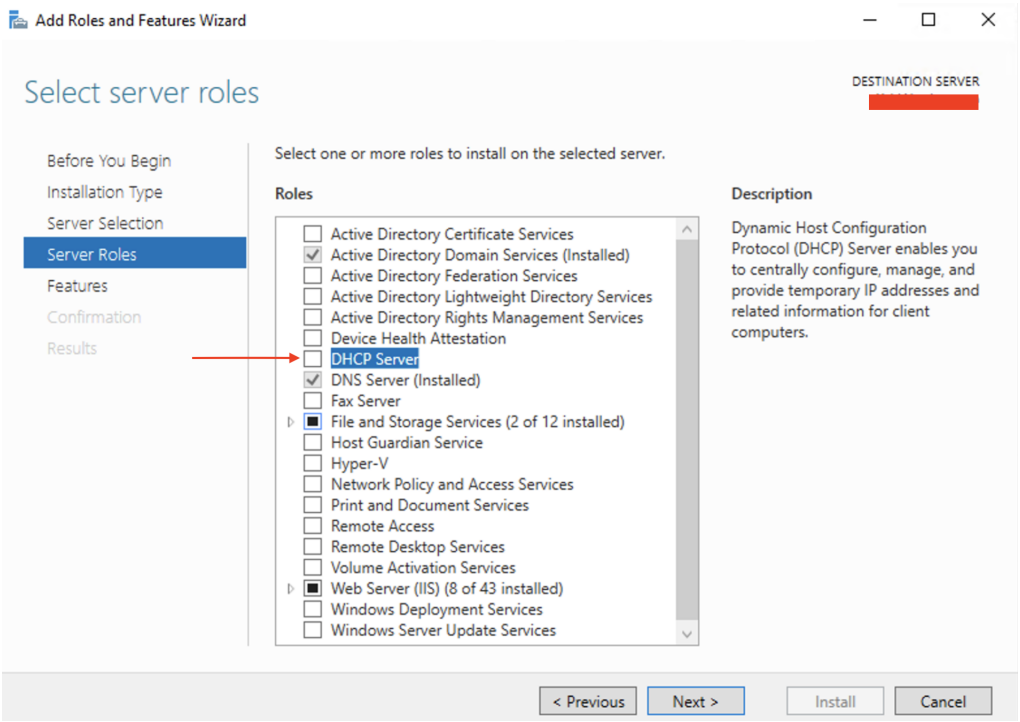


Figure 49: Select server roles

Features are required for the installation of DHCP shown in figure 50.

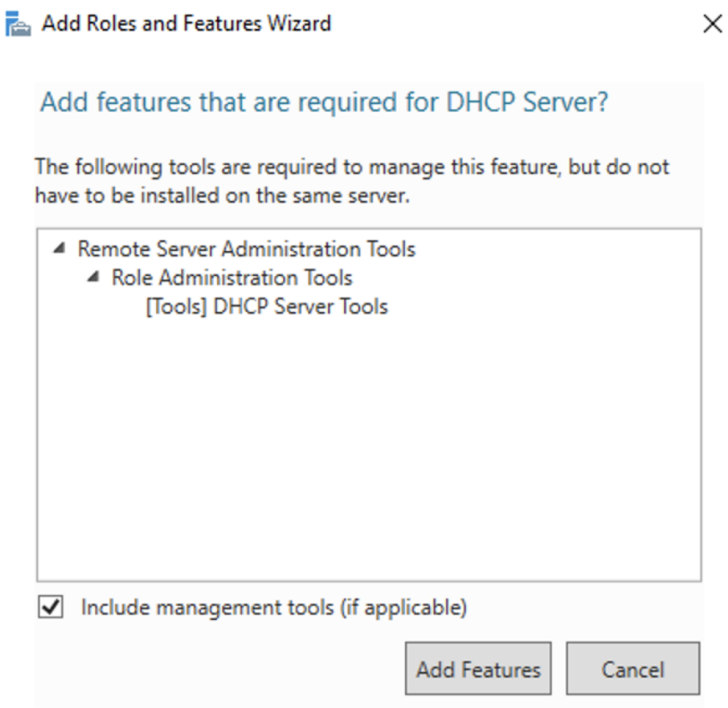


Figure 50: Features required to install DHCP

As displayed in figure 51, the option to restart the server automatically, if necessary, is selected. Here, paying particular attention to this process is essential to avoid conflicts with the current DHCP service on the old server. To avoid conflicts, this task must be carried out outside the standard working hours of the server's location.

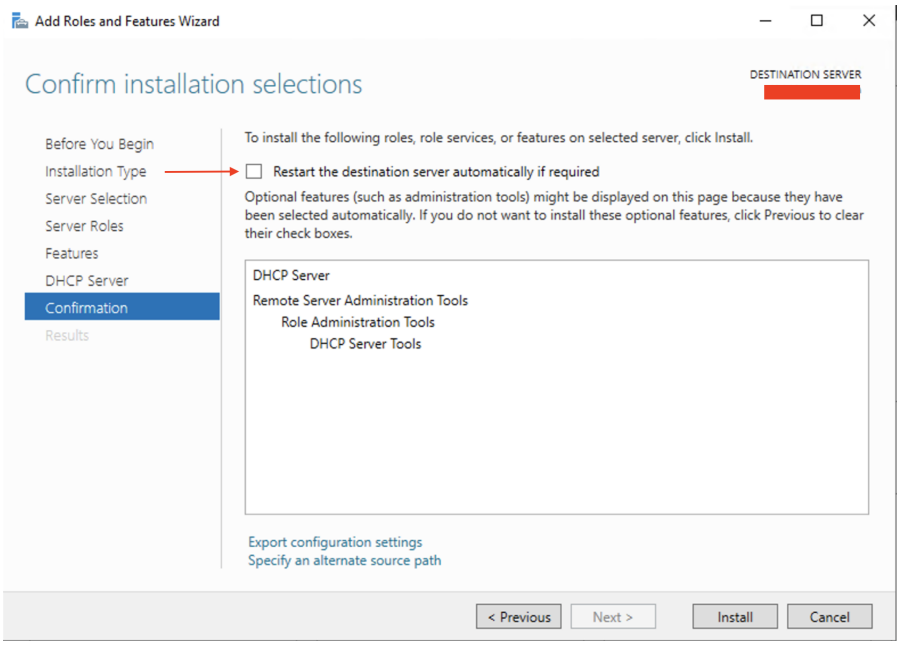


Figure 51: Installation confirmation

After the installation, the server will automatically restart as previously selected.

When the server restarts, a yellow triangle will be displayed in the top left corner on opening the Server Manager. A message will inform the need to complete the DHCP configuration by clicking on the triangle, as shown in figure 52.

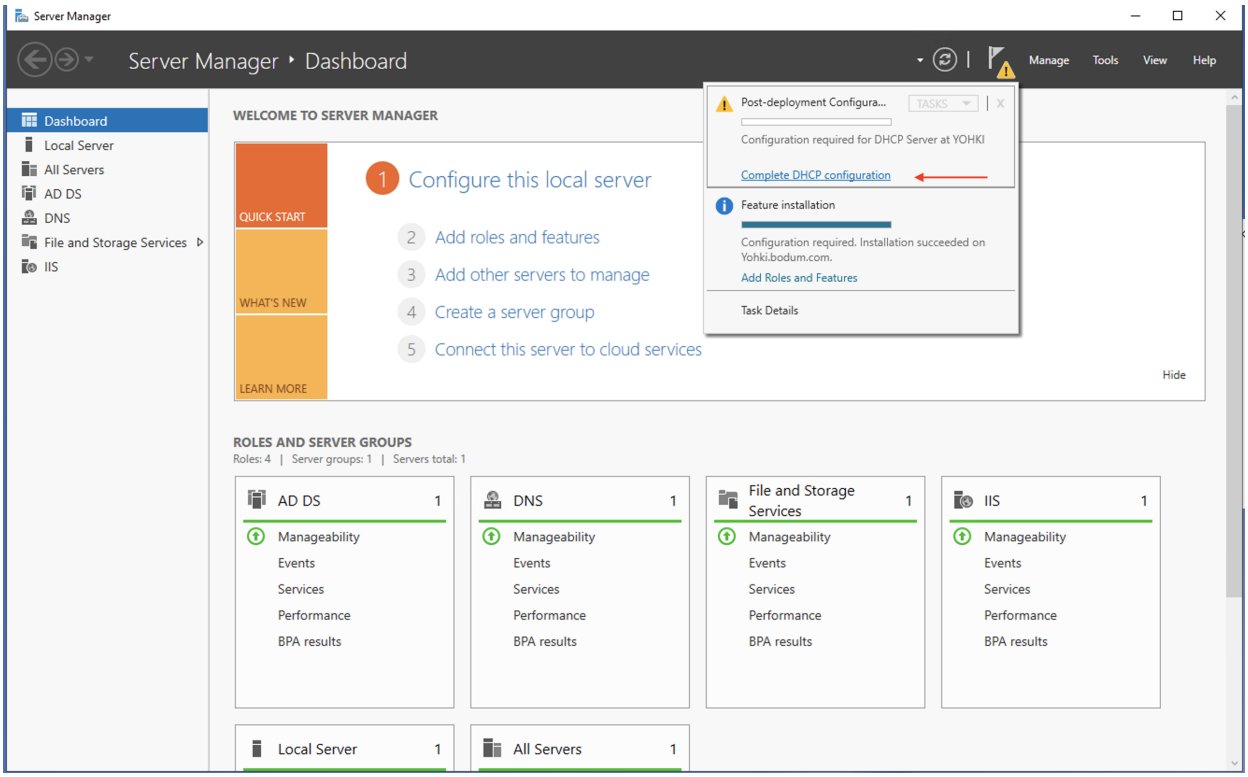


Figure 52: Complete the installation configuration

Next, it is necessary to indicate credentials to authorize DHCP in AD DS, as shown in figure 53.

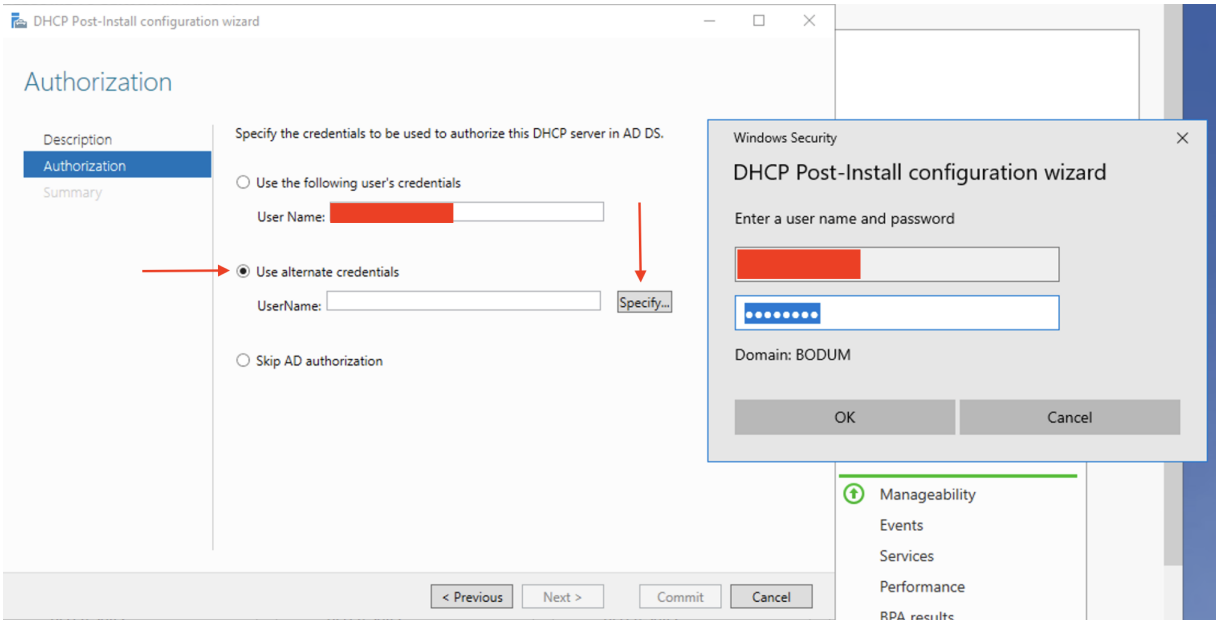


Figure 53: Add Roles to the server

After the DHCP Service is installed and authorized by the AD DS, it must be configured to replicate the old server. The old server will be accessed, and the DHCP configuration will be exported so it can be imported to the new server, as described below.

First, the DHCP configuration on the old server is exported, as shown in figure 54, using cmd with the script "netsh dhcp server export C:\dhcp.txt all". This script will create a text file called dhcp in directory C: with the DHCP service configuration.

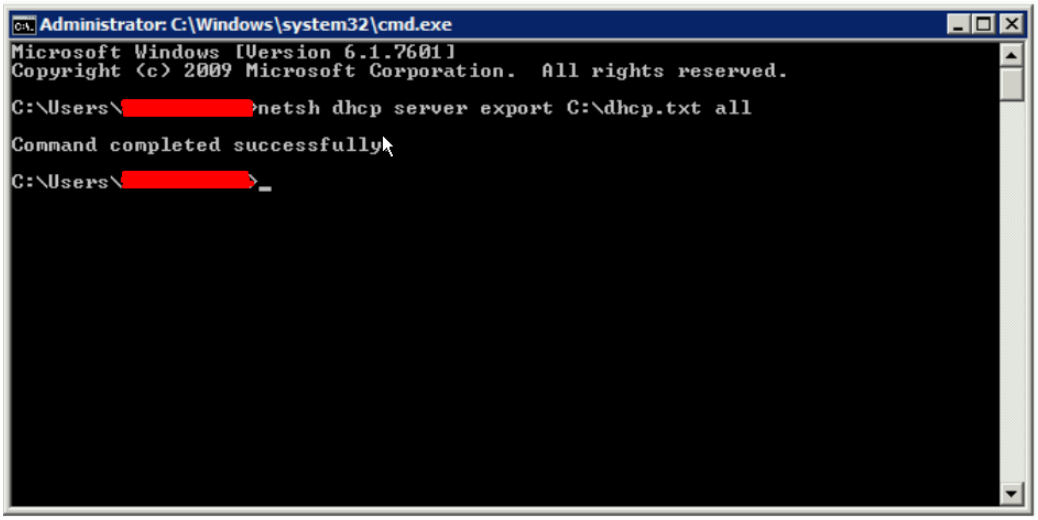


Figure 54: Export DHCP configuration file

Now that we have the DHCP configuration file, it needs to be imported to the new server. However, before importing it, the DHCP service on the old server should be stopped to avoid conflicts. Figure 55 shows how the DHCP service from the old server was stopped.

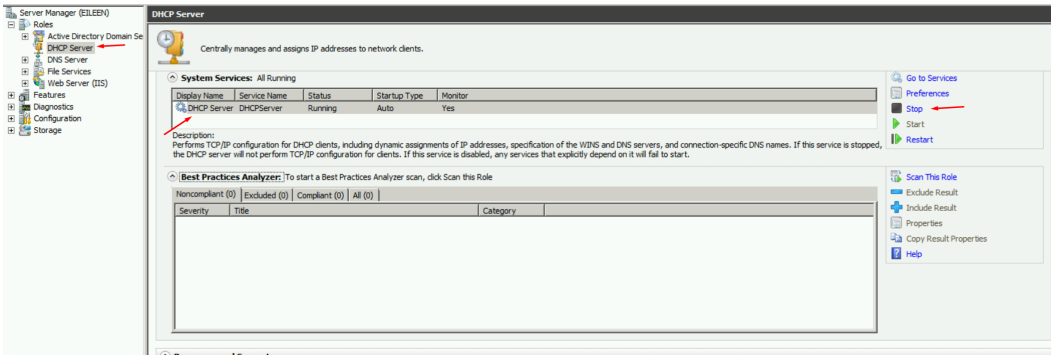


Figure 55: Stop DHCP service

After the DHCP service in the old server stops, the DHCP mentioned above configuration file will be imported, as shown in figure 56. In short, the file previously exported from the old server will be copied and imported to the new server. After the file has been copied to the new server to location c:, it will be imported through cmd by the script ”netsh dhcp server import c:\dhcp.txt all" If any change to the name or location of the file is needed, the script must be changed to be able to carry out the import.

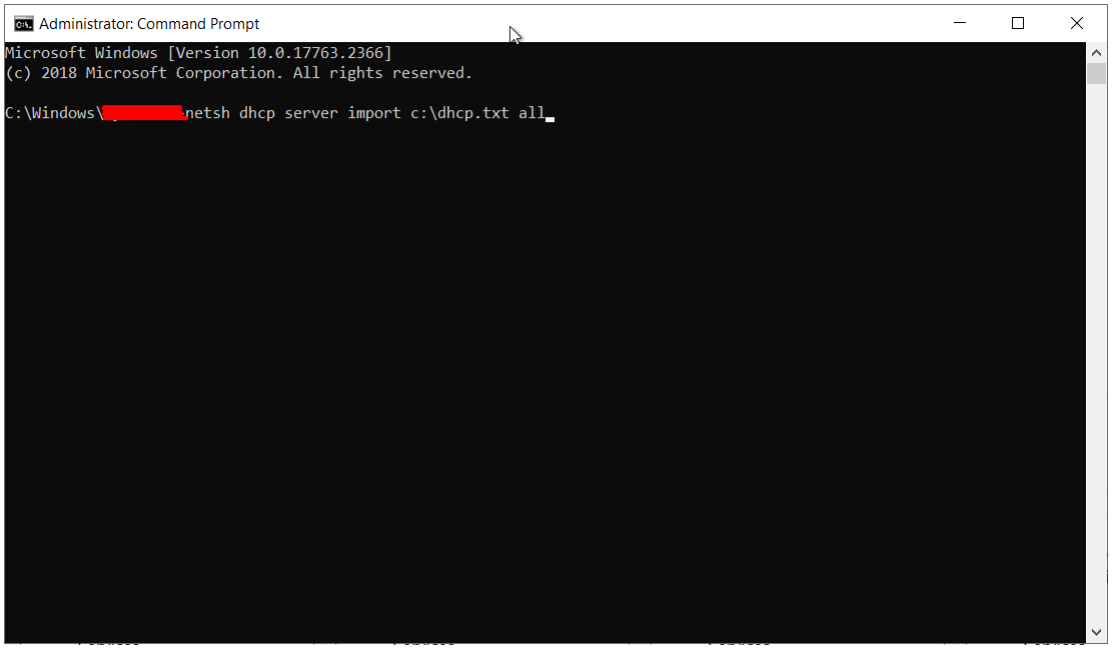


Figure 56: Import DHCP service

4.3.5 Select Server Features

At this step, the features that will be installed on the server are chosen. Only the SMB 1.0/CIFS File Sharing Support feature will be installed for this specific case, as shown in figure 57. This service is mandatory since all servers' backups are sent to Switzerland's storage that communicates through this SMB 1.0/CIFS protocol. Although the servers are being replaced, the remaining equipment stands, making it mandatory to install this protocol on all new servers.

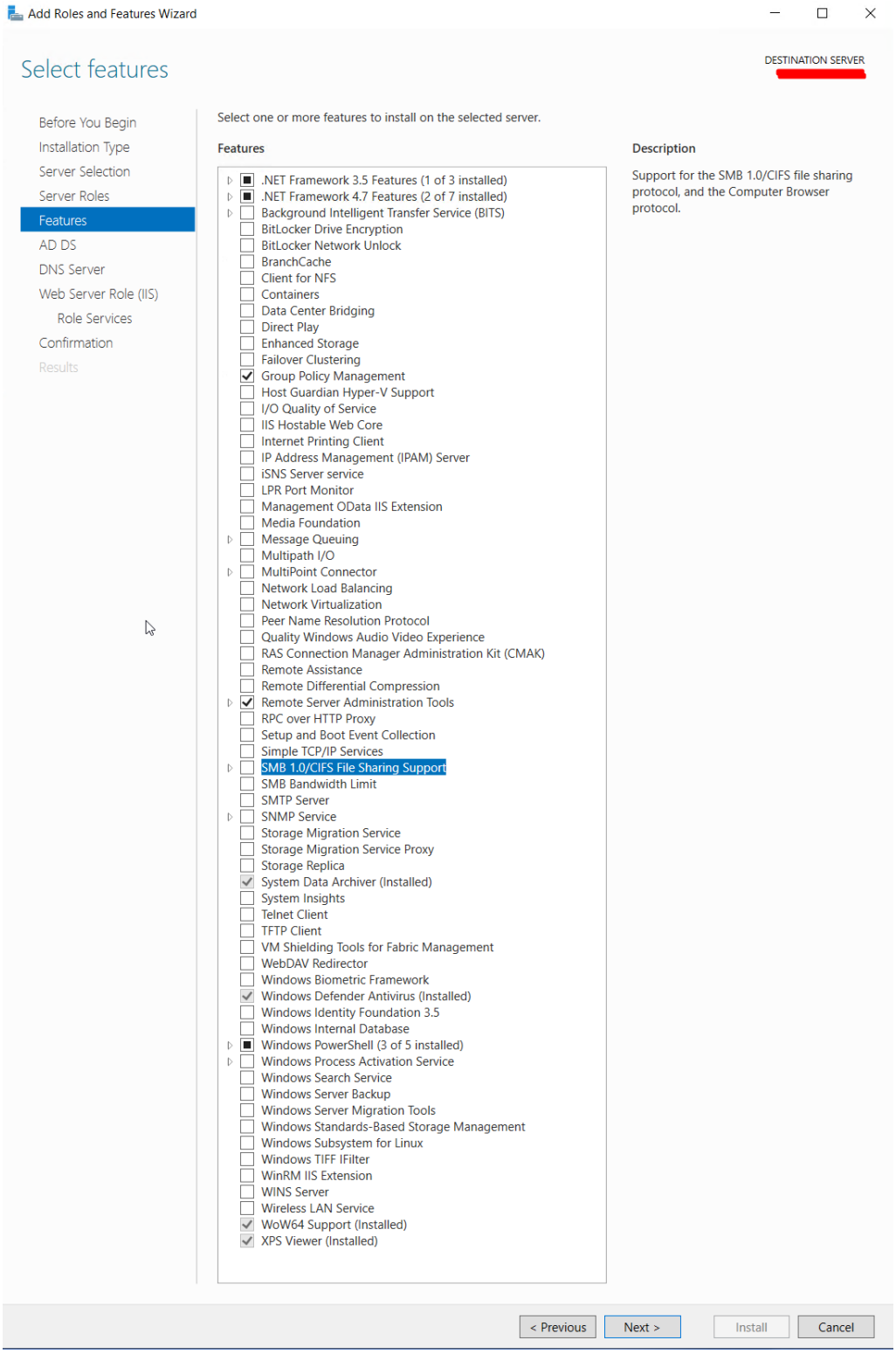


Figure 57: Features to install on the server

This step will briefly describe each role previously selected to be installed on the server. Figure 58 is the Active Directory Services, figure 59 is the Domain Name System, and figure 60 is the Web Server Role.

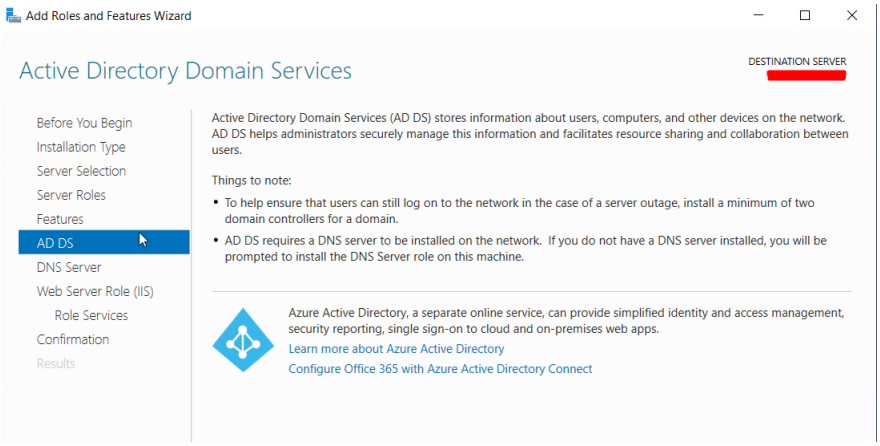


Figure 58: Brief description of Active Directory Domain Services

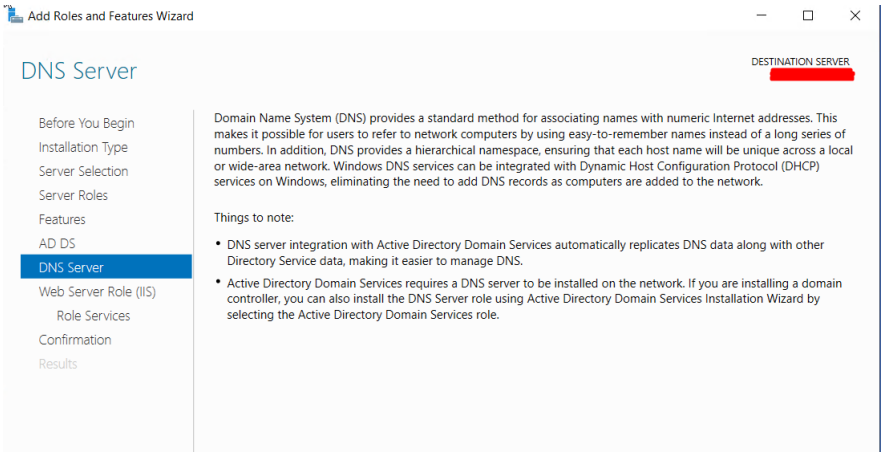


Figure 59: Brief description of Domain Name System

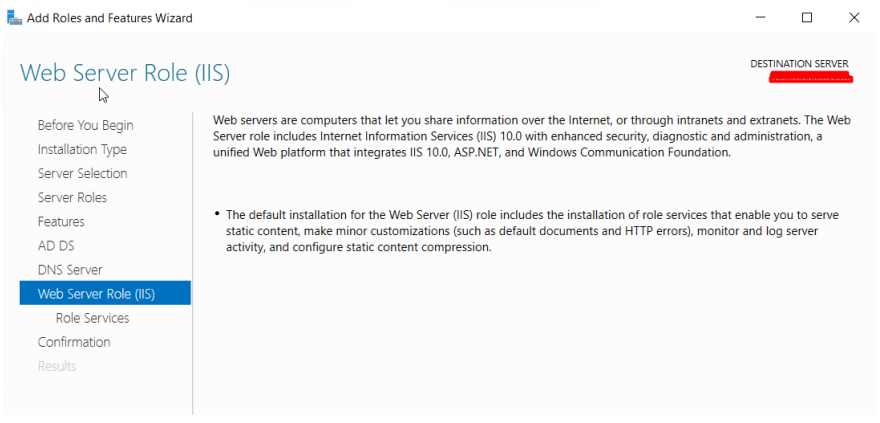


Figure 60: Brief description of Web Server Role

Default roles will be installed, as shown in figure 61.

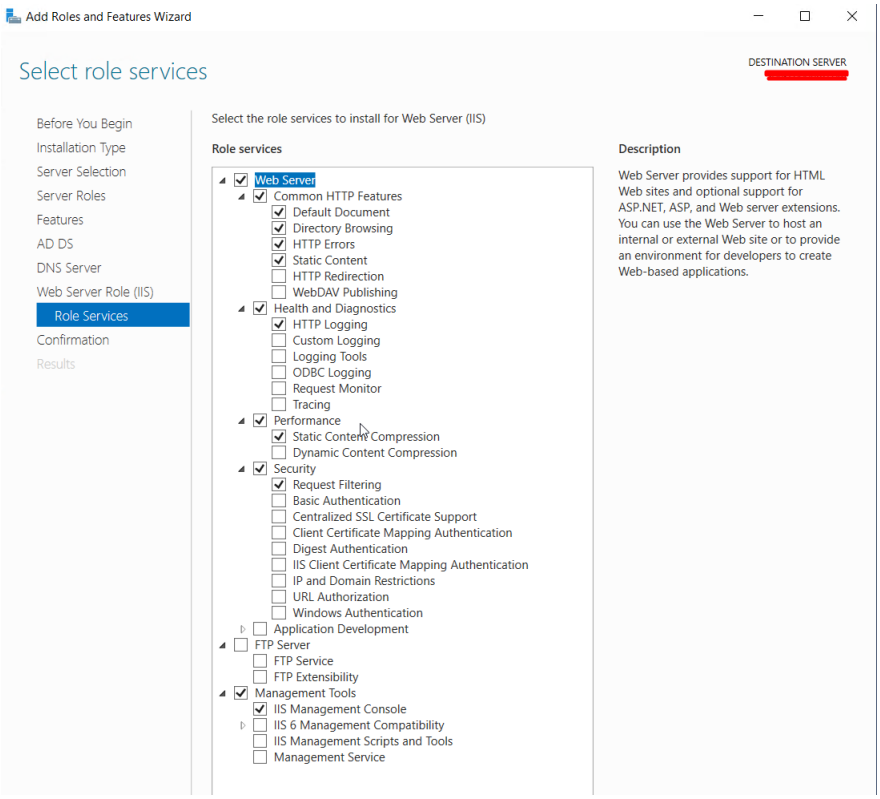


Figure 61: Select role services to install Web Server

Figure 62 shows all the information regarding installing the selected roles, role services, and server features. In this step, confirmation of the chosen installations and the respective installation is made.

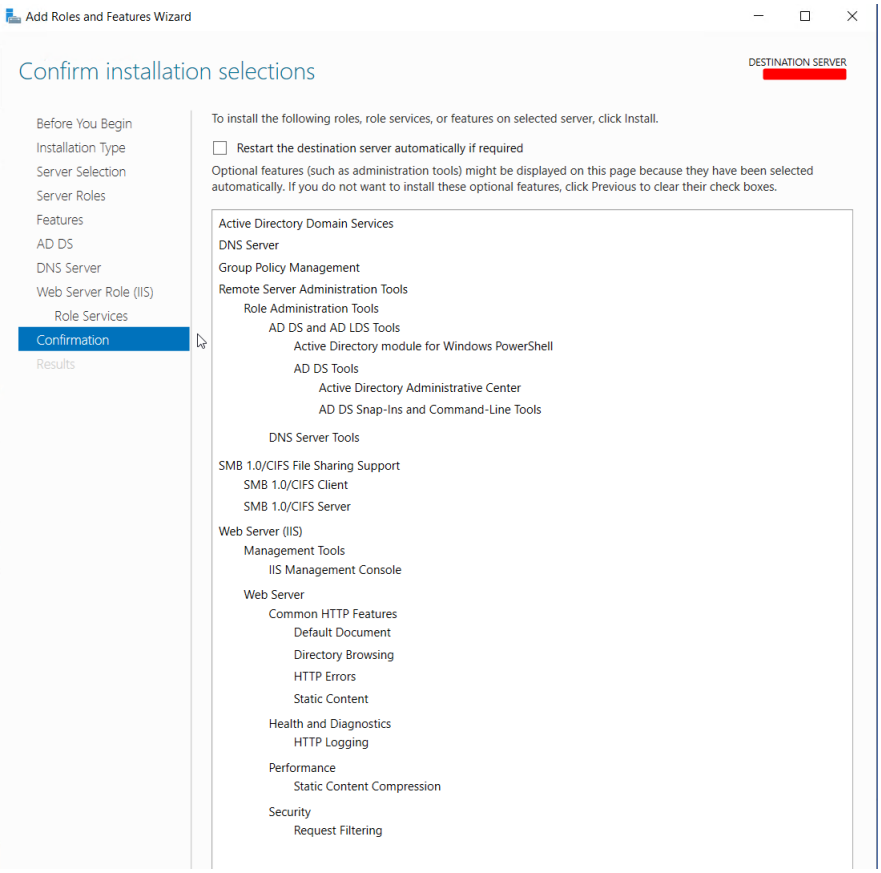


Figure 62: Confirm installation selections

4.3.6 Promote the Server to a Domain Controller

After the previously selected services are installed, it will be necessary to promote the server to a Domain Controller (DC), as described below. When opening the server manager, a yellow triangle will appear with an alert message in the top right corner next to the flag icon, like the one in figure 63.

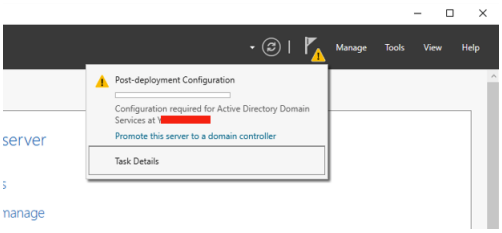


Figure 63: Promote the server to a Domain Controller

Following this warning message, a configuration window is shown to promote the server to DC, as shown in figure 64. The DC deployment method will be chosen and added to a domain in this step. In this case, the Bodum domain and the respective domain credentials are requested to perform this operation. As already mentioned, some of this information will not be shown due to confidentiality.

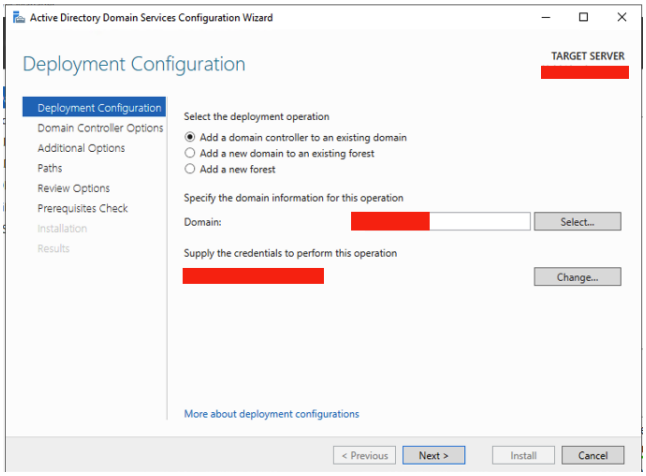


Figure 64: Deployment configuration

As shown in figure 65, it is necessary to define the site where the server is and a Directory Services Restore Mode (DSRM) password in case something goes wrong and a reset is necessary. In this case, the server belongs to the Tokyo site.

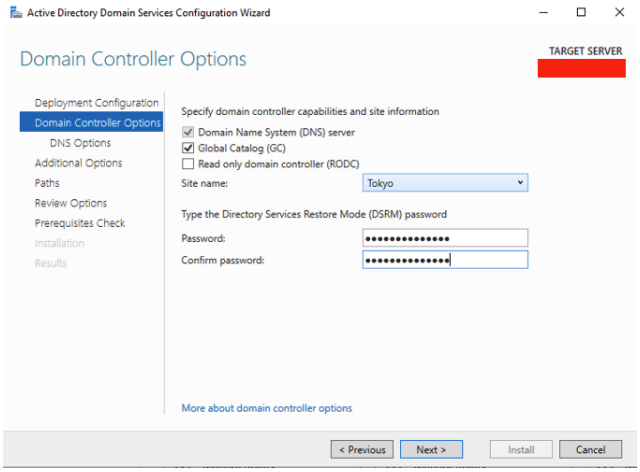


Figure 65: Domain controller Options

In this stage, the server from which the configurations will be replicated will be shown, in this case, the primary domain controller of Bodum. Information in figure 66 regarding the primary domain controller is not possible to reveal.

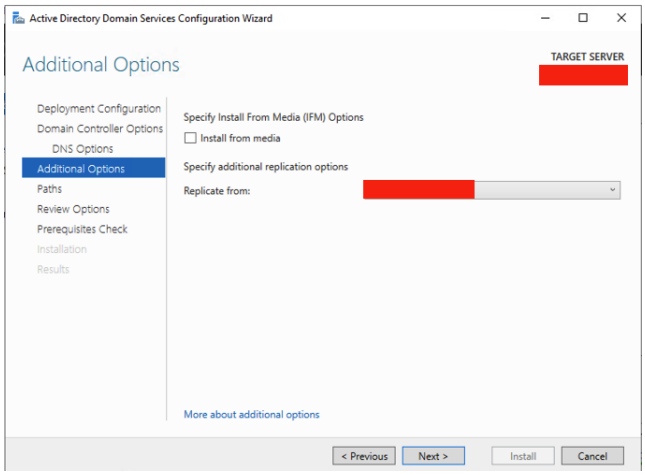


Figure 66: Additional options

Next, the path to the ADDS database will be defined. The data location will be defined by default in this case and on the other servers. See figure 67.

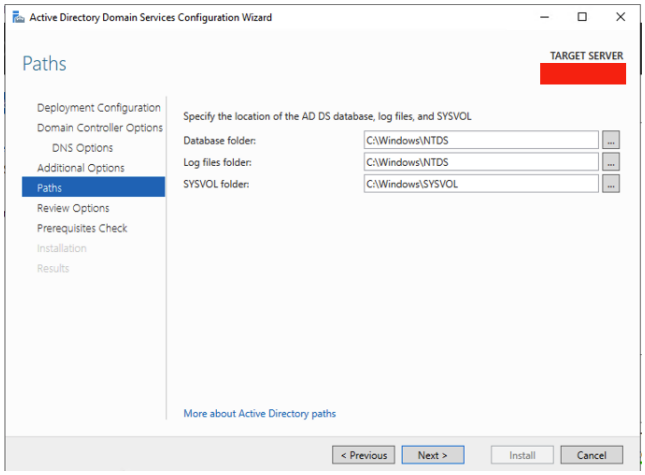


Figure 67: Paths for the location of the AD DS database

At this point, all installation prerequisites will be verified as per figure 68. After confirming that everything is as expected, the installation will go ahead.

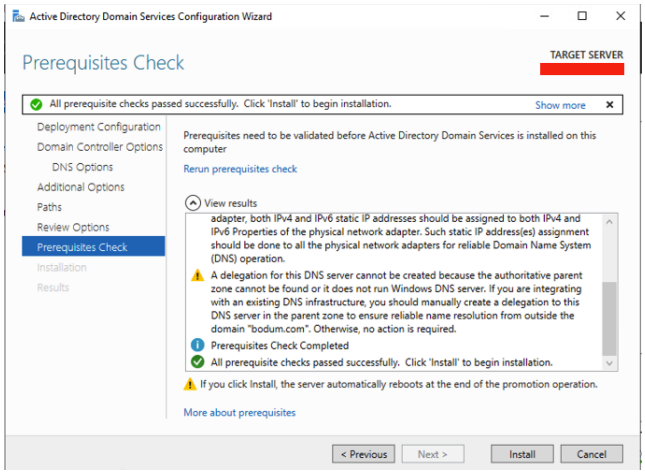


Figure 68: Prerequisites checks

4.3.7 Copying Data from the Legacy Server to the New Server

To copy the data from the old servers to the new ones, the tool used was the script robocopy. This script is a replication command for Windows that replicates files. The process will be carried out through the Windows command prompt (CMD) with admin privileges.

As shown in figure 69, the script used is "ROBOCOPY "\\source server\source folder" "\\destination server\destination folder" /MIR /SEC /LOG:c:\logs\filename log.txt" where \MIR means that it will replicate the data and security/access of the files, the \SEC refers to files that have some changes. This way, the data will be copied along with the respective accesses of each user and access group, thus avoiding the need to manually assign accesses after copying the data to the new server, /LOG:c:\logs\filename.txt This log file is generated with status information of copying files.

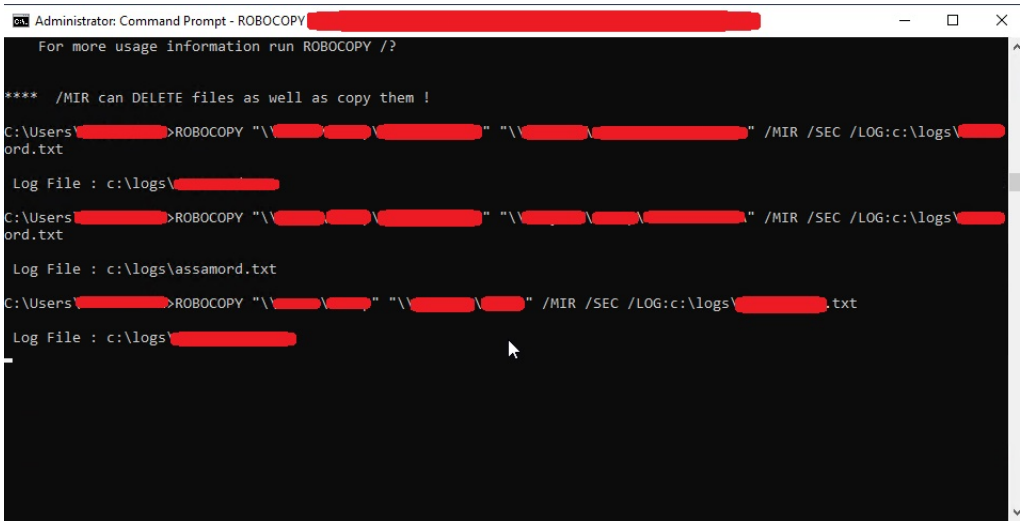


Figure 69: Copying data to the new server

Figure 70 shows the result of copying one of the folders copied by the script above. This process is repeated as often as necessary until all the required information is copied

to the new servers.

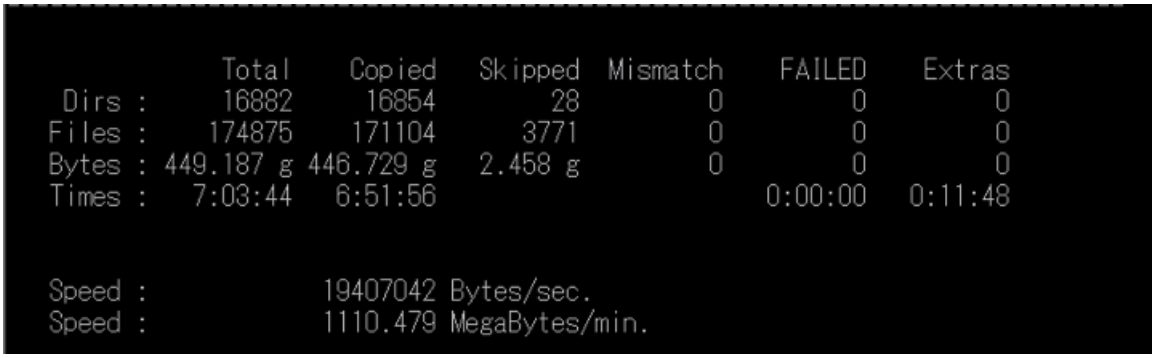


Figure 70: Summary of the copy

Since part of this project consisted of the migration of six servers, the main actions described in this chapter (Migration Process) were repeated six times, once for each server, and everything went smoothly, although it took some time to perform the migrations of all the servers everything went as expected. All the new servers are now online running all the necessary services with the data that was imported from the old servers without any loss of information. So we can say that the migration to the new servers was a success.

Chapter 5

Migration to the Cloud

This chapter proposes a possible solution for the future migration of the Bodum Servers to the cloud, aiming to improve the company's system and reduce operational costs. The creation and configuration of all the necessary components to simulate the migration scenario on AWS will be described as a step-by-step tutorial. To carry out this simulation without monetary cost to the author, this project was submitted to a draw for a credit of 300$ carried out by AWS. This credit was given to the author for simulating on AWS.

Subsequently, meetings were scheduled with AWS experts. In the first phase, the author explained the project's objectives, both from a work and an academic perspective. In the second phase, the AWS experts helped to draw up a plan to carry out a concise simulation of the proposed improvement on AWS, figure 71 represents that plan. The emails exchanged with AWS support, specifically with Olena Polishchuk, contributed to the simulation plan described in this chapter, are in appendix A.

This plan consists of migrating all the existing services running on current servers (AD DC, DNS, DHCP, IIS) through IaaS. Two instances will be created with the minimum processor and RAM requirements with the aim of being the cheapest possible solution. The storage will not be touched since data is critical and must remain locally according to the company's policies. The services used in this simulation are VPC, Subnets, Internet gateway, route table, and EC2 instance, as detailed below.

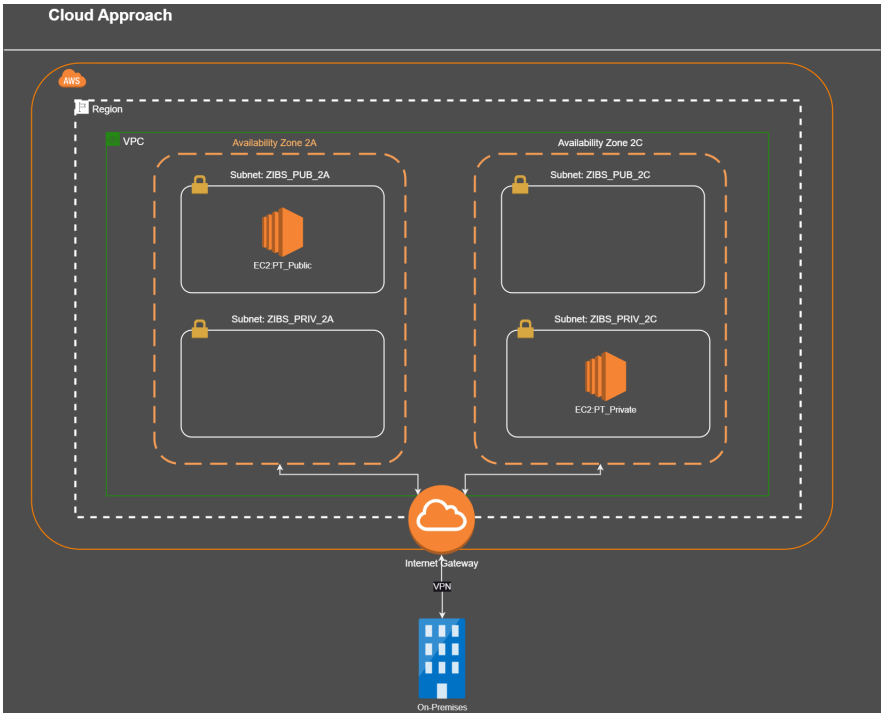


Figure 71: Cloud Approach

A VPC will be created with two availability zones; in each of them, two sub-nets will be created, one public and one private for each sub-net. Two EC2 instances will be created, one for each availability zone. One will be allocated to availability zone 2A in a public subnet and the other to Availability zone 2C in a private subnet. To simulate the current scenario that the company has on-premises. Even in different sites with different subnets, it is possible to communicate between them and between users. As you can see in figure 71, communication between on-premises and the cloud will be done via VPN.

5.1 Create a VPC

First, log in to the AWS console. Then, as shown in figure 72, go to the menu "Service", then "Networking & Content Delivery" and select "VPC". Next, a VPC dashboard will be shown, as shown in 73, and on the left-hand side menu, go to "Your VPCs" and then "Create VPC" figure 74

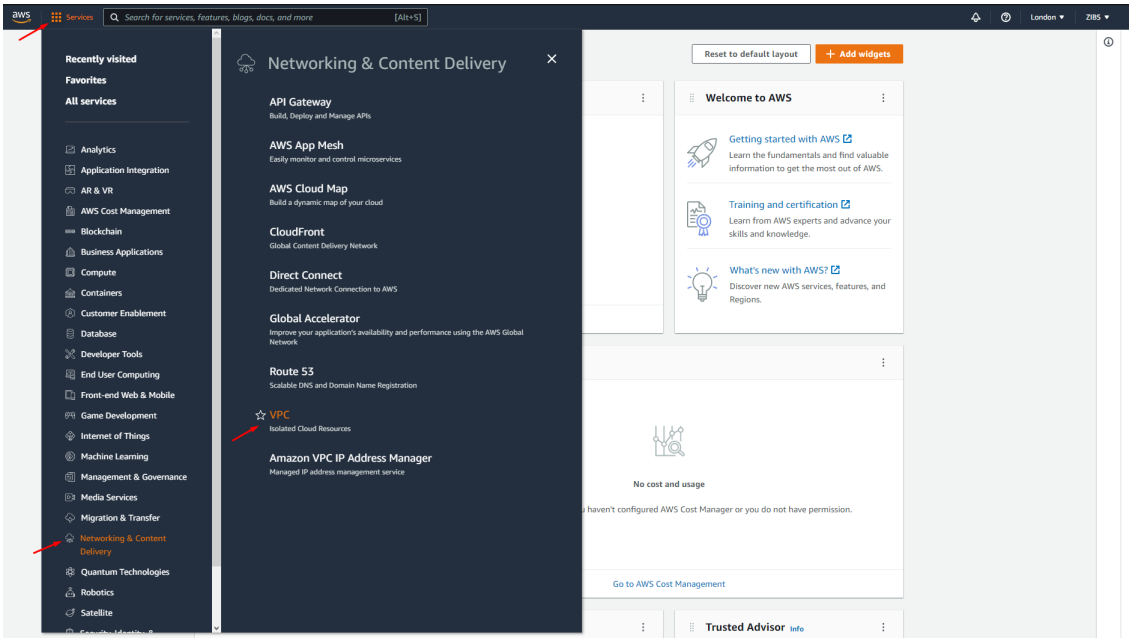


Figure 72: Open VPC Set up

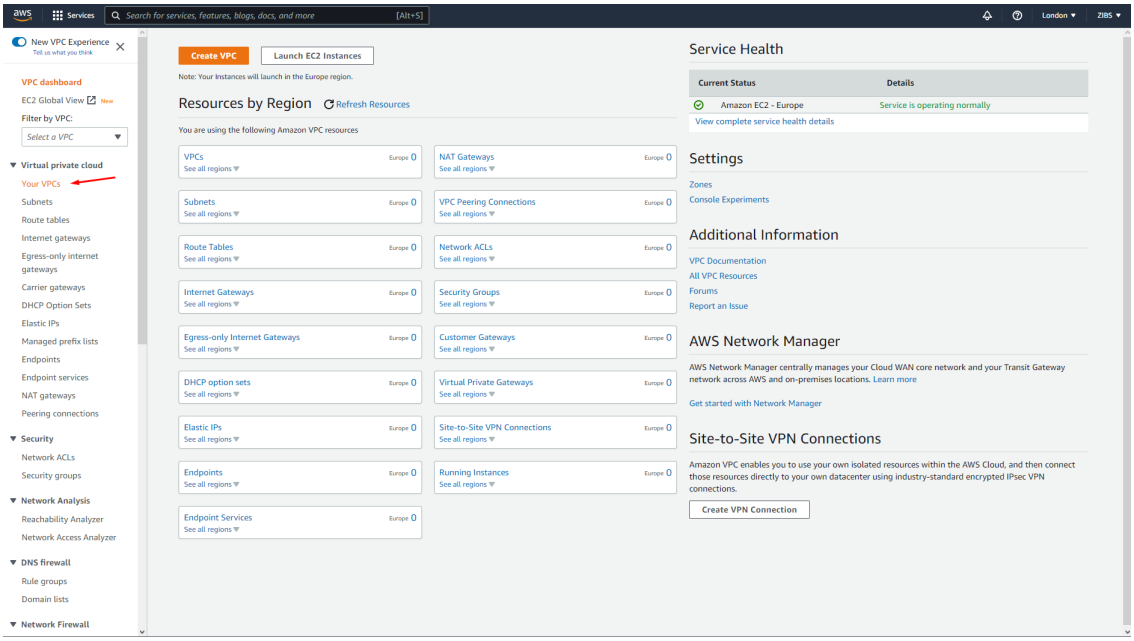


Figure 73: Your VPC

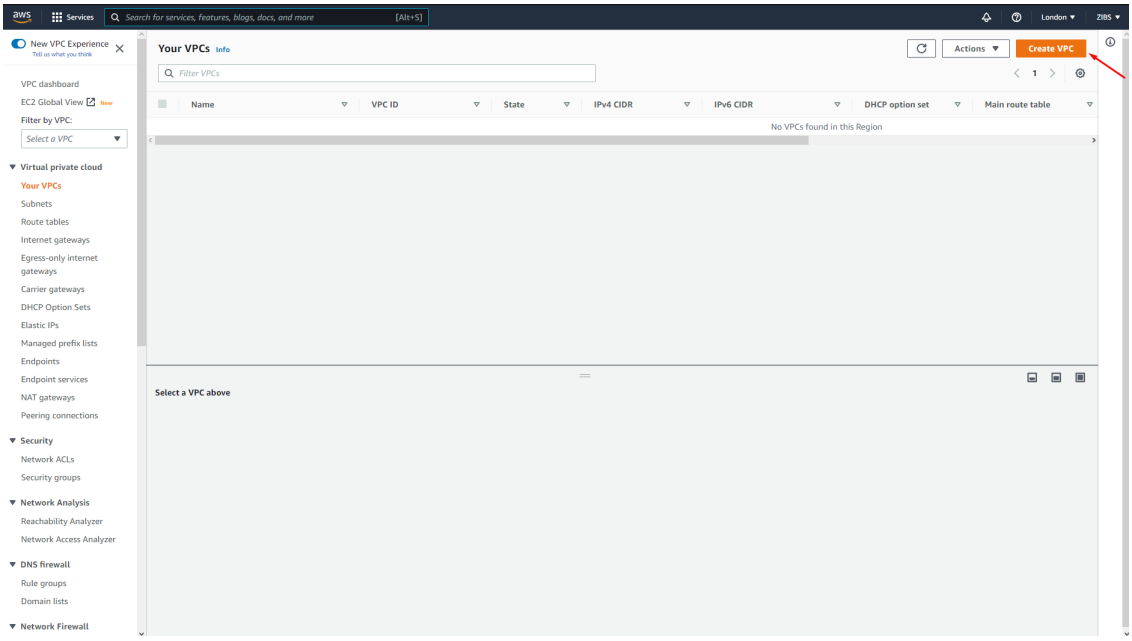


Figure 74: Create VPC

To create a VPC, it is necessary to fully fill in the form shown in figure 75 with the desired settings. In this specific case, the VPC will be called ZIBS, and the IPv4 CIDR will be 10.0.0.0/16. It is also possible to assign IPv6, but it will not be relevant for this specific case. The Tenancy field will be set to “default” as the “dedicated” option is only used if dedicated network hardware is required, a choice that requires special attention as it has high costs.

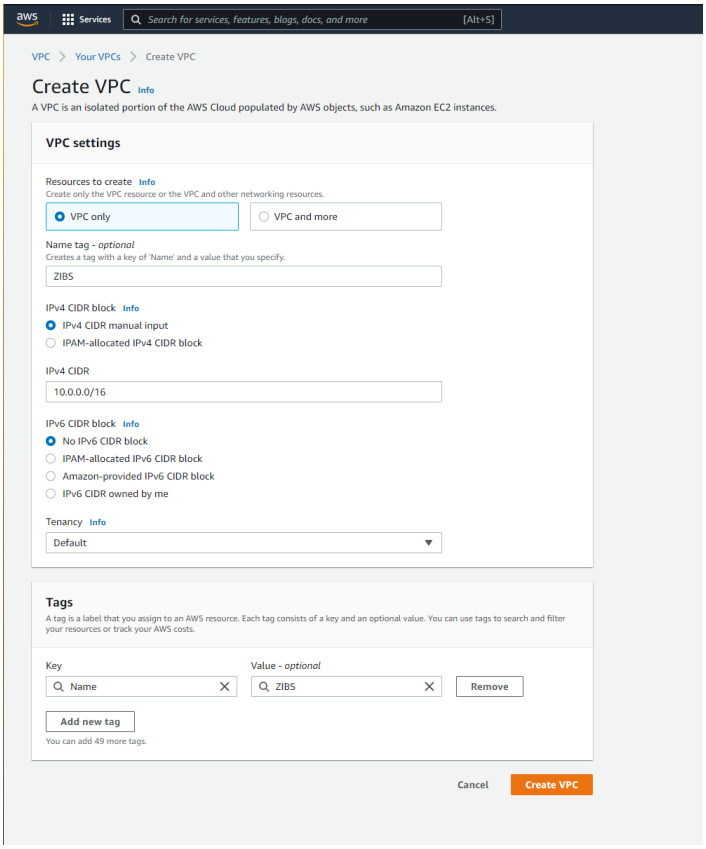


Figure 75: Create VPC

As figure 76 shows, the VPC is now created.

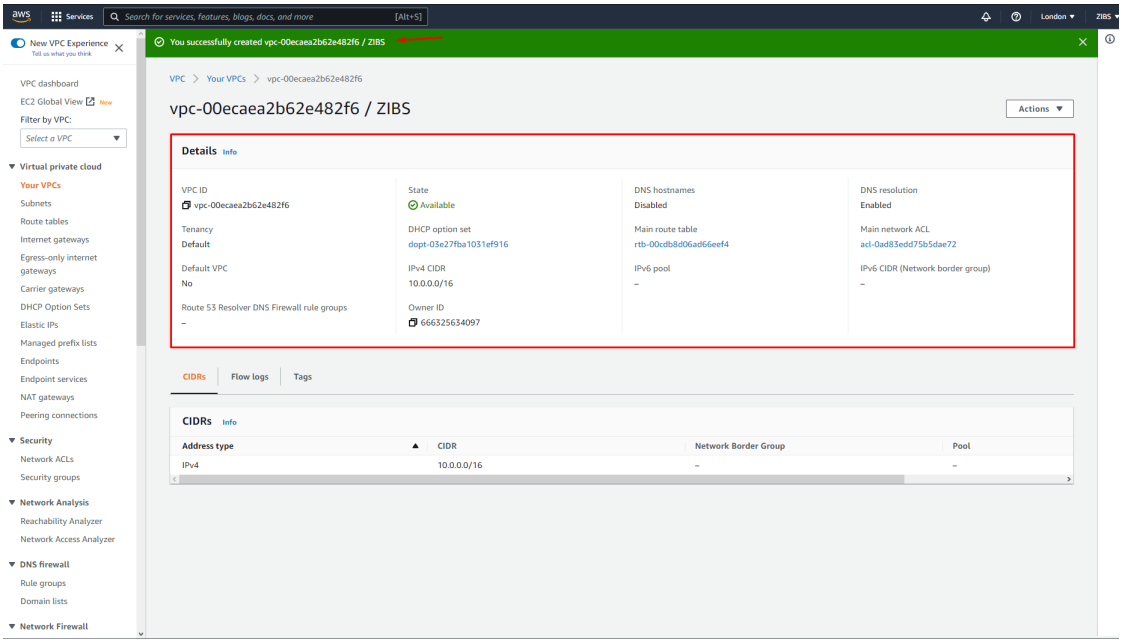


Figure 76: Create VPC

5.2 Create Subnets

As shown in figures 77 and 78, it is necessary to go to the menu "Subnets" and then "Create Subnet".

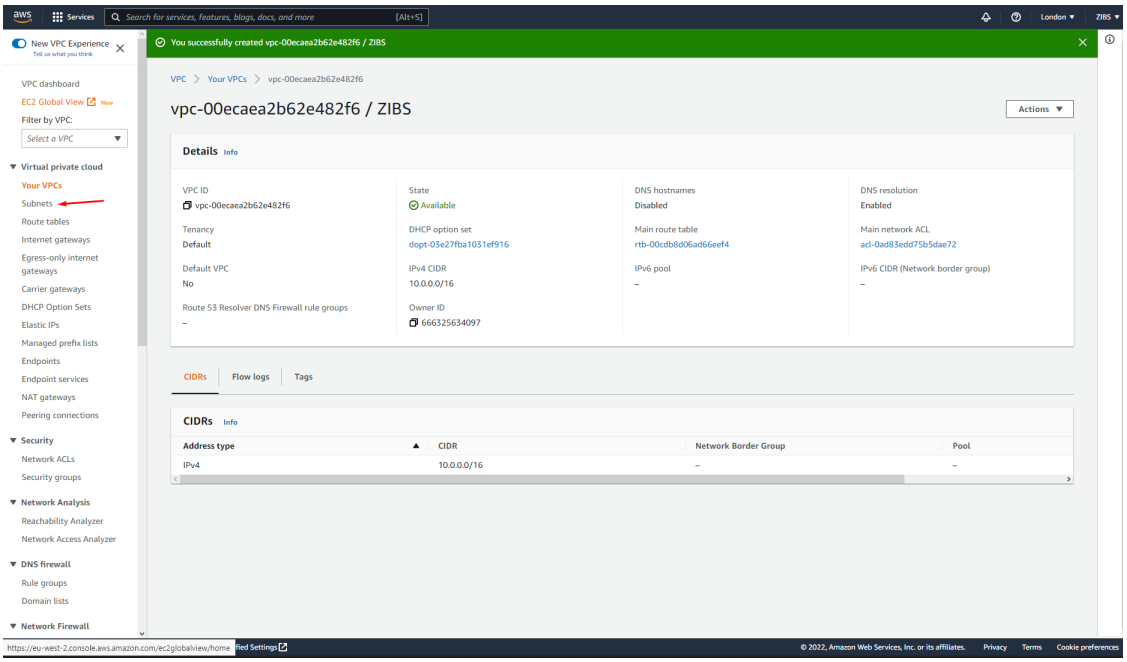


Figure 77: Menu Subnets

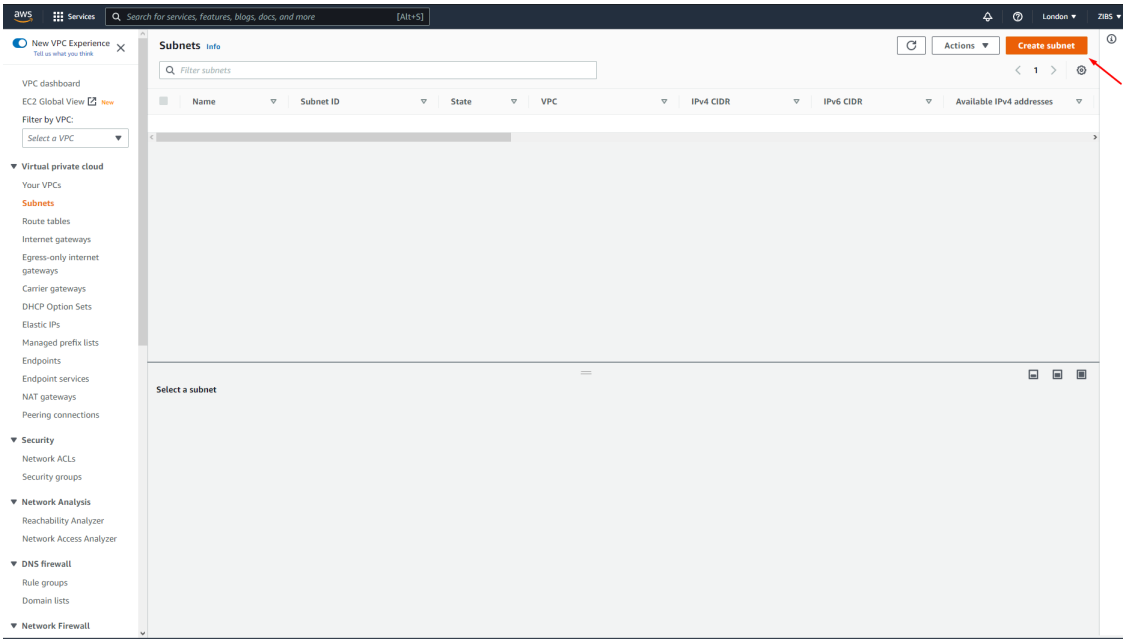


Figure 78: Create Subnet

As shown in figure 79, the first Subnet will now be configured. To be easy to identify where the Subnet belongs, the name ZIBS_PUB_2A was assigned, that is, the name of

the VPC plus "PUB" of public communication and the 2A from the Availability Zone to which it belongs, the IPv4 CIDR will be 10.0.1.0/24, and the Availability Zone will be EU-west-2a. If the form in figure 79 is carefully analyzed, it is possible to see that the ending of the Subnet name is the same as the ending of the Availability Zone name. It is not by chance but to facilitate identifying where each Subnet belongs.

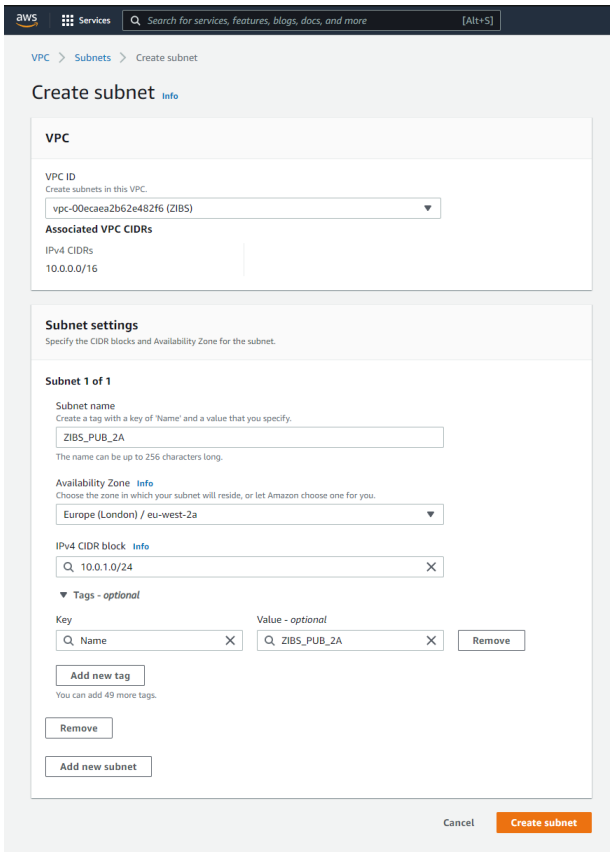


Figure 79: Configure Subnet

Now three more Subnets will be created; one will be ZIBS_PRIV_2A with IPv4 CIDR 10.0.2.0/24, another Subnet ZIBS_PUB_2C with IPv4 CIDR 10.0.30.0/24 and another Subnet ZIBS_PRIV_2C with IPv4 CIDR 10.0.31.0/24. In short, we have two Availability Zones with two Subnets in each of them, one private and the other public, as shown in detail in figure 80.

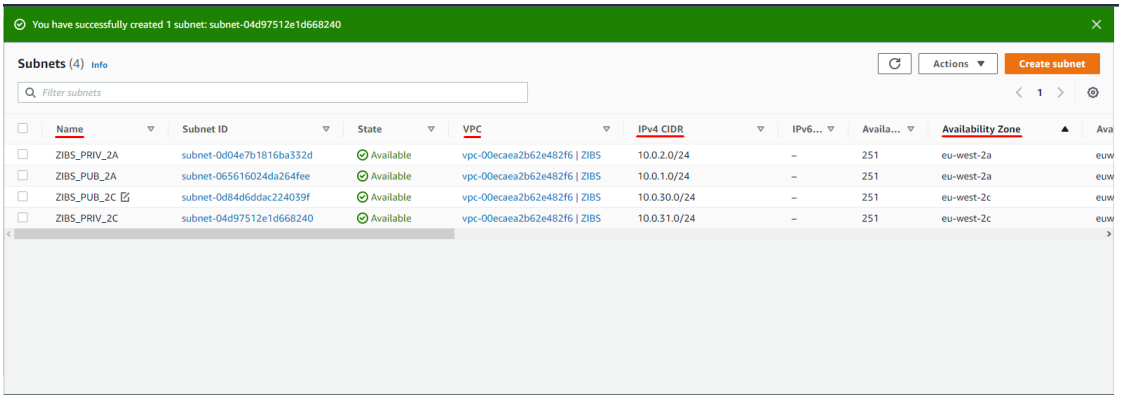


Figure 80: All Subnets

5.3 Internet Gateway

For the VPC to communicate on the internet, it is necessary to create an Internet Gateway. This process will be shown in figures 81 to 85. First, go to the "Internet Gateway" menu and then "Create Gateway", as shown in figure 81.

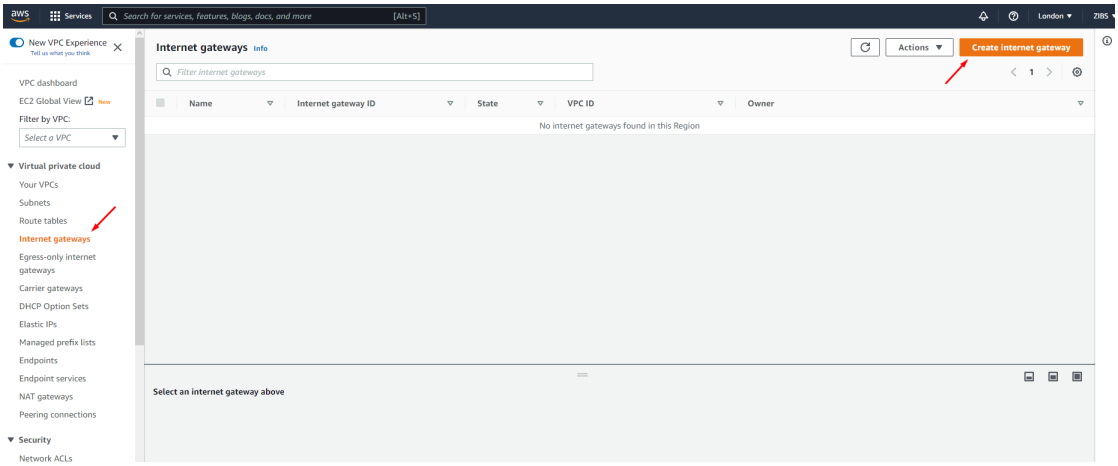


Figure 81: Create Internet Gateway

Now the Internet Gateway will be given a name, which in this case, was the same as the VPC, for the sake of consistency.

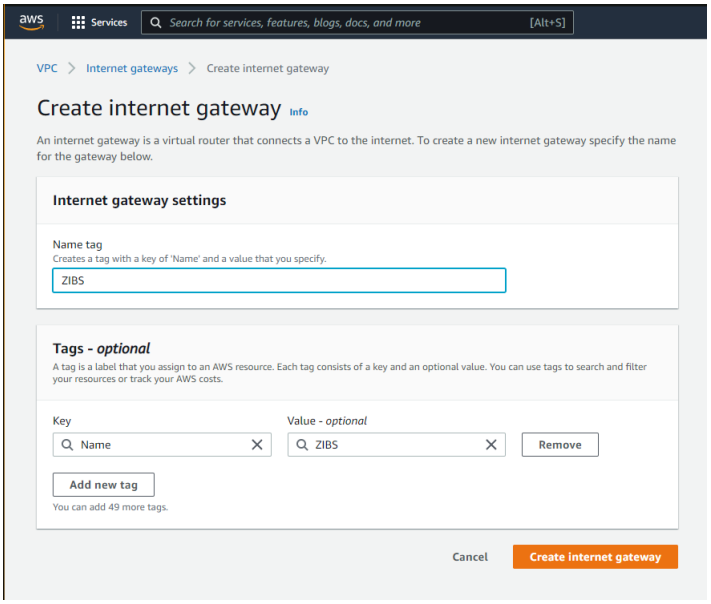


Figure 82: Setup the name of the Internet Gateway

The Internet Gateway has been created, but it is now necessary to attach it to the VPC created previously so that the VPC can communicate with the internet, as indicated by the alert message with a green background at the top of the figure 83. To do so, follow the "Attach to VPC" button as shown in figure 83.

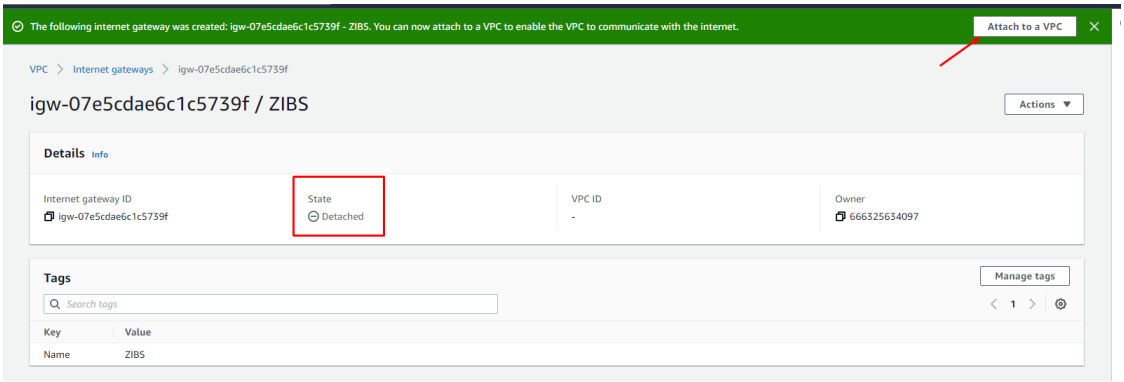


Figure 83: Attached the Internet Gateway to the VPC

Now select which VPC the Internet Gateway will be attached to. In this case, there is only one VPC, so the choice is obvious. When placing the cursor over the "Select VPC" field, a drop-down menu appears, as shown in figure 84.

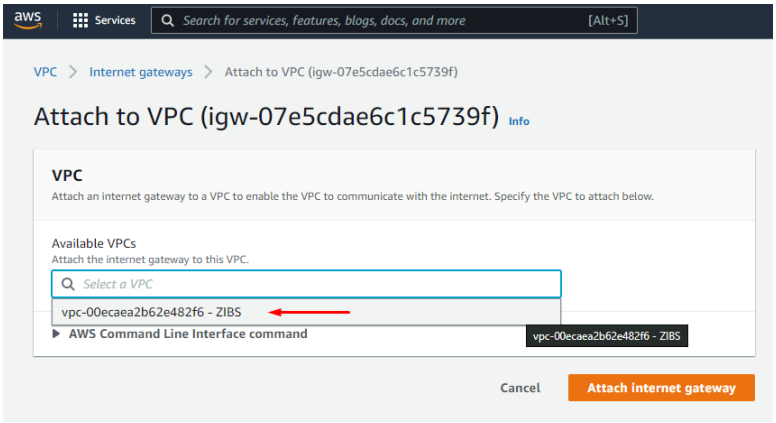


Figure 84: Select the VPC to attache Internet Gateway

From figure 85, it is possible to confirm that the Internet Gateway was created and is attached to the VPC.

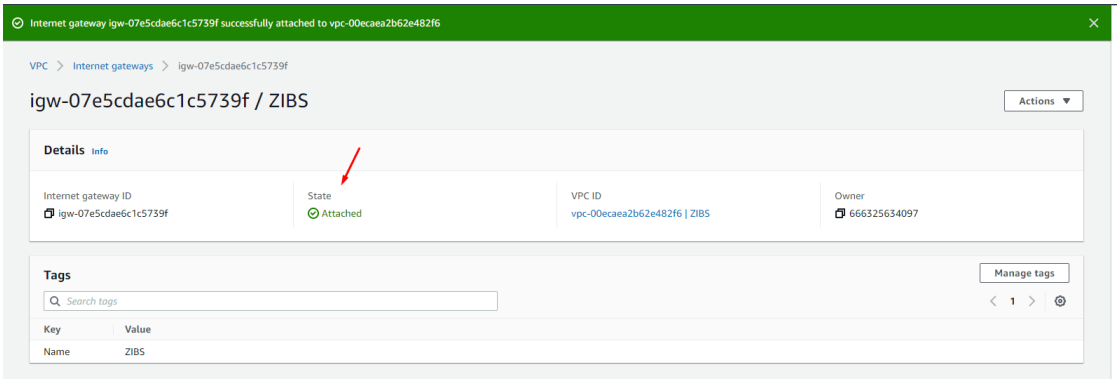


Figure 85: Confirm attachment

5.4 Route Tables

As shown in figure 86, there is already a Route Table created by default. It will not be used for this specific case because two new Route Tables will be created, one public and the other private, as shown in figures 87 and 88.

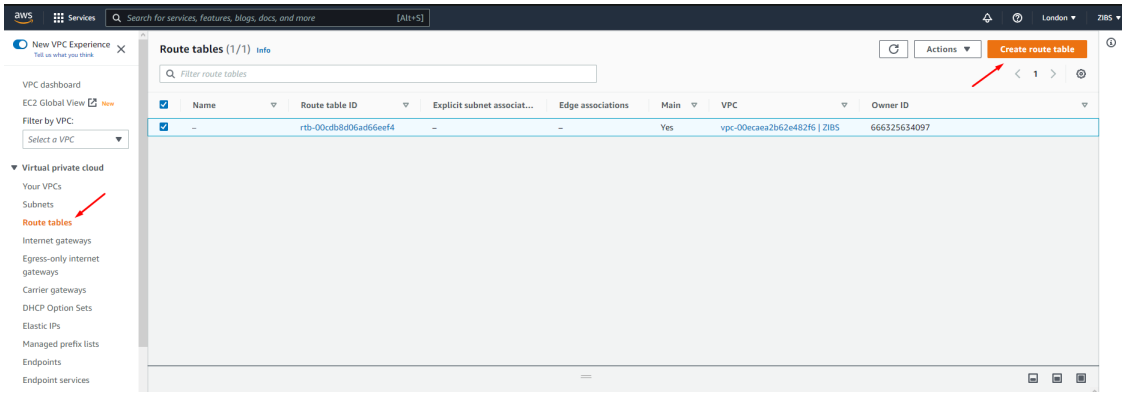


Figure 86: Create Route Table

Now it is necessary to define the name of the Route Table and associate it with the VPC. See figure 87 for the Public Route Table and figure 88 for the Private Route Table.

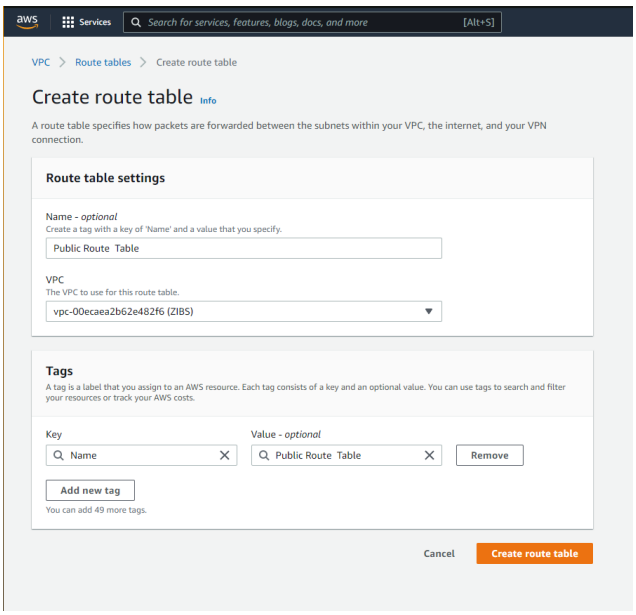


Figure 87: Public Route Table

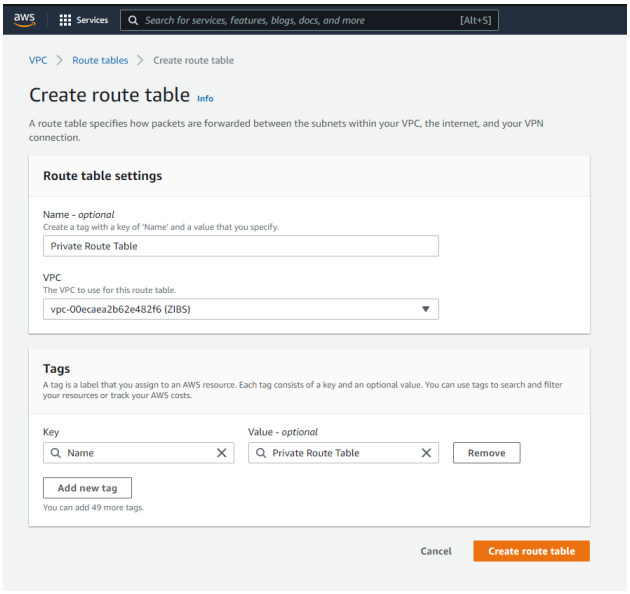


Figure 88: Private Route Table

By default, when the Route Table is created, the routes are always local. That is, communication is only local. For this case, it is necessary to edit the public route table, which, as the name implies, will allow public communication, as shown in figures 89 and 90.

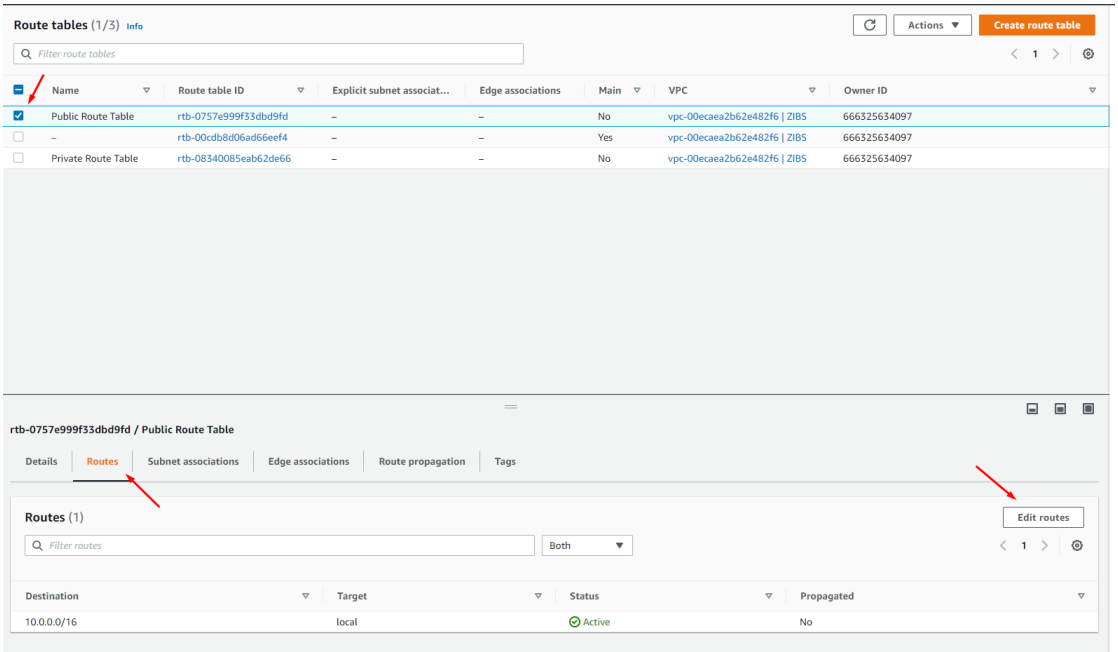


Figure 89: Public Route Table

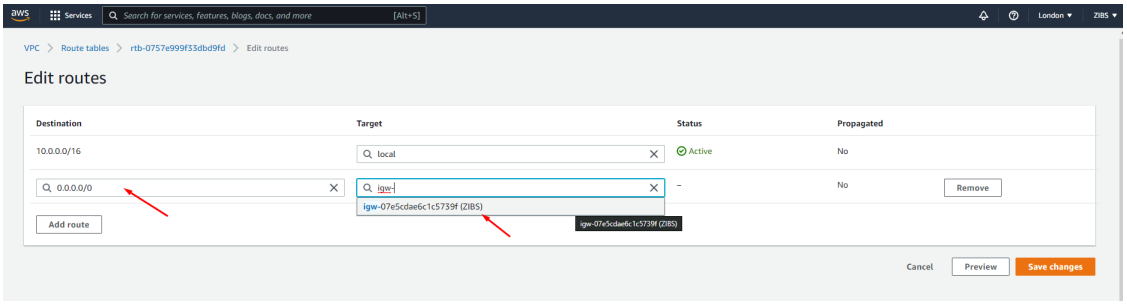


Figure 90: Edit Public Route Table

Figure 91 shows how a new route allows public communication by assigning a destination IP range. In this case, it will be 0.0.0.0/0, and the target will be the Internet Gateway for going to the outside world.

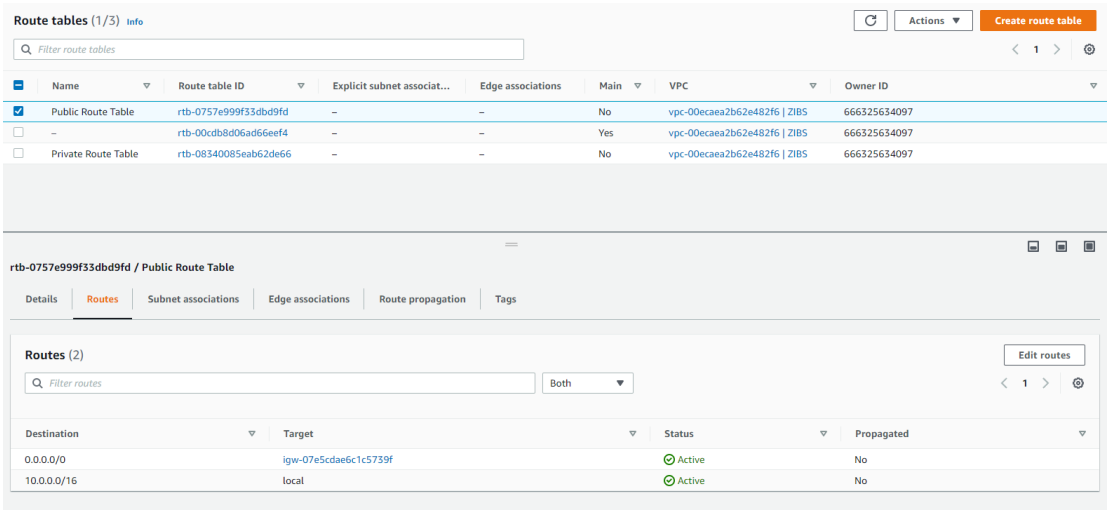


Figure 91: Private Route Table

Figure 92 is related to the Private Route Table. As we can see from the name, it is private, so the communication will always be local since there is no defined route to communicate with the outside world.

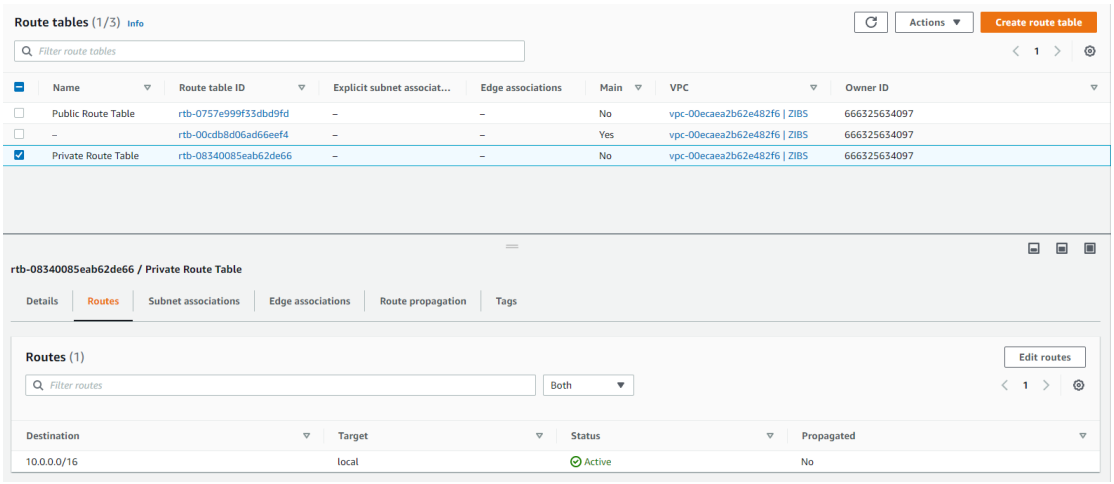


Figure 92: Private Route Table

Next, associate the subnets with the route tables created because the subnets are still associated with the default route table. This process is demonstrated by figures 93 and 94.

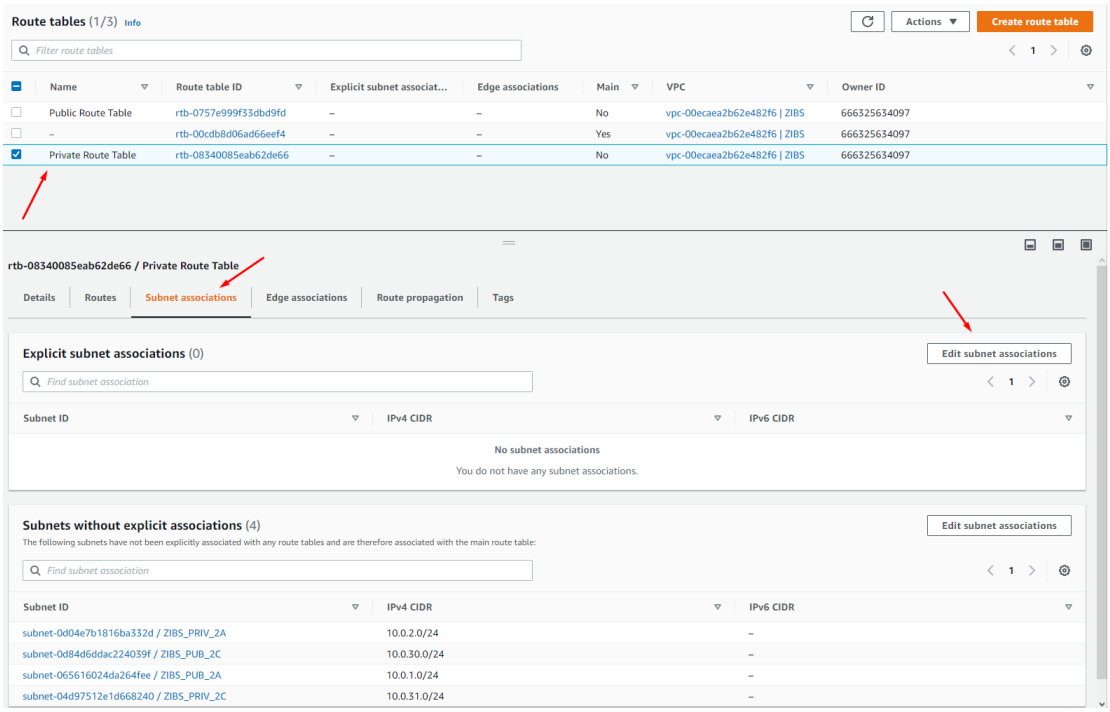


Figure 93: Subnet association

Since the selected route table is private, it will be associated with the private subnets, as shown in figure 94.

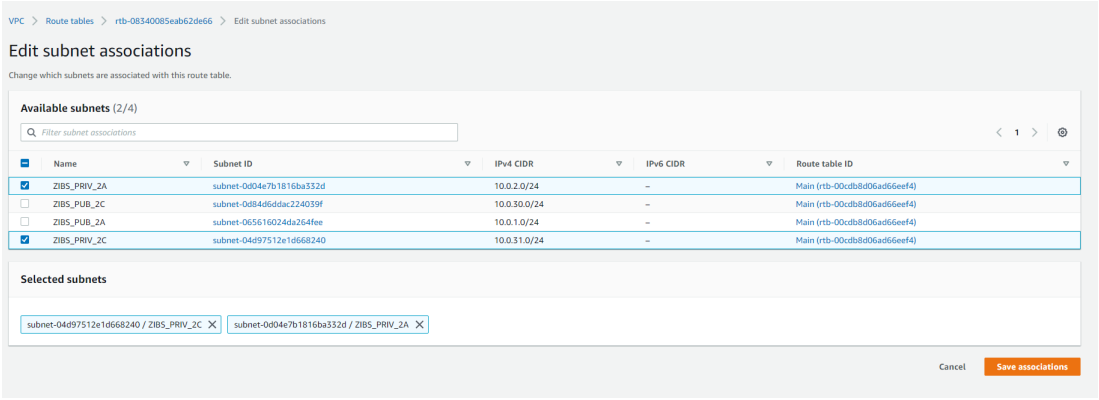


Figure 94: Edit Subnet association

In figure 95, it is already possible to see two associated subnets in the private route table. These subnets are now made private by being associated with the private route table.

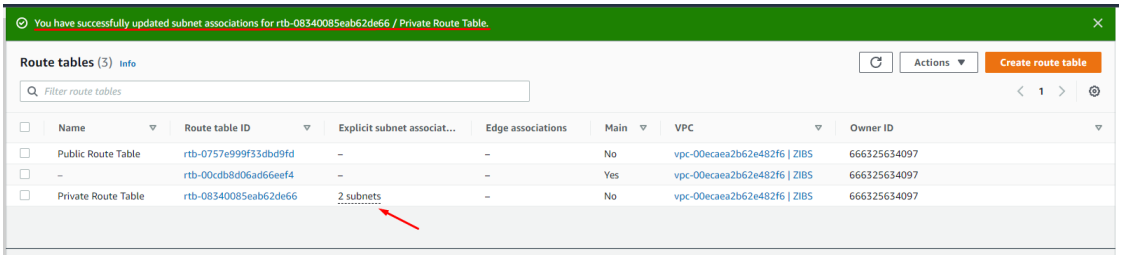


Figure 95: Private Subnet association

The same is done for the Public Route table, but the associated subnets will be public, as shown in figure 96.

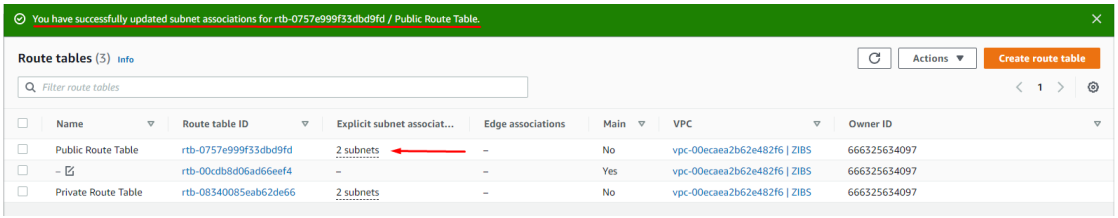


Figure 96: Public Subnet association

5.5 EC2 instance creation

To launch EC2 instances, go to "services", "compute" and "EC2", as shown in figure 97. Then, as shown in figure 97, "launch Instance". This is where the EC2 instance is configured, as shown in figures 97 to 104. Two EC2 instances will be created; one will be placed in a public subnet and the other in a private subnet. After the EC2 instances are created, the communication between them will be shown next.

5.5.1 Public EC2 instance

Within the services, select the "compute" menu and within it, select "EC2" and select "Launch Instance" as shown in figure 97 and 98.

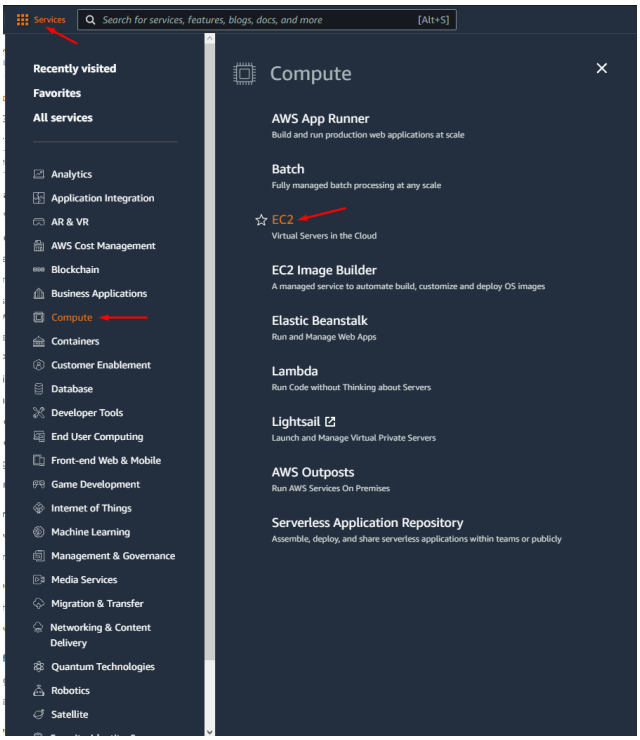


Figure 97: EC2 selection

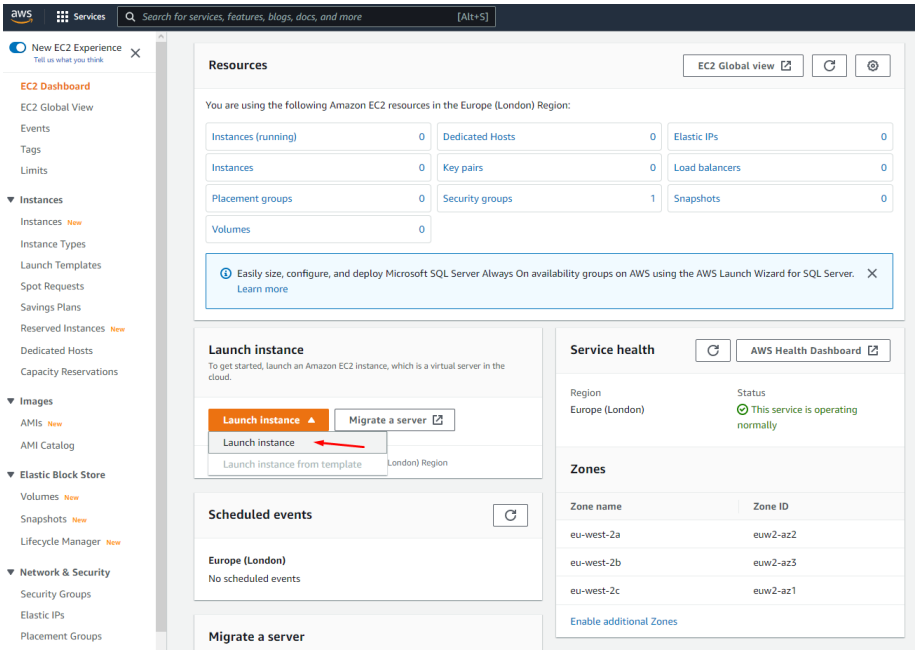


Figure 98: Launch Instance

Now the EC2 instance will be configured. as shown in figure 99, the instance will be called "PT-Public", and the OS will be Windows server 2019 to be as accurate as possible to the infrastructure Bodum's.

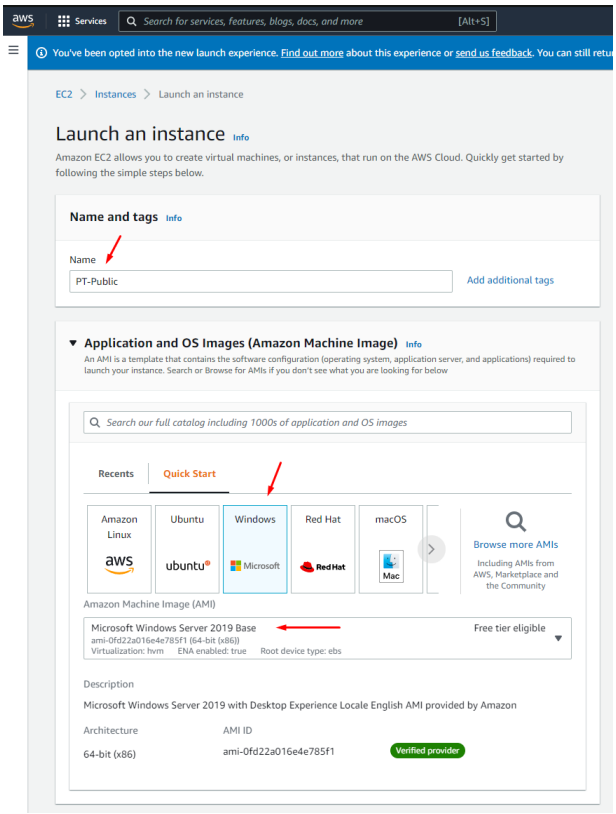


Figure 99: Setup instance

The type of instance chosen was "t2.micro" since this type of instance is "free tier eligible" as shown in figure 100.

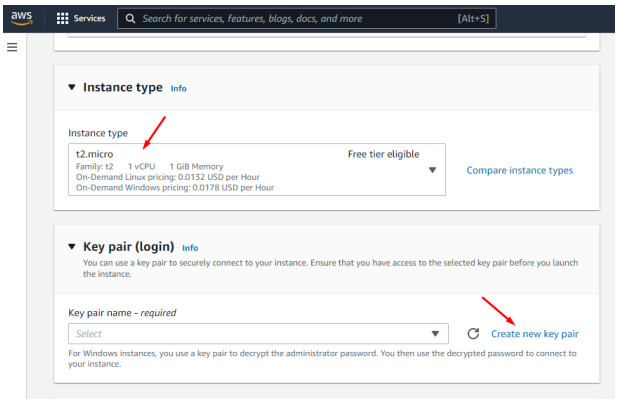


Figure 100: Instance type and Key pair

The key pair (login) is used to secure the connection to the instance; as the name implies, it is a pair of keys, a private key and a public key, that serves as security credentials to access the EC2 instance. The EC2 instance keeps the public key, and the private key is

controlled by the person who creates the instance. The private key decrypts the administrator password; after that, we can use a decrypted password to access the EC2 instance. The following will show how to create a key pair. First, it is necessary to assign a name to the key pair that will be created, and then it is essential to choose the file format of the key. In this case, the format ".pem" will be selected as shown in figure 101.

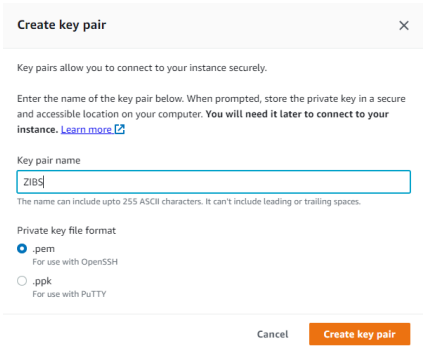


Figure 101: Create key pair

After creating the key pair, we go back to the instance configuration and, this time to the networking setup as shown in figure 102. The network settings will be edited, as shown in figure 103. Here is where the VPC and subnets that were previously created will be associated with this instance. At this point, security groups, a set of firewall rules that control the instances traffic, will be created and added to all network interfaces. Traffic rules will be specified for communication with the instance in these groups.

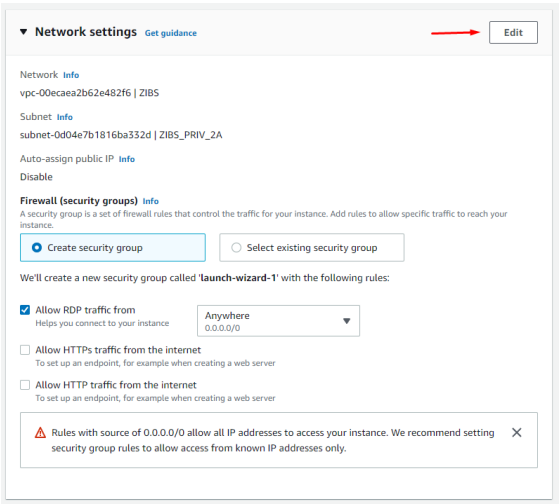


Figure 102: Network settings

As we can see in the figure 103 this instance will be allocated to a public subnet "ZIBS-PUB-2A" and for that reason, it will have the "Auto-Assign public ip" option enabled. A security group will be created as well as the name "SecurityGroupA", and this group, shown in figure 103, will allow all types of traffic on all protocols and ports from any source

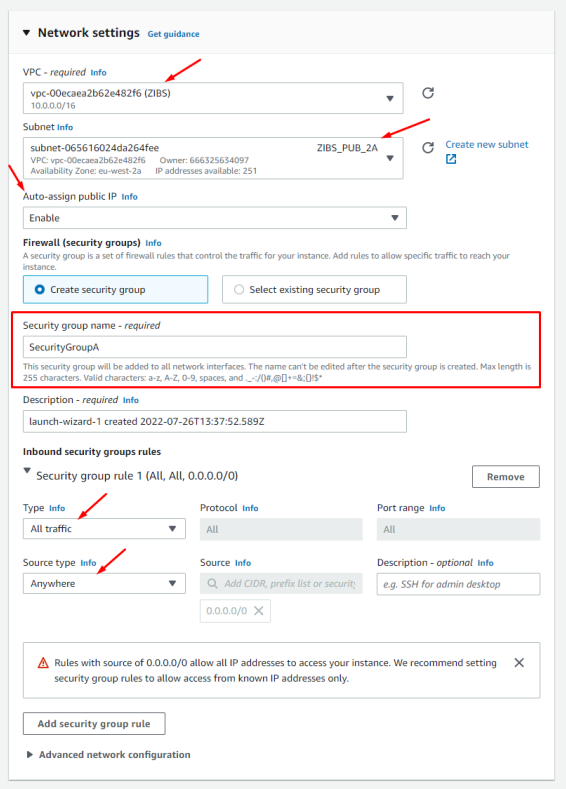


Figure 103: Network and security groups

As shown in figure 104, the storage configuration is the default setup as it is "Free tier eligible". Some resources in AWS are cataloged as Free tier, meaning they are basic and free resources usually used in tests. For this case, it is enough because the instance will only have the services mentioned above running, so it doesn´t need more than 30GB of storage.

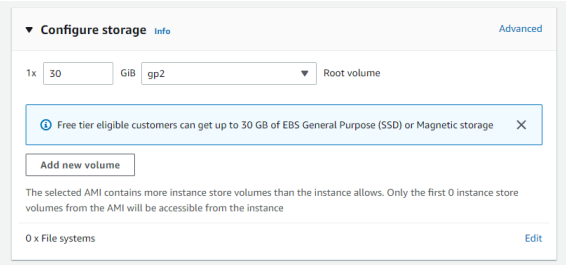


Figure 104: Setup storage

5.5.2 Private EC2 instance

Now the private EC2 instance will be configured. As shown in figure 105, the instance will be called "PT-Private".

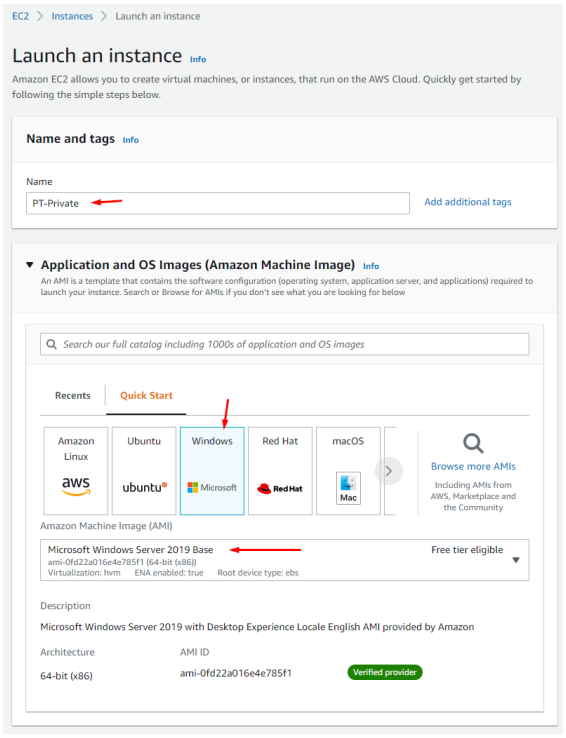


Figure 105: Launch private instance

The type of instance will be the same as "PT-Public" so "t2.micro" because this type of instance is "free tier eligible" as shown in figure 106.

As shown in figure 106, the previously created key pair is offered as an option, which will be used. There is no need to create a new one.

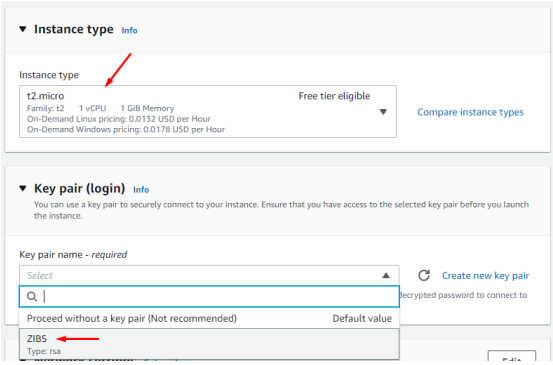


Figure 106: Private instance type and Key pair

As we can observe in figure 107, the instance will be allocated to a private subnet "ZIBS-PRIV-2C" and for that reason, it will have the "Auto-Assign public ip" option disabled since it is on a private subnet it does not make sense to have this option enabled. A security group will be created with the name "PrivateSecurityC". For this group shown in figure 107, no security group rules are included. Later this security group will be edited.

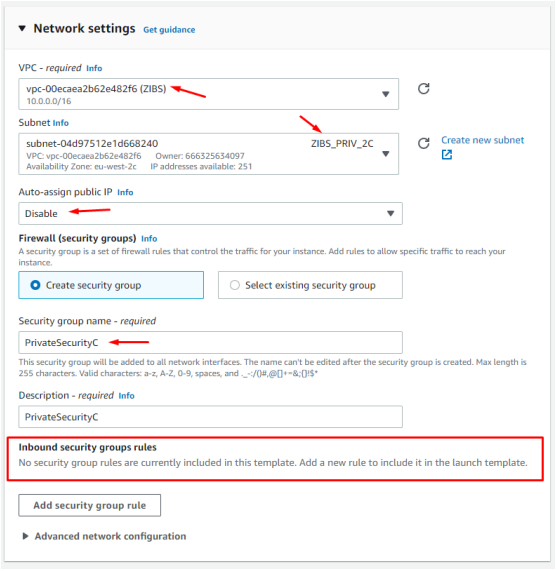


Figure 107: Private network settings

As shown in figure 108, the storage setup will be the same as the public instance, the default configuration.

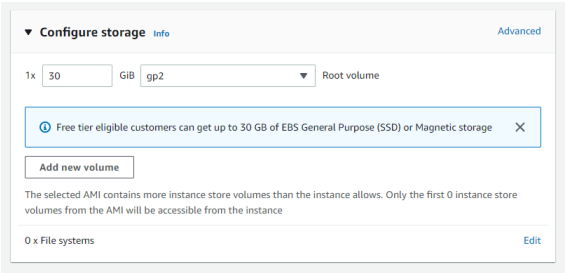


Figure 108: Instance storage

Now the security group "PrivateSecurityC" will be edited. As shown in figure 109, select the instance "PT-Private" and the "security" menu. Under that, choose "Security groups" and select "sg-06d6854c65ff7b7fc(PrivateSecurityC)"

As shown in 110, a new window is shown with some details of the security group "PrivateSecurityC". Now select "Edit inbound rules", and we will be redirected to another new window, as shown in figure 111 to add inbound rules to the security group.

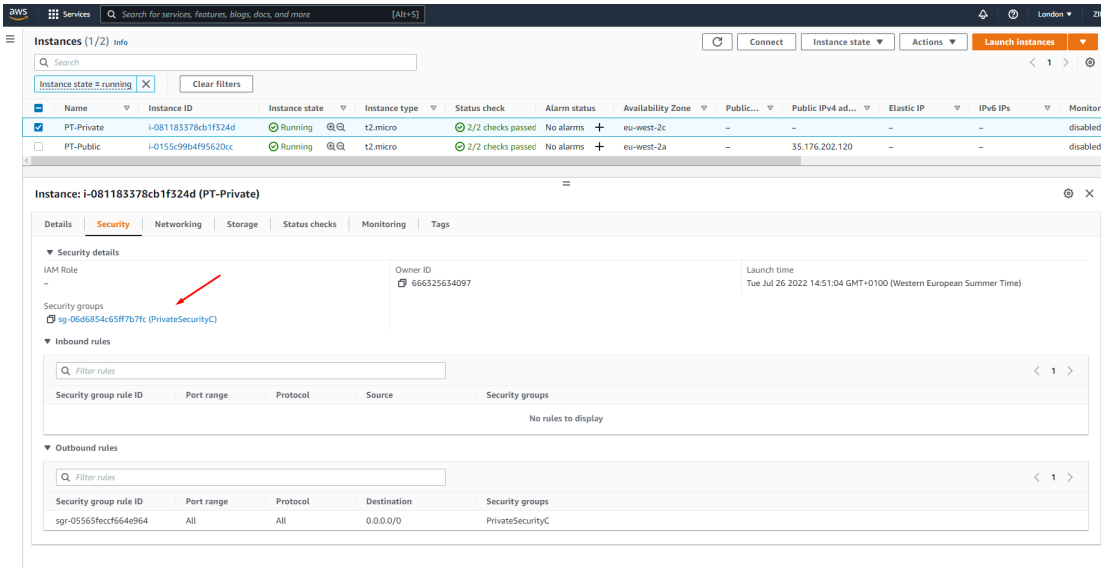


Figure 109: Security groups setup

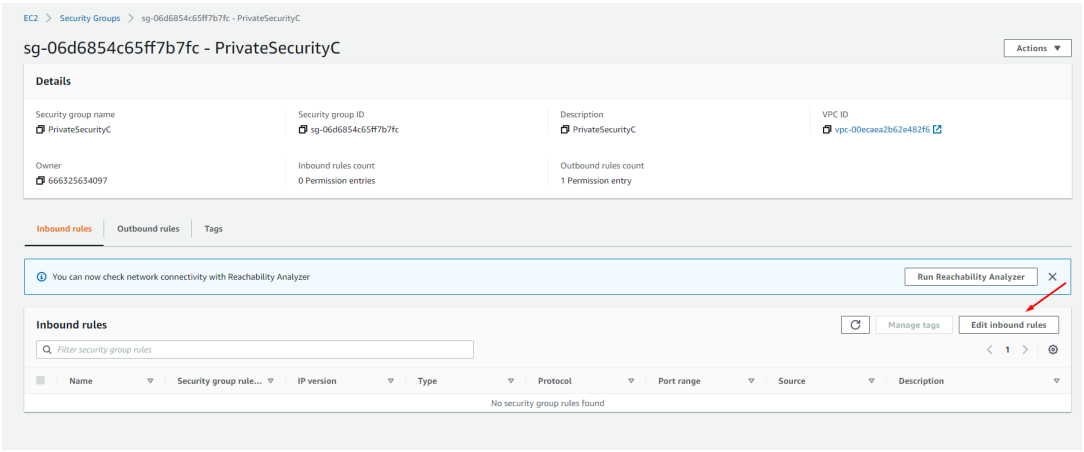


Figure 110: Inbound rules

Now an inbound rule will be added which, as shown in figure 111, allows all types of traffic from the public subnet "ZIBS_PUB_2A". This, in theory, means that everything inside the public subnet "ZIBS_PUB_2A" will be able to communicate over any protocol with everything inside the private subnet "ZIBS_PRIV_2C". Some tests will be carried out to corroborate this statement.

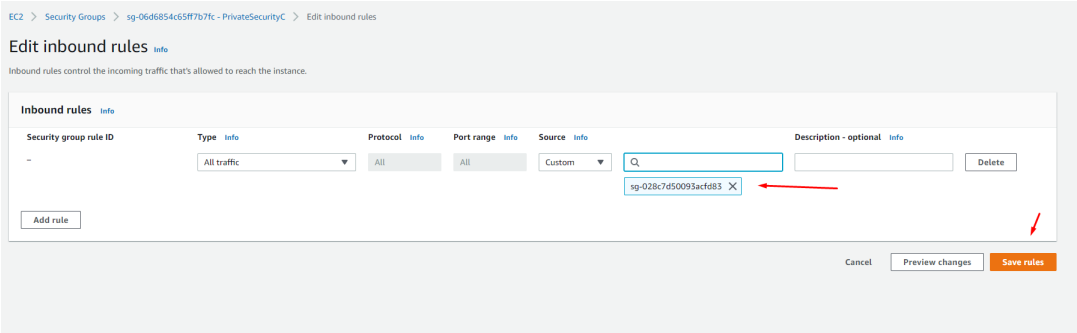


Figure 111: Edit inbound rules

5.5.3 Communication tests

Public EC2

Next, the communication tests between EC2 instances are explained. To perform a remote connection to an EC2 instance, select the desired EC2 and click on "connect" as shown in figure 112. Then a new window is shown as shown in figure 113.

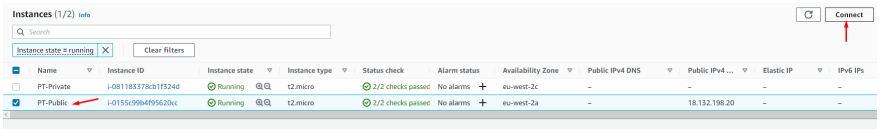


Figure 112: Public instance connection9

Select the "RDP client" and proceed to the "Get password" field as shown in figure 113.

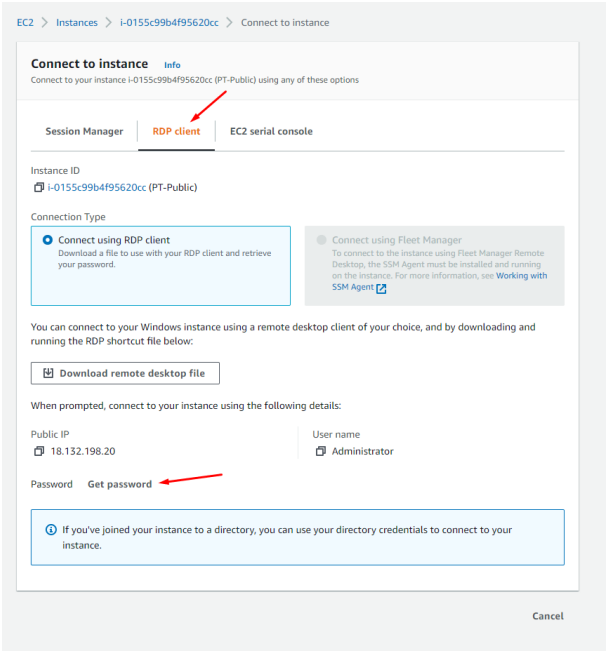


Figure 113: Get windows login password to public EC2

The key pair will be used here, as shown in figure 114. Then we select "browse" to upload the key pair. After uploading the key pair, we select "Decrypt password" to get the administrator password to access the EC2.

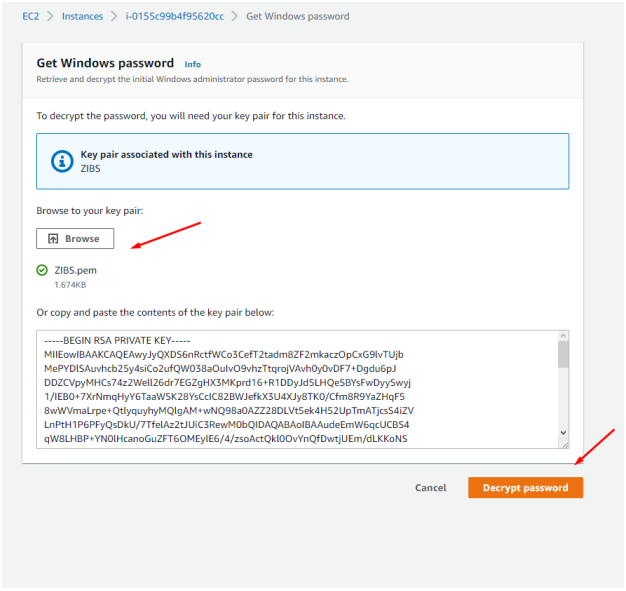


Figure 114: Decrypt password to public EC2

As shown in figure 115, we already have the necessary information to connect remotely to the EC2 instance, namely, public IP, user name, and password. Now one should select "Download remote desktop file" and an RDP file will be downloaded. In this case, the RDP files will be opened through Microsoft Remote Desktop, a free tool from Microsoft themselves.

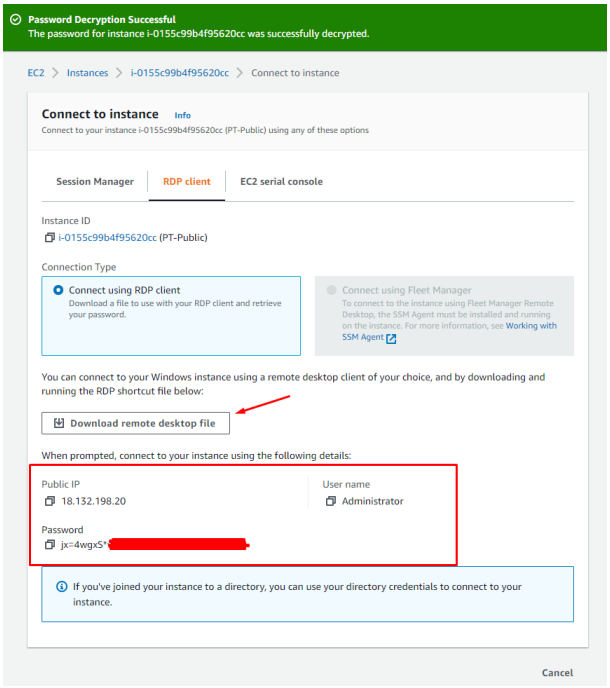


Figure 115: Credentials to connect to public EC2

When the RDP connection is made, as shown in figure 116, enter the EC2 access credentials. These credentials were previously generated, as shown in figure 115.

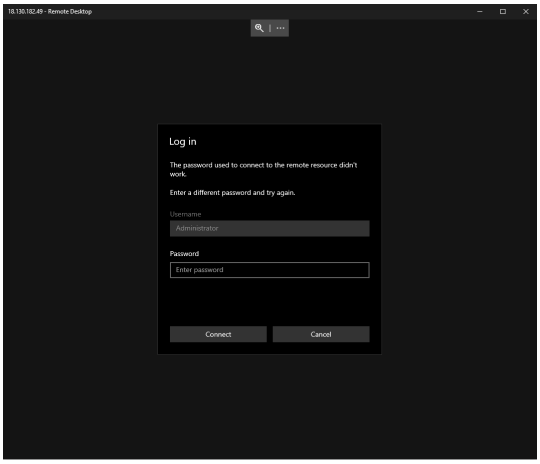


Figure 116: RDP connection to public EC2

In figure 117, it is possible to see that the connection from the author's physical machine to the public EC2 was successful.

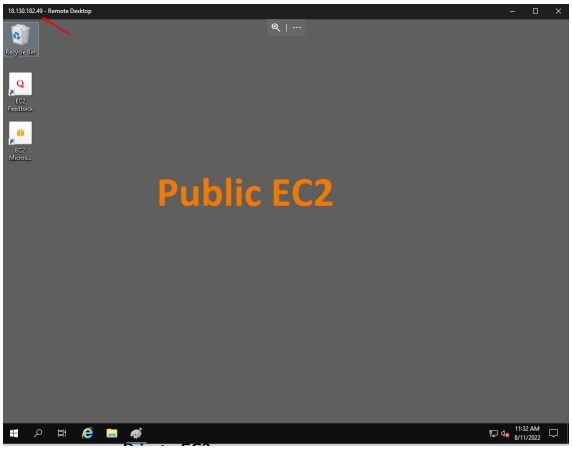


Figure 117: Successful RDP connection to public EC2

Private EC2

The process to initiate a remote connection to a private EC2 is identical to the connection between a public EC2. The difference is that remote access will have to be carried out through the public EC2 instance as the private EC2 is in a private subnet that can only be accessed from the public subnet, as defined in this chapter on subsection 5.4- Route Tables through the setup of route tables. Therefore, if the remote connection is performed by another machine that does not belong to the public subnet, there will be no communication.

Private EC2 will be selected and then "connect" as in figure 118 and "RDP client" will be chosen and "Get password" as shown in figure 119.

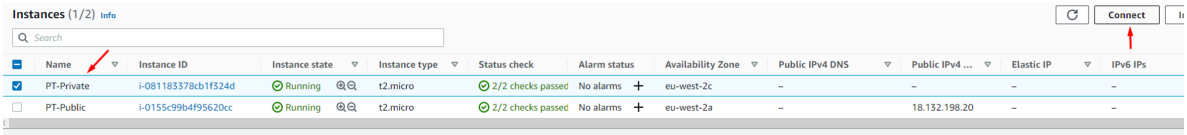


Figure 118: Private instance connection

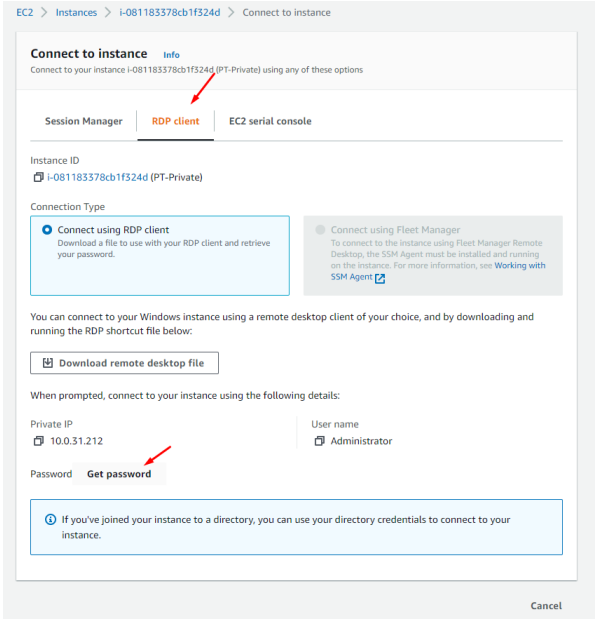


Figure 119: Get windows login password to private EC2

"Browse" will be selected, and since a key pair has already been created for the public EC2, the same file will be used, as it´s possible to see in figure 120.

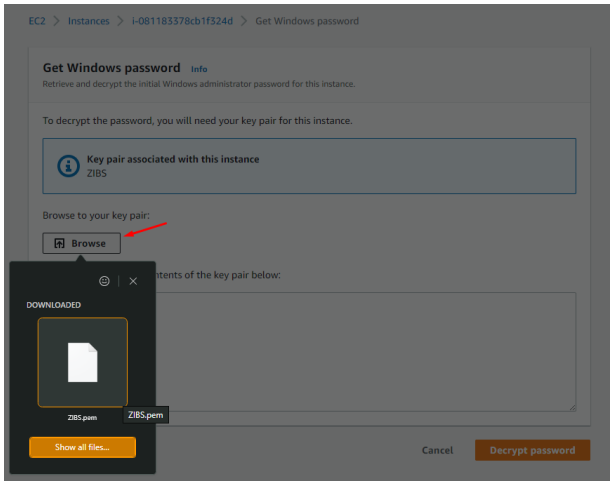


Figure 120: Upload key pair

After uploading the key pair, "decrypt password" will be done the same way it was for the public EC2 as shown in the figure114. As shown in figure 121, credentials are already available to access the private EC2 instance.

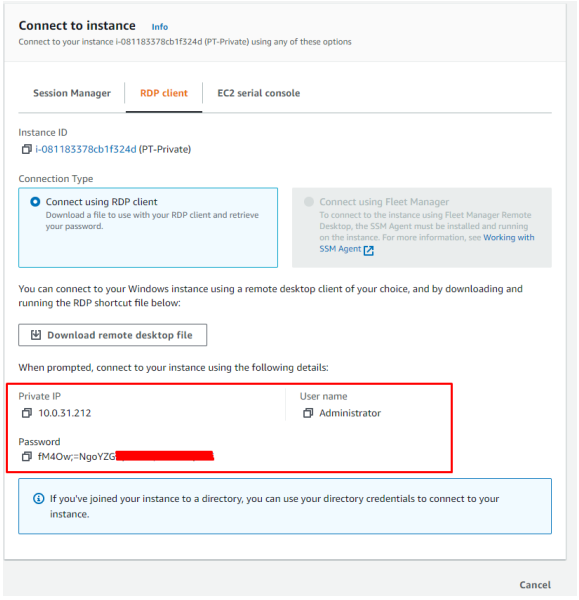


Figure 121: Credentials to connect to private EC2

Inside the public EC2, a connection with private EC2 will be started through the Remote Desktop Connection. The private IP of the private EC2 will be placed, as shown in figure 122, and the connection between the two EC2s will be established. Before the connection is established, the access credentials generated previously will be requested, as seen above in figure 121.

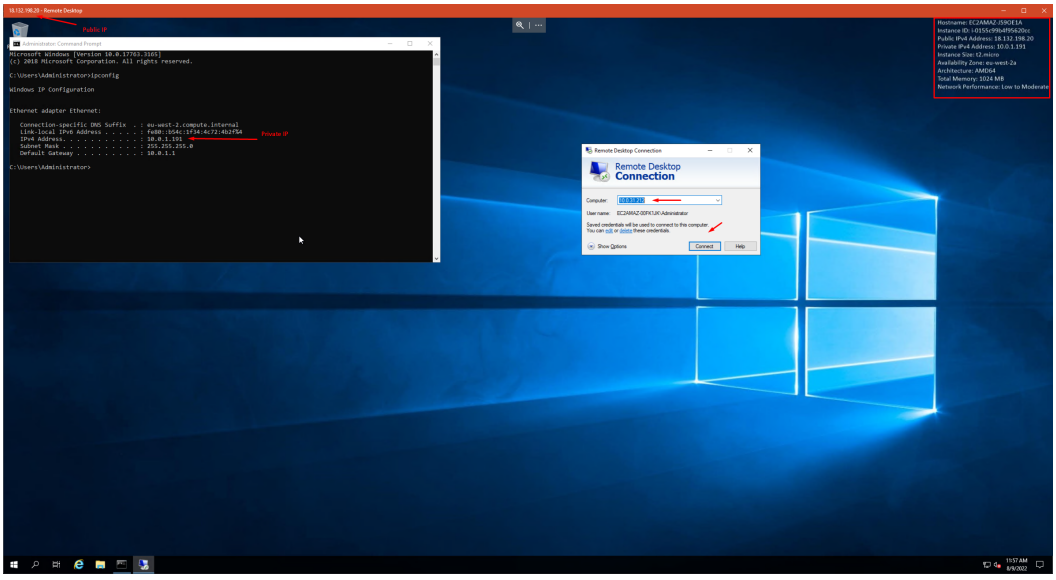


Figure 122: RDP connection to private EC2

Thus, the connection established between the EC2 instances, as shown in figure 123, is an RDP connection from the author's machine to the public EC2 with the public IP 18.132.198.20 and the private IP 10.0.1.191. It shows that this EC2 belongs to the public subnet ZIBS_PUB_2A. In the same figure 123 there is another RDP connection from public EC2 to private EC2 with the private IP 10.0.31.212, which means that it belongs

to the private subnet ZIBS_PRIV_2C. This means that they are in different subnets and availability zones and that communication between them is possible.

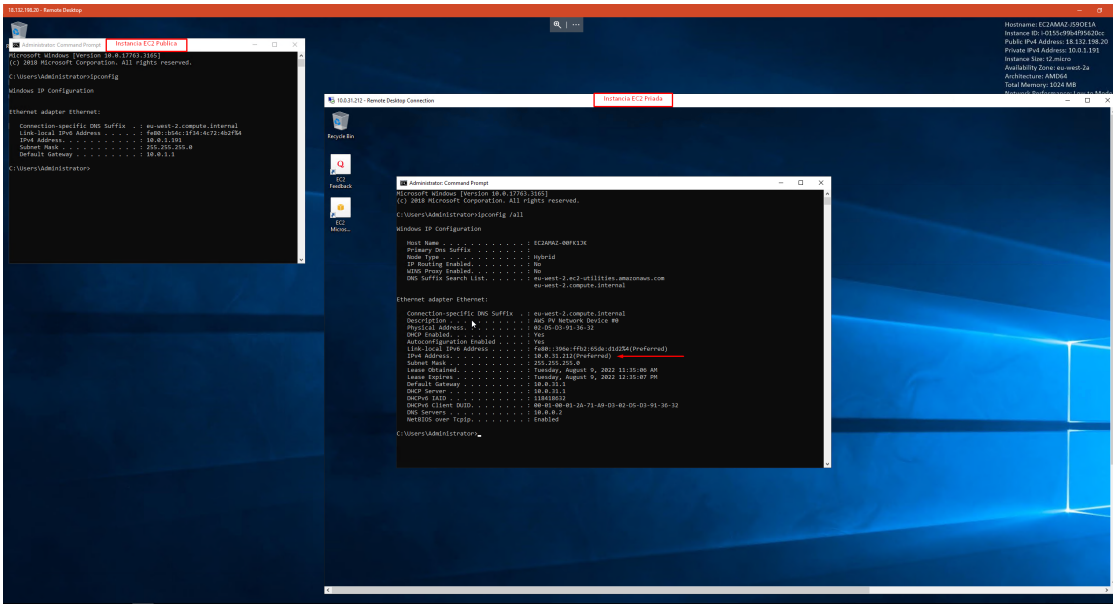


Figure 123: Successful RDP connection to private EC2

In figure 124, it is possible to analyze and confirm the IP range of each EC2 and in which availability zone each instance is.

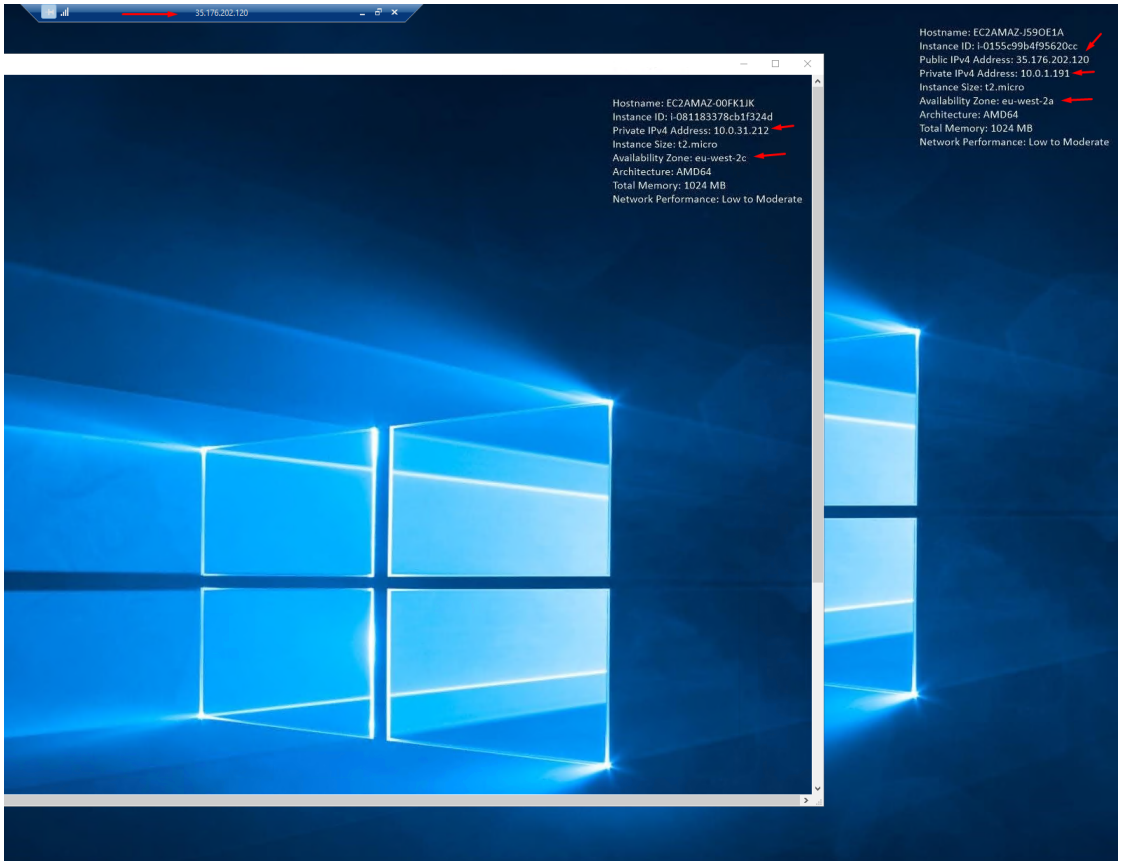


Figure 124: Check IP and availability zones

Now we have an identical company architecture on a smaller scale. Analyzing figure 125 and comparing it with reality, we can look at the VPN as the company's main network. Inside it, we have Availability zones that we can consider as countries, and within them, we have subnets that we can consider as Vlans where the EC2 instances are. We can view them as servers and virtual machines.

Based on the company's architect, this scenario assumes that there is public and private communication. That is, everything that is published services will be within the Sbunet ZIBS_PUB_2A or ZIBS_PUB_2C, the rest that does not require communication with texterior is within the Sbunets ZIBS_PRIV_2A and ZIBS_PRIV_2C, respectively to each country (Availability zones) that communicate with each other, and users will communicate with each of them depending on the accesses assigned to each user.

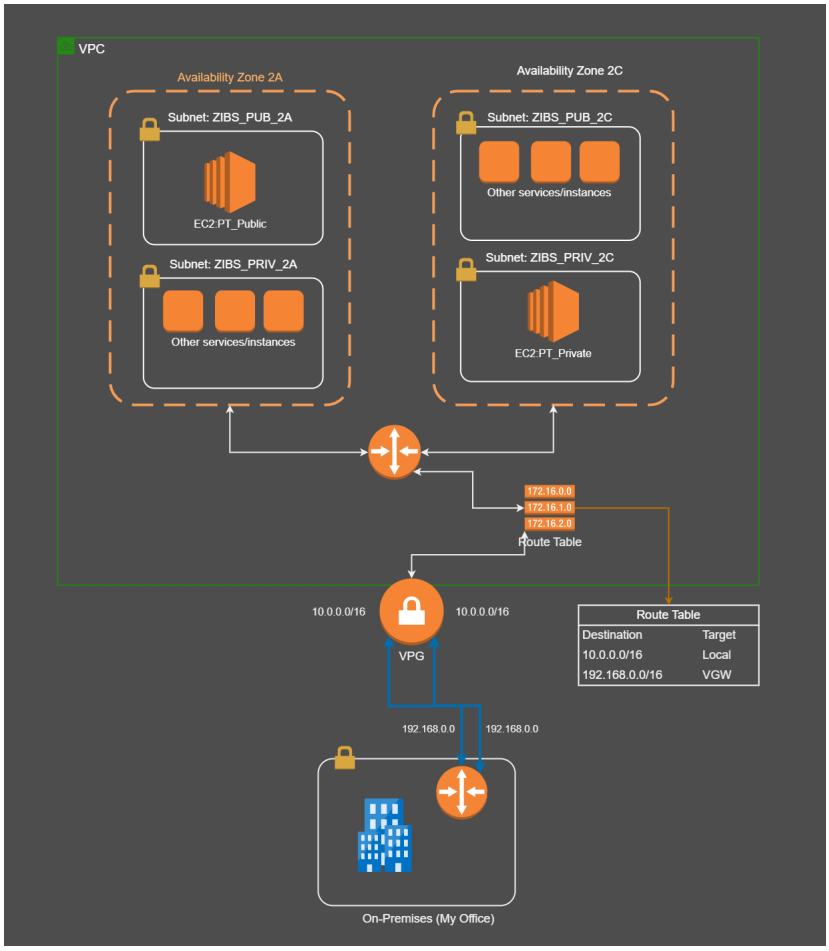


Figure 125: Simulation architecture

After the instances were communicating with each other, the company's services were replicated to one of the EC2 instances, in this case, the one that is public to facilitate the process, as shown in figure 4.2.

With this process, a simulation in the AWS Cloud was built identical to the system currently in the company on a smaller scale.

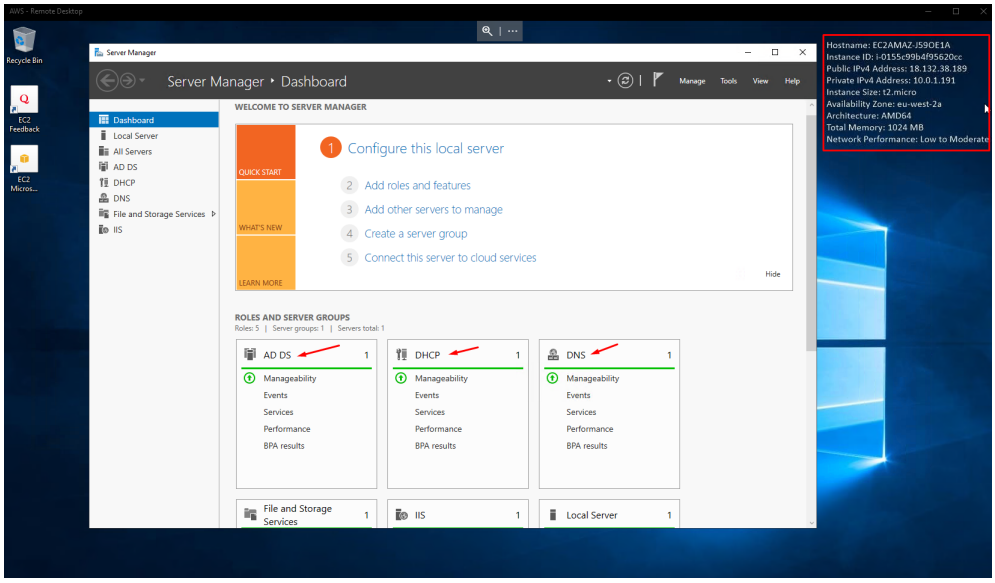


Figure 126: Services migrated to Cloud

5.6 Discussion

With this project, it became clear that the proposal made by the author contributes to solving the processing waste issue. Although there is still some processing waste, it is substantially less in the EC2 than in the physical server and less expensive, which will discuss later. The EC2 will also impact the costs channeled to the company's SI infrastructure. This proposal will also make the work of the company's IT team easier because everything is centralized and managed more efficiently and effectively.

Figure 127 shows the performance comparison between the EC2 instance and the physical server, where both have the same services and roles installed, and it is clear that on the physical server, there is a considerable waste of processing since the processor is at 0% usage against 21% usage on EC2. In figure 127 on the right side, it is possible to see some usage spikes, but it is a residual thing. In a processor with this capacity, it is insignificant.

The services on these servers require few resources, which is why the processing waste is too high. The EC2 instance was created to reduce resources to avoid waste of processing, and as it is possible to see in the figure 127 below, this purpose was achieved. An EC2 with a substantially weaker processor than current physical servers and only 1 GB of RAM can perform the same tasks as existing physical servers.

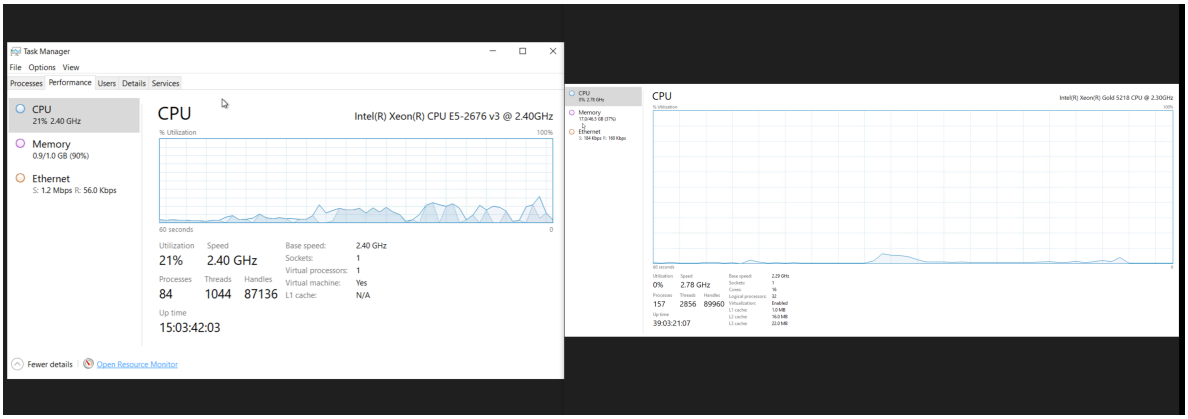


Figure 127: Performance compare

Regarding costs, an EC2 instance capable of running the company's services and roles has an annual cost of 237.97 USD (or 19.83 USD Monthly). This value was calculated using a platform provided by AWS, which can be found at this link `https://calculator.aws/#/addService/ec2-enhancement`. These calculations were based on the EC2 used during this project. Below in figure 128 it is possible to see the calculated value. This value can be reduced by changing some payment options, as shown in figure 129. In this case, the default option was chosen to facilitate the process.

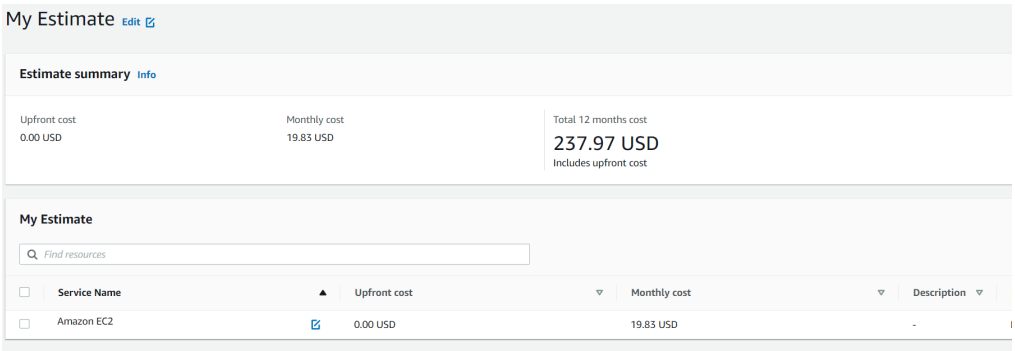
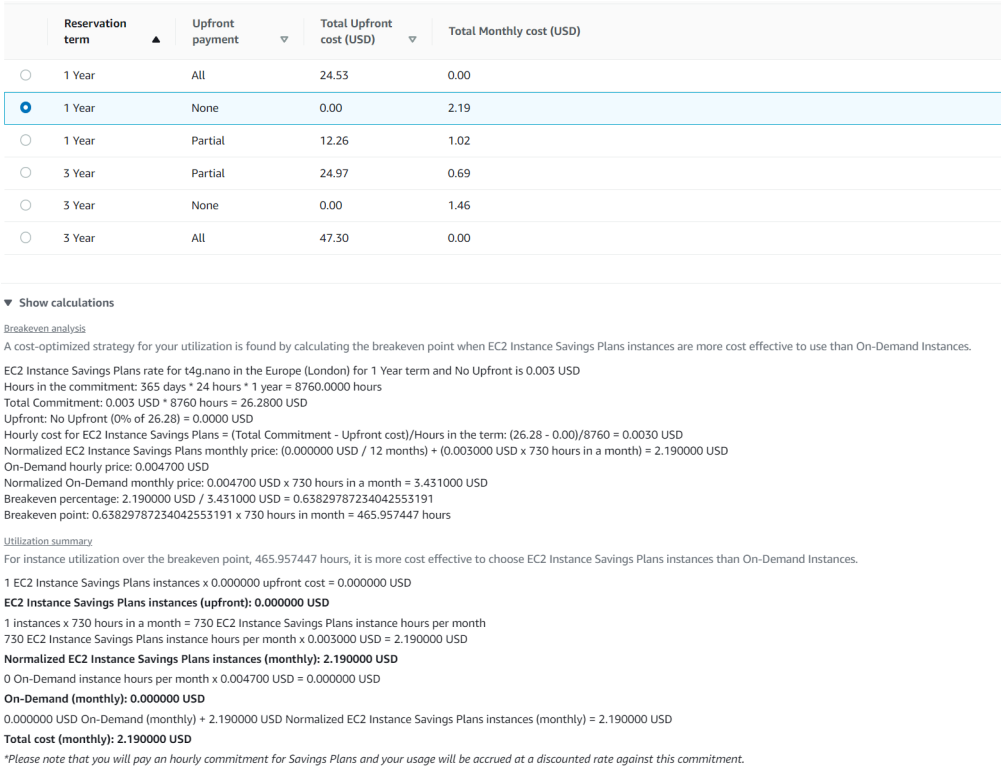


Figure 128: EC2 costs



Reservation term	Upfront payment	Total Upfront cost (USD)	Total Monthly cost (USD)
1 Year	All	24.53	0.00
1 Year	None	0.00	2.19
1 Year	Partial	12.26	1.02
3 Year	Partial	24.97	0.69
3 Year	None	0.00	1.46
3 Year	All	47.30	0.00

Figure 129: Cost calculation details

Simulations and tests are essential in any project since they give us data and information of great value and serve as a learning tool for future projects. The simulations and tests carried out in this project played a crucial role in understanding and predicting certain system behaviors. The simulation carried out in this project made a real comparison between Cloud systems, AWS, and local on-premises systems. In this case, migrating the company's systems to the Cloud will bring cost reduction to the company. Still, the company will gain advantages such as less maintenance, more availability, scalability, and control.

The company currently has physical servers worldwide, which mainly need repairing regarding availability, control, and maintenance. For example, suppose there is a problem with a server. In that case, it is often necessary to contact support locally, which brings costs to the company and access to information to one more entity for each country where the company has servers. In this case, this is one of the significant disadvantages of on-premises systems, such as the cost of acquiring hardware, acclimatization, energy, and the physical space in the building and its surroundings.

The core of the company's IT is located in Portugal and is responsible for handling all the support. In this context, it makes sense to migrate the company's infrastructure to the Cloud because everything becomes centralized and allows to reduce costs, namely the acquisition of hardware, physical space, and contracting local support. Furthermore, the company would gain more flexibility in the system. For example, suppose it is necessary to close or relocate one of the offices. In that case, it is possible to turn off the components allocated to that office with some time and some clicks, and the company will no longer be billed for these components. At the same time, this process becomes more complex

and expensive on an on-premises system. If it is necessary to relocate an office from Portugal, we can make the required changes, such as public IP, DNS, Vms, etc., and the office will be up and ruining much faster than on-premises.

For example, while writing this document, the company is relocating its offices to Switzerland. It has been an extensive struggle buying equipment, configuring it here in Portugal, then sending it to Switzerland, sending someone to Switzerland to receive the equipment, mounting them in place, and finishing with some configuration. It took almost a month for the hardware to arrive at its destination. Furthermore, it is necessary to send someone from the company's IT team to assemble all the hardware and make the connections and final configurations. If the company had the infrastructure in the Cloud, this process would be simpler, faster, and cheaper. Based on the tests and simulations carried out throughout this project, it would be possible to relocate the infrastructure of the offices in Switzerland in less than a month and without having to go there. Only an internet connection is needed on site. The rest could be done from Portugal, avoiding the costs of sending hardware and acquiring it, travel, and on-site support in case of hardware failures, hardware upgrades, and backups, among other costs.

From the above, it is clear that the company can benefit from migrating to the Cloud.

Chapter 6

Conclusions and Future Work

6.1 Conclusions

This project comprises two essential components, academic and industrial, since it is a real practical case. This project contributes to solving several problems related to the performance and stability of Bodum.SA servers, which in turn impact users' daily lives through applications, and file sharing, among others. These servers were good in all hardware and OS aspects.

New servers were purchased and placed on the respective sites, and the author successfully migrated all services and data on all servers, thus leaving each site with a new server in production. For the author, this migration was exciting because it was a continuous process with a beginning, middle, and end. This process was very gratifying because it is a real migration scenario with all the good and bad things it entails.

This project consisted of a complex migration to be carried out in some situations. For instance, when the time zone was significantly different from the author's location, meetings and decisions on dates and times to make the necessary stops on the servers to carry out specific tasks to affect the final user as little as possible were challenging to manage. Since this migration process was carried out remotely, sometimes support was needed on-site, which was also complicated by the time zone and the need for more technical knowledge of the people in the places.

This project was a challenge and an achievement for the author, considering the dimension in terms of technology, human resources, and ethics. This project had a positive impact on all sites in the technological sense, as it was an improvement to the technology used to date, both in terms of use, as at the moment the users of each site no longer have problems with the speed of applications, performance, and reliability.

This project was an added value for all those involved. The author enriched the knowledge of IT, management, hierarchy, and responsibility. The company was left with the migration done and everything working according to the defined needs and requirements. However, more important, the company keeps the internal know-how. In addition to a copy of this document, the company received a document with more technical details that can be useful in the future, if necessary.

In addition to completing the migration, the author conducted a study and proposed to improve the company's infrastructure. A study is presented regarding a future migration to the AWS Cloud. In addition, the author simulated a cloud scenario identical to the

existing one at the moment (on a smaller scale), where it is shown through simulations and real tests a possible migration path to the cloud and how to do it.

6.2 Future work

Looking at this project, the author believes that a good path for his work so far would be to complete the migration to the AWS Cloud. Since through the study that was carried out and the tests carried out, the company can reduce infrastructure costs and, at the same time, gain more security, scalability, and reliability in the system. The author suggests migrating to a hybrid cloud in which the network and processing infrastructure would be migrated to the AWS Cloud. At the same time, all the company's storage would continue locally.

The proposed future work would have the best of both worlds. It would have the network infrastructure and processing in the cloud, which brings advantages, as shown in this document through the study carried out in the 5 chapter. The company would benefit from more resources, scalability, and centralized management. Since the storage would continue on-premises, the company is not concerned about having critical information in the cloud. In this way, this proposal for future work will safeguard the company's interests, needs, and requirements.

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Appendix A

AWS expert contact

Figures 130 to 133, below, show the emails exchanged between the author and AWS support.

After speaking to Olena Polishchuk on the phone, she sent an email so I could could schedule two dates to discuss the content of this project.

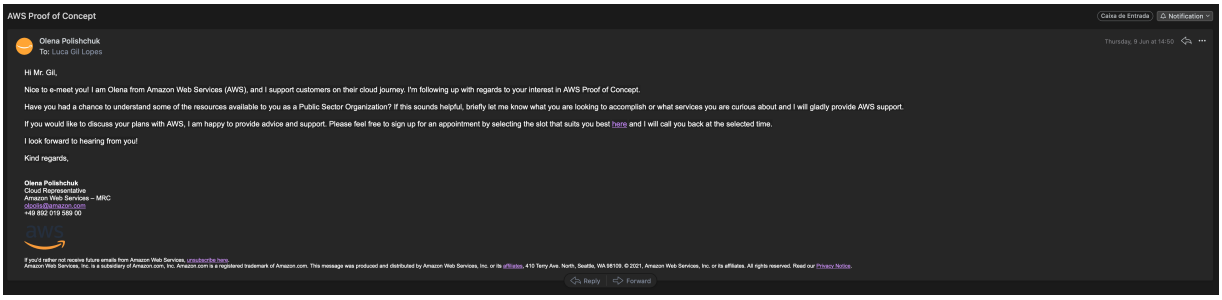

Figure 130: AWS First Contact

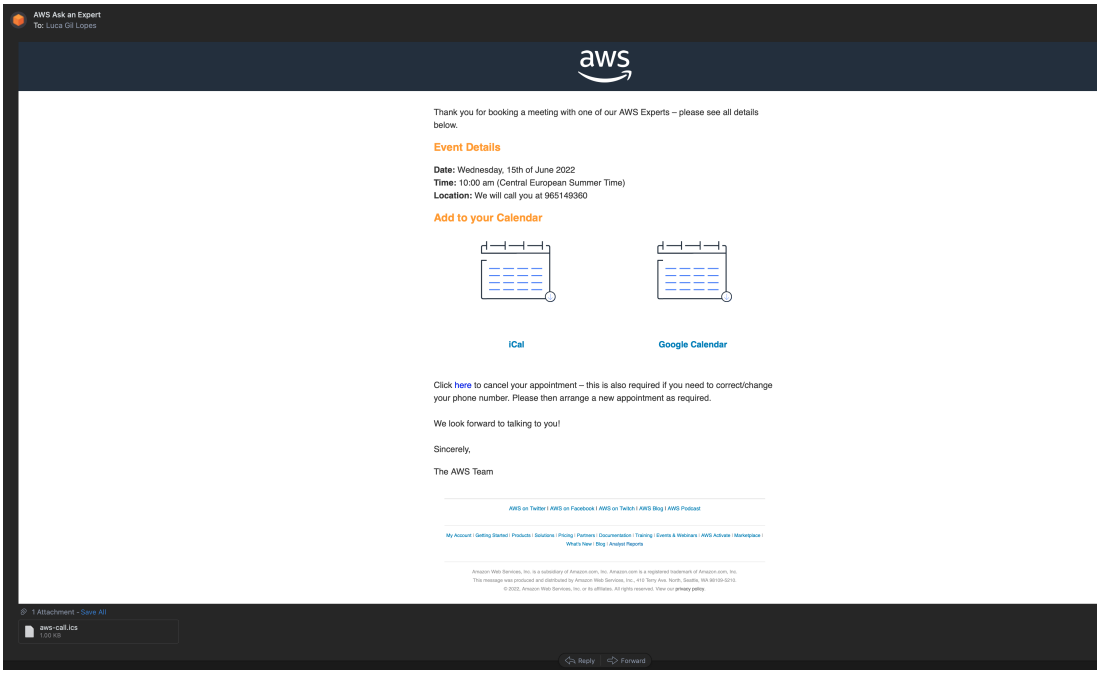

Figure 131: Meeting with a AWS Expert

After I had talked a bit about this project, Olena Polishchuk asked for some details about this project, as shown in the figure 133, in order to guide me through these stages.

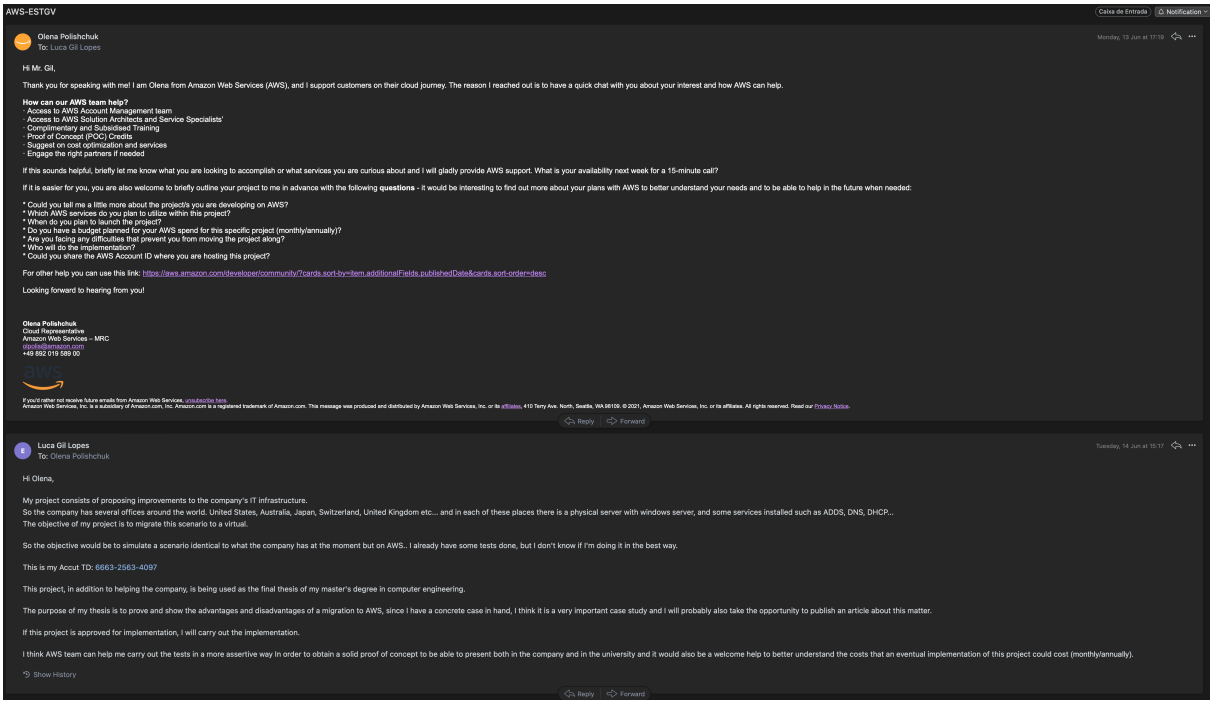

Figure 132: Details about the project

Figure 133: Second meeting with AWS expert

In a second phase, the author had the support of AWS experts to help design a better simulation plan for AWS simulation.

Appendix B

Integrated Dell Remote Access Controller

The Integrated Dell Remote Access Controller (iDRAC) is a tool that was developed by Dell, in order to facilitate the life of the IT team in managing remote and local servers, securely. iDRAC has several advantages, including streaming telemetry, scalable automation, security management, and simplified support. This tool uses a separate network from the system where the IT team can connect each other via login to perform system reboot actions even if the OS has crashed. The IT team can connect remotely through the console available in the iDRAC to access the operating system. (This process was carried out in the present project to access some servers as described in the chapter 4, section 4.2).