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Original Article

Server Virtualization: Success Story in a Peruvian Company

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Abstract *- The state company Sedapal contains a wide variety of obsolete technological standards that do not allow the growth of the technological infrastructure due to the limited financing by the state for the operation, maintenance, and renovation of a new structure. Due to this, the objective of this research is to design a server virtualization plan. Virtualization allows physical components to be abstracted and logically replicated. With this, a reduction in operation and maintenance costs can be achieved, in addition to allowing the new virtualized infrastructure to be scalable, expanding the resources that are acquired in the company. Likewise, the methodology used in this research is the waterfall methodology, which is divided into 5 stages, the first stage being the analysis of requirements, to move on to the design of the solution, its subsequent implementation, and the verification stage and ending with maintenance. The result obtained is the design prototype of a virtual architecture which allows a virtual technological infrastructure, concluding that the methodology and software used allow the design of a virtualization plan that can be applied to companies.*

Keywords *- State company Sedapal, Technological infrastructure, Virtualization servers, Waterfall methodology.*

1. Introduction

In recent years, virtualization has become a way of providing computer services using an abstract layer in which the physical components of the logical ones used in it are divided, making it possible for different environments to coexist in the same physical device [1]. This has evolved over time so that it can be applied in different technological fields such as servers, mobiles, storage, desktop, networks, applications and the Internet itself [2]. Among these applications, server virtualization has positioned itself in the technological market over the others due to its advantages for organizations, such as long-term scalability, high availability, reduced maintenance costs and business continuity [3], with respect to the current variety of companies that use data as their main resource, which are processed, stored and protected on servers and are in the company's data center to generate information that allows them to meet their objectives and goals. However, few have achieved the implementation of a complete data center due to economic, geographical and legal factors, the economic factor being the main one due to the high infrastructure costs [4]. Currently, the company Sedapal has different types of servers which host the processes, programs and main development tools that support the software for the drinking water and sewage treatment services business. Within its strategic map is to improve its business management after modernization, which is financially limited by FONAFE.

The acquisition of new infrastructure in the long term is viable if the virtualization of its current infrastructure is achieved, which allows the reduction of operation and maintenance costs and the acquisition of new equipment that allows the growth and improvement of its infrastructure [5]. In addition, there is the risk of buying obsolete technology due to long and complex legal acquisition processes, which prevents scalability and flexibility in your infrastructure, where the objective of the research is to propose a server virtualization plan that facilitates productivity, high availability, migration, reduction of maintenance costs and scalability [6].

2. Literature Review

In recent years, virtualization has become a way of providing computer services using an abstract layer in which the physical components of the logical ones used in it are divided, making it possible for different environments to coexist in the same physical device [1]. This has evolved over time so that it can be applied in different technological fields such as servers, mobiles, storage, desktop, networks, applications and the Internet itself [2]. Among these applications, server virtualization has positioned itself in the technological market over the others due to its advantages for organizations, such as long-term scalability, high availability, reduced maintenance costs and business continuity business [3].

With respect to the current variety of companies that use data as their main resource, which are processed, stored and protected on servers and are in the company's data center to generate information that allows them to meet their objectives and goals. However, few have achieved the implementation of a complete data center due to economic, geographical and legal factors, the economic factor being the main one due to the high infrastructure costs [4].

Currently, the company Sedapal has different types of servers which host the processes, programs and main development tools that support the software for the drinking water and sewage treatment services business. Within its strategic map is to improve its business management after modernization, which is financially limited by FONAFE. The acquisition of new infrastructure in the long term is viable if the virtualization of its current infrastructure is achieved, which allows the reduction of operation and maintenance costs and the acquisition of new equipment that allows the growth and improvement of its infrastructure [5]. In addition, there is the risk of buying obsolete technology due to long and complex legal acquisition processes, which prevents scalability and flexibility in your infrastructure. Therefore, this research aims to propose a server virtualization plan that facilitates productivity, high availability, migration, reduction of maintenance costs and scalability [6].

The amount of information handled in companies today has been increasing over time; the use of technology has allowed this information to be stored and transformed into knowledge that allows businesses to enrich their strategies and add support to decision-making decisions. This information is stored on servers, which vary according to the scope and sector of the company but are also affected by time and capacity, being an investment that not many companies prioritize. Here virtualization is presented as a technological tool that generally allows cost savings.

This research work will cover the design of a server virtualization plan. With virtualization technology, creating different virtual machines capable of replicating physical servers on a single computer is possible. It will be possible to reduce investment and maintenance costs of computer equipment since only a few servers will be purchased, which means savings in terms of energy costs, capable of supporting the entire IT infrastructure of the company. In addition, it allows for simple, centralized management as there are fewer physical machines to manage. The term virtualization is not recent; it originated in the 1960s with the creation of the time-sharing system, a system that allows resources such as CPU execution time, memory, etc., to be shared. Among several users from the company, IBM called TSS/360 (Time Sharing System or System of Shared Time), which did not have a great impact due to being so big and slow. A group at the IBM Scientific Center in Cambridge, Massachusetts, made a radical adaptation that was accepted as a linear descendant product of this system, known as z/VM or virtual machine Z, which is currently used as IBM's virtualization technology [1].

Another of the initial advances in the 1970s was the so-called CP/CMS, which was renamed VM/370. Its design had the objective of separating 2 characteristics of time-sharing systems: multiprogramming and an extended machine, an operating system that interpreted the orders to manage the hardware [1]. The virtual machine monitor is the one that manages all virtual machines that are created on and with the characteristics of the hardware, running any operating system, such as OS/360, extensive batch processing or transaction processing operating systems. With this, IBM strengthened its power in this technology for more than 40 years, which was only used in mainframes of large companies [1].

This technology has evolved along with the spread of the Internet; virtualization can be applied to various technologies that have been emerging, such as network virtualization that allows efficient LAN and WAN networks to be created, storage virtualization that can be implemented as a tolerant measure to high-performance failures and finally the virtualization of systems, where it is possible to virtualize physical equipment with the characteristics of independence between each virtualized equipment [7]. It is possible to integrate virtualization with the emerging cloud computing technology, which offers end users the computing resources necessary for their company, such as servers, networks, databases, or software, all this on demand, paying for service [8]. Anbazhagu's research focuses on how virtualization, together with cloud computing, allows for the reduction of investment costs in computing resources and improves efficiency in information technology operations [9].

The research presents a comparative analysis between the possible implementation of a physical server and a virtualized one in an electric power company, where the number of physical servers is limited, which favors virtualization technology for the creation of more virtual servers, which will improve the information security of the company thanks to the isolation characteristic that virtualization has, in addition to offering a great difference between the consumption and maintenance of a physical and virtual server [10]. One factor that must be identified before using both technologies is the location where the virtual machines will be created. Although cloud computing makes it possible to eliminate the physical location factor of data centers, it is necessary to consider the speed of communication between them and the end user. Linn et al. [11] propose in their research variables that must be considered in the problem, using linear programming to find the ideal objective function that allows the optimal allocation of virtual machines in multiple data centers, which is

compared with other results—of past research, concluding in an improvement of the method to allocate the virtual machines in multiple data centers. In contrast, Mochalov's research [12] presents us with an algorithm for the optimal allocation of virtual machines in a physical data center that can be used for companies that wish to incorporate virtualization technology.

Multiple solutions on the market allow us to use virtualization and cloud computing. Dumas's publication [13] allows us to contrast whether the possible reinvestment in new technologies such as virtualization, cloud computing, or the purchase of new hardware for the data center infrastructure of a mobile phone company was viable and would allow it to extend the life of the current one, concluding in the reinvestment in these new technologies that will make the company more competitive but taking care that some product does not have a unique feature that must be purchased infrastructure separately. Rycaj's article [14] shows a performance comparison of the 5 most popular hypervisors on the market, Proxmox, OpenVZ, OpenNebula, Vmware ESX and Xen Server, using OpenSSL, Geekbench and Phoronix Test Suit testing tools, resulting in Vmware hypervisor ESX the one that surpassed the other hypervisors by a large margin. Similarly, Borsewicz [15] compares high availability virtualization solutions from Microsoft and Vmware companies, Hyper-V and Vsphere in performance and availability tests. Finally, the work of Surahmat [16] allows a particular approach in a single hypervisor when analyzing the performance of Citrix XenServer in terms of processor use, network consumption, and memory use, concluding in the recommendation of the use of XenServer as an open-source option when looking for virtualization.

Regarding the power consumption of hypervisors, Jiang et al. [17] present a report on the energy efficiency of 5 hypervisors in different workload situations on the same hardware, concluding that there is not a great difference between each one since they use different characteristics to deal with workloads and consumption of energy. Virtualization, on the other hand, is a cost-cutting solution needed to maintain availability in a data center.

According to [26], it analyzes the use of this technology to obtain the optimization of resources in a company with 3 servers and limited financing, which seeks to implement 7 dedicated servers with high availability, with virtualization being the technological solution analyzed and implemented obtaining a reduction in costs in general and the optimal use of the servers by virtualizing 7 servers. In Nie's work [19], he shows the advantages of virtualization implemented in the servers of a university to reduce energy consumption, operation and maintenance costs, and improve the complex infrastructure. However, another investigation demonstrates the analysis of the application of virtualization in an IP cameras company, in which each server has the capacity to host 64 IP cameras, comparing the performance of physical and virtual servers in terms of use. of CPU, RAM and network using the virtualization software from the company VMware vSphere 5.5, with the conclusion that the use of virtualization did not cause a great impact on performance, the margin of difference being very narrow. We can conclude that the migration from physical to virtual servers does not greatly affect the servers' performance, but in the long term, it avoids the need to buy more servers thanks to virtualization so that the company can increase its IP camera capacity [20].

Likewise, the issue of security must be taken with relevance. Virtualization proposes multiple security options, isolation being the most important since each virtualized machine is independent of the other. If one of these suffers a data theft attack, the hypervisor can restore to a state prior to the attack without compromising the other virtual machines. Another security feature offered by virtualization is the multiple layers of abstraction between the hypervisor, the virtual machines and the physical components, which prevents knowing the hardware details of the host machine [21]. Despite these and more features that virtualization provides, it has given rise to the appearance of new vulnerabilities that can compromise the hypervisor. These vulnerabilities can be classified according to the origin and target to be attacked, being the guest-hypervisor the most dangerous since the hypervisor is responsible for receiving the instructions from the host machines and being able to simulate the necessary components, as well as provide the isolation feature, which will compromise all virtualized machines.

An example of this is the vulnerability reported by VMware in the SVGA II video codec and in the VMware ESX Server 4.0.0 software, with which it was possible to gain control over the vmware-vmx host process. It can be concluded that companies like VMware, Microsoft, etc., that offer this technology have given priority to the vulnerabilities reported and that are presented every day [27]. Thanks to these vulnerabilities, it has been possible to improve research on virtualization security. Sano presents us in his research how combining two types of virtualizations, machine and application, allows a server to be resilient to cyber-attacks that affect its activity [23].

From a national perspective, Lobaton's research [24] demonstrates the implementation of server virtualization in the data center of the Ministry of Transport and Communications to reduce investment costs in technology, minimize physical space, the possibility of scaling for future projects, and how this aligns with the organization's IT strategic objectives. An adapted sequential methodology was used to design the architecture to be virtualized with its subsequent implementation.

In conclusion, it was possible to implement virtualization with support for the infrastructure of the public entity, allowing a central administration and the possibility of creating new virtual servers that meet the organisation's needs. Based on what was described in the previous investigations, it was determined that virtualization technology is a solution that allows reducing costs in server infrastructure; in the same way, it allows the addition of new equipment in the long term and finally ensures the high availability of information thanks to the migration feature, allowing an improvement in the administration and security of the infrastructure.

3. Methodology

3.1. Waterfall Methodology

The execution of research will be conducted according to the cascade methodology. This methodology is carried out in several stages, which must be executed sequentially, following a descending order [25] (See Figure 1).

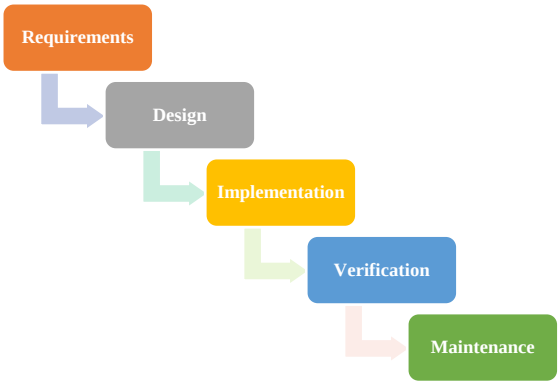

Fig. 1 Waterfall Methodology

3.1.1. Requirements Analysis

All requirements are detailed, especially the project software to be developed. These requirements should be documents for use in the next stage.

3.1.2. Design

At this stage, the requirements are studied, and the system design is prepared. This can be focused on four attributes: data structure, software architecture, procedural detail, and interface characterization. The plan for creating a virtualized environment for the servers of the Sedapal company data center, the architecture design, the hardware to be used, and its proper configuration will be defined.

3.1.3. Implementation

The software to be used is prepared, often in programs called units, which are integrated as a system to meet the design description of the environment to be virtualized.

3.1.4. Verification

The software units that make up the final product are evaluated, ensuring compliance with the requirements.

3.1.5. Maintenance

In the final and longest stage, the software can undergo changes, either due to errors not detected in the previous stage, the adaptation to new external changes or the change of requirements by the client.

3.2. Methodology Development

3.2.1. Requirements Analysis

We proceed to analyze the current situation of the state company Sedapal's computer equipment through inventories and reports, such as servers, terminals, and a connectivity diagram. With this information, we will proceed to evaluate the characteristics of the new virtualization infrastructure.

Sepadal has several data centers where its servers are housed around Lima. The main data center is located at Jr. Chota 998, Cercado de Lima, Lima. For this investigation, the Sedapal data center on Au Ramiro Prialé, El Agustino 15008, was chosen due to its old state in infrastructure that was found at the time of collecting the information shown in Tables 1 and 2.

Table 1. Total Hardware

Hardware	Total
Servers	58
Storage	2
Contingency	2
Personal Computers	1722
Laptops	197
Connectivity	292
TOTAL	2273

Table 2. Total Sedapal servers

S.O.	Environment	Location	Status	Total
Windows 2003	Development	Sedapal	Operative	1
Windows 2012	Production	Sedapal	Operative	1
Windows 2016	Production	Sedapal	Operative	1
Windows Server 2008 Enterprise	Production	Sedapal	Operative	24
Windows Server 2008 Standard	Production	Sedapal	Operative	4
TOTAL				**31**

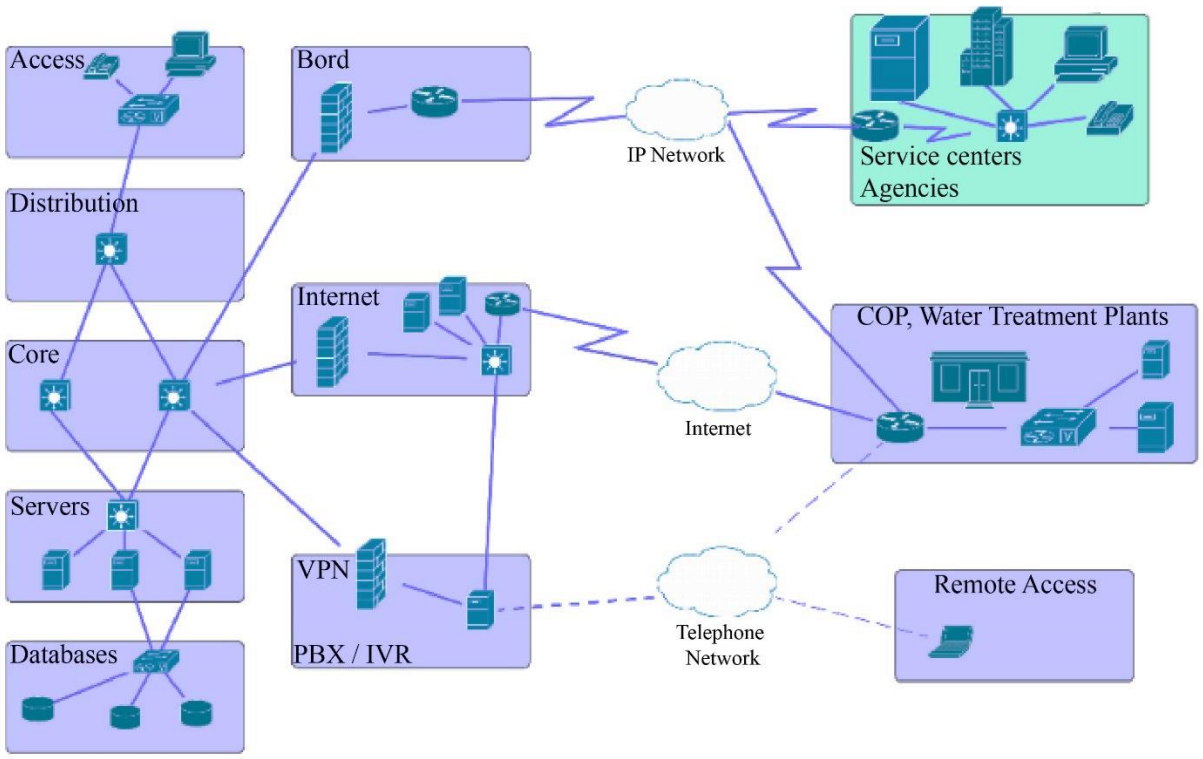

Fig. 2 Sedapal Atarjea Network Diagram

Regarding network connections, Figure 2 illustrates a representation of the architecture used in the Atarjea headquarters of the company Sedapal, which is a redundant architecture oriented to the availability and continuity of company operations. Sedapal's network hardware requirements are detailed in Table 3.

Table 3. Total Network Hardware

Connectivity	Total
Switches	18
Routers	3
Hubs	7
Others	4
TOTAL	32

3.2.2. Design

Once the current requirements to be virtualized have been obtained, the virtual infrastructure is designed. In this research, VMware vSphere 6.7 will be used as a virtualization platform, with different modules that help the organization take the infrastructure to virtualization in a detailed and less complex way. Figure 3 shows how the hypervisor, in this case, ESXi, enables the management of multiple virtual machines through a single administration center. Not only does it provide a web interface that allows the administration and creation of virtual machines, but it also allows the automation of many of the features of virtualization technology mentioned above and prepares them for a later infrastructure in the cloud, as shown in Figure 4.

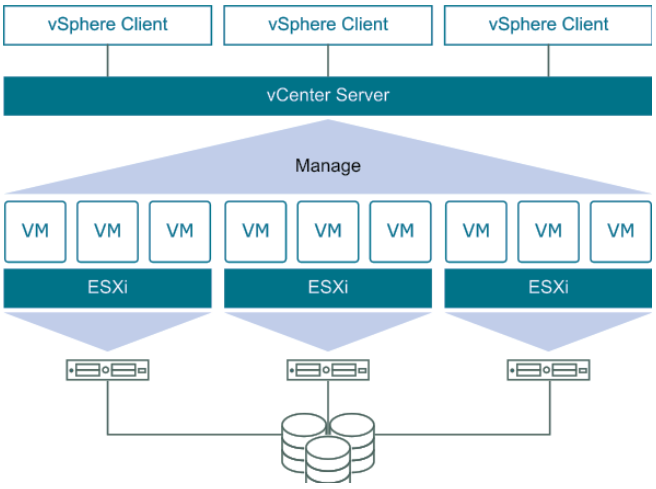

Fig. 3 Vmware Vsphere Infrastructure

After reviewing and analyzing the requirements, we proceeded to design the new infrastructure capable of supporting virtualized servers, which is detailed in Figure 5.

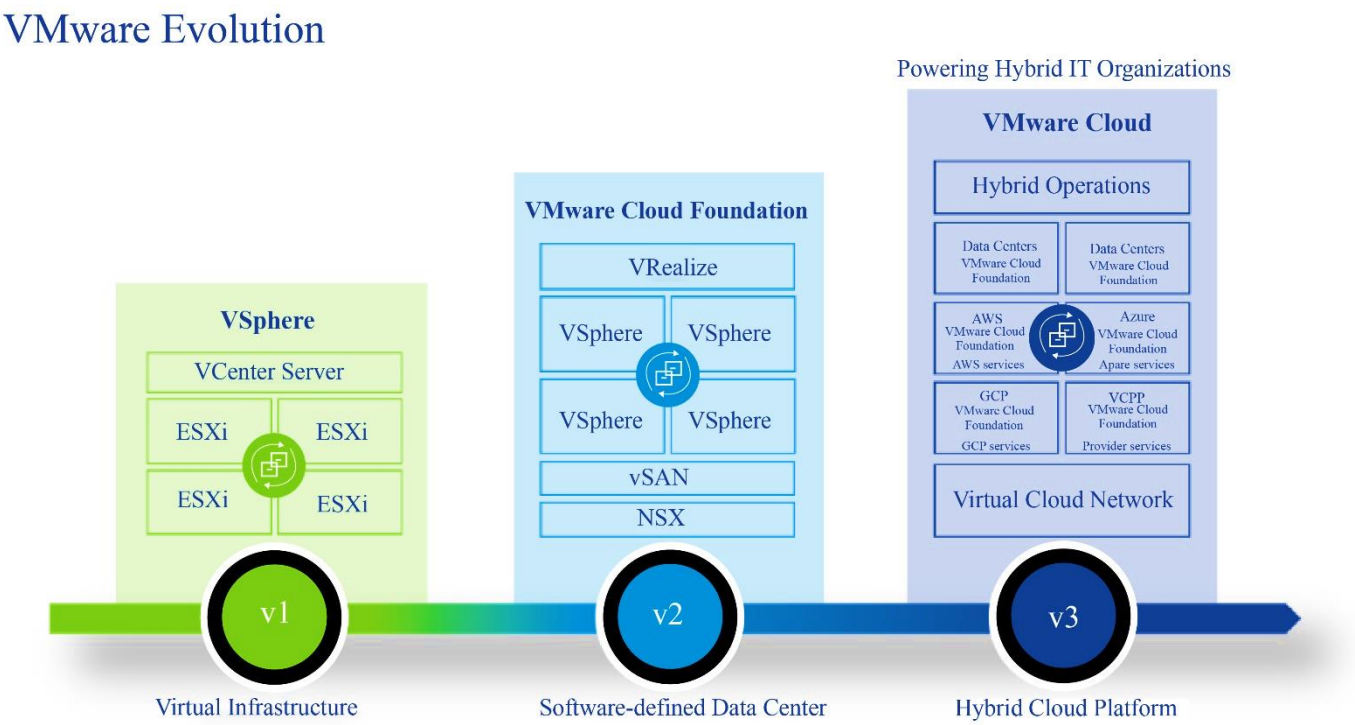

Fig. 4 Vmware Sphere Evolution

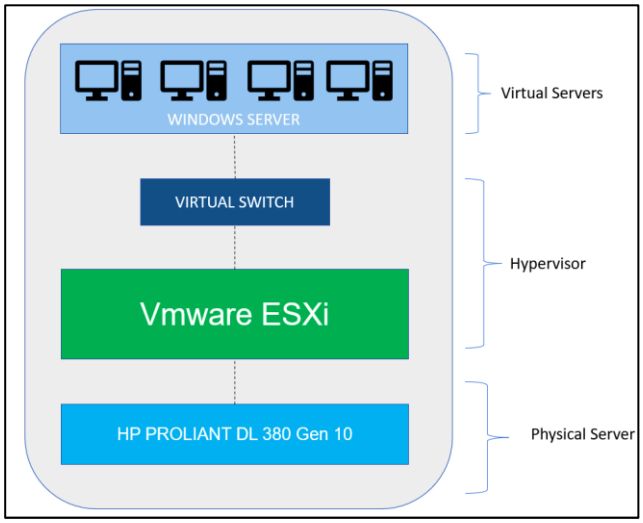

Fig. 5 Proposed Architecture.

4. Results and Discussions

4.1. Implementation, Verification and Maintenance

4.1.1. About Prototypes Implementation

Before proceeding with the implementation, the minimum requirements to virtualize a server must be known, which are the following:

• Host with at least 2 CPU cores.
• Multicore x86 and x64 bit processors.
• 4GB minimum, 8GB for business environments.
• Enable NX/XD in BIOS, in addition to Intel VT-x or AMD RVI on x64 CPUs.
- Network Controllers Gigabit, Ethernet.
- Storage disk, minimum 32Gb of space. Supports being HDD, NVMe or SSD

After identifying the minimum requirements, proceed to the installation of ESXi 7.0, which must be configured before creating the virtual machines. Figures 6, 7 and 8 points to the installation of ESXi 6.7.

Fig. 6 Installer Initialization

Figure 9 shows the end-user license agreement that must be accepted to use the software.

Figure 10 specifies where the hypervisor will be installed.

Fig. 7 Kernel Load

Fig. 8 Installation

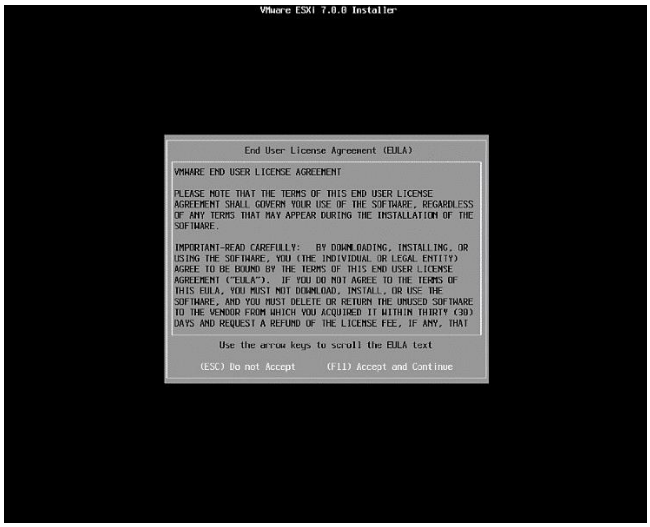

Fig. 9 End User Agreement

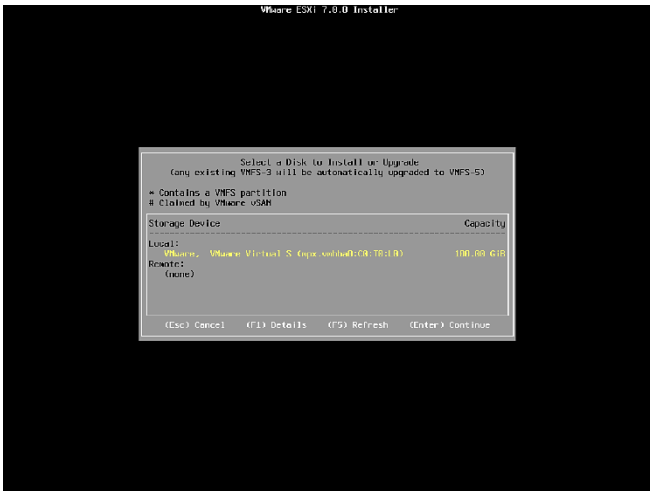

Fig. 10 Installation disk selection

The administrator has the option to change the keyboard configuration before setting the password that will be used to manage the hypervisor, as detailed in Figures 11 and 12.

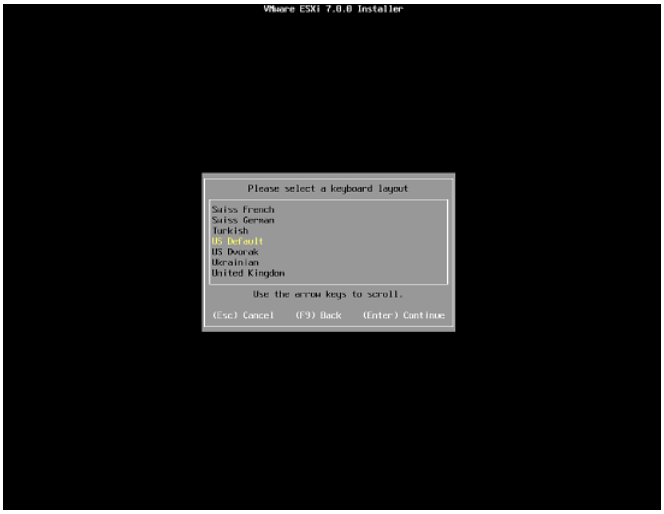

Fig. 11 Keyboard settings

Fig. 12 Password creation

Finally, a summary of the installation was shown and asked to confirm, as in Figure 13.

Fig. 13 Installation Confirmation

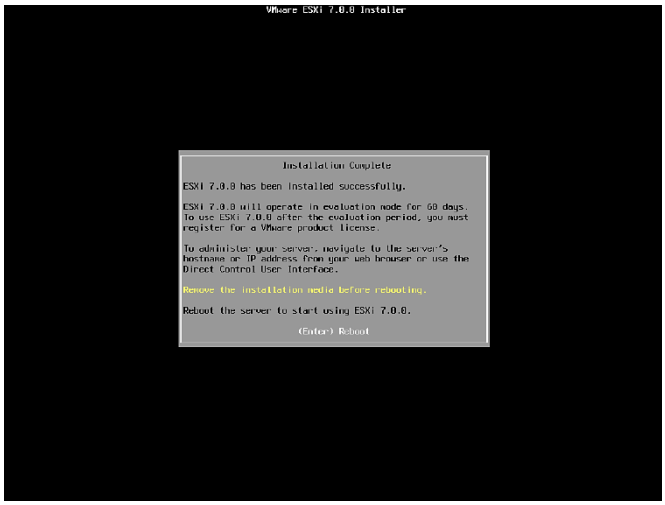

Fig. 14 Vmware ESXi installed

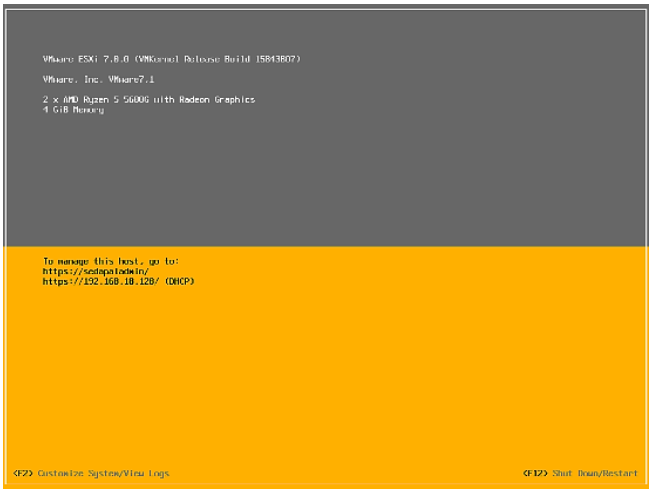

Fig. 15 Vmware ESXi on the server.

When the hypervisor is installed, it will show us the message in Figure 14 and ask us to restart.

Once these steps are completed, the server will start with the host operating system described in Figure 15.

When the ESXi host is already started, you must enter the link that has been previously configured by the administrator, for example, 10. X.X.X, as well as the username and password. Figure 16 shows the home screen of the ESXi web platform, which you must enter with the aforementioned data.

Fig. 16 ESXi web interface

Figure 17 details the status of the host server when entering the ESXi platform. Proceed to create the virtual machines specified in Table 2 with their respective operating system.

As shown in Figure 18, 31 virtualized servers were created, resulting in the virtualization of Sedapal's infrastructure. Each server is independent of the other, so each one will take the resources from the hypervisor to execute the functions the company wants.

4.1.2. Verification

The condition of the servers can be seen through the ESXi platform in Figure 19. It provides graphs of the state of the virtual server, as well as other components, events, logs, and so on.

4.1.3. Maintenance

The correct functioning of the servers must be confirmed, as well as the integrity of the information that each one entails. The ESXi platform provides different options to safeguard the integrity of virtual machines, as shown in Figure 20. Snapshot creation is the restore point that allows you to restore the virtual machine to a normal state before an incident or anomaly within the guest system. The Export tool allows the creation of Virtual Machine Disk (vmdk) files, which save the information of the virtualized hard disks, which can be read by other VMware company software.

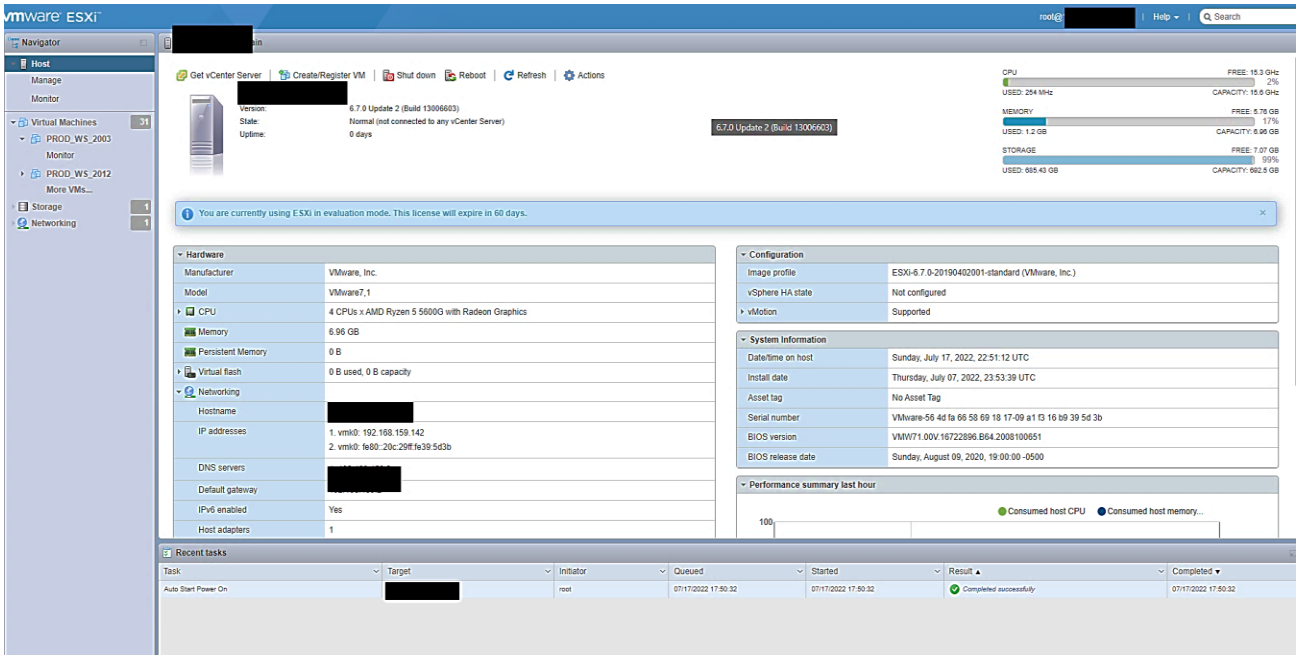

Fig. 17 ESXi web platform

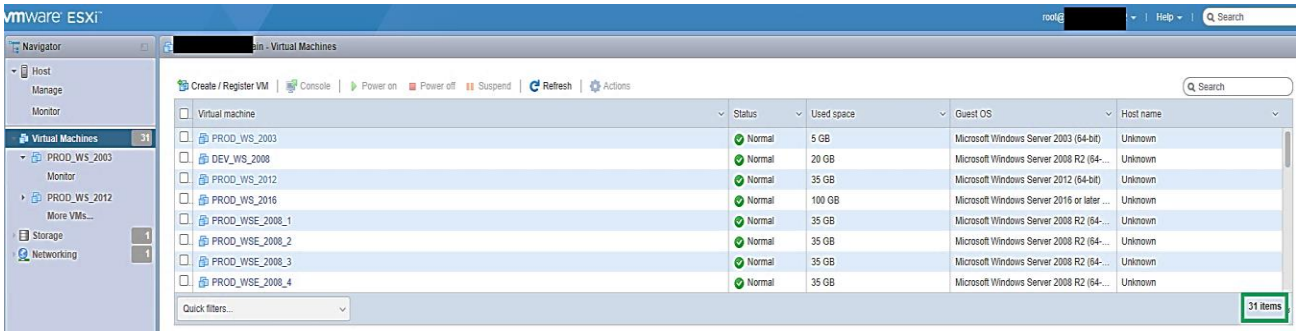

Fig. 18 Virtual machines created

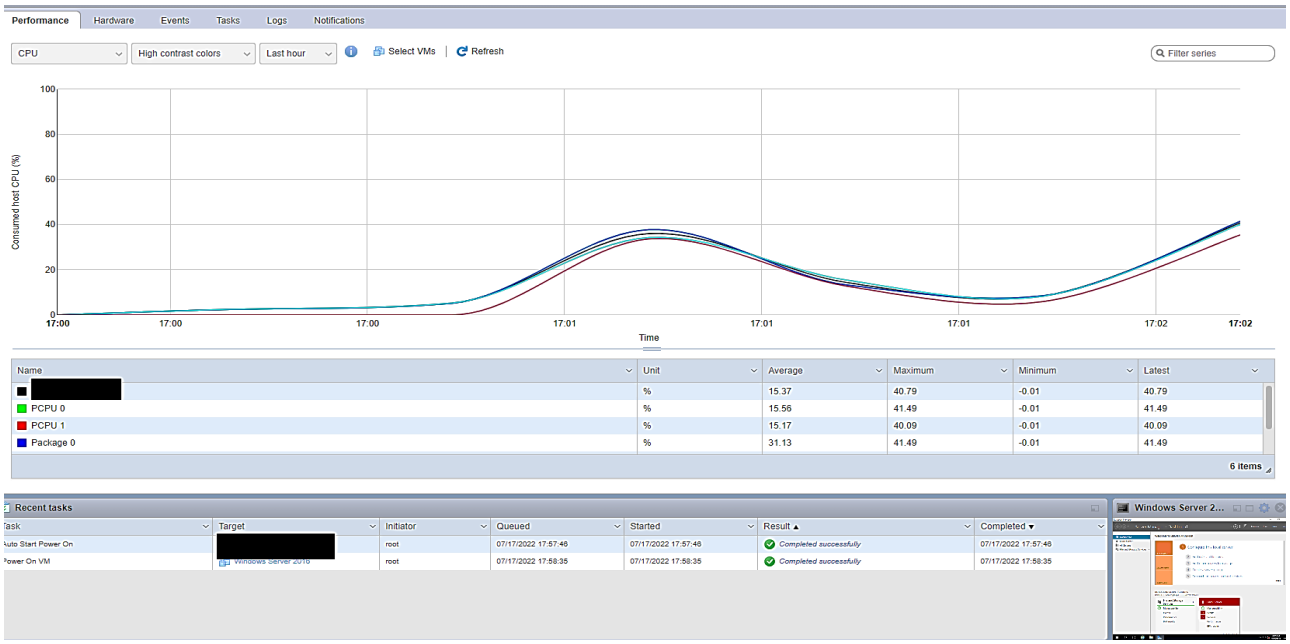

Fig. 19 ESXi Performance Graph

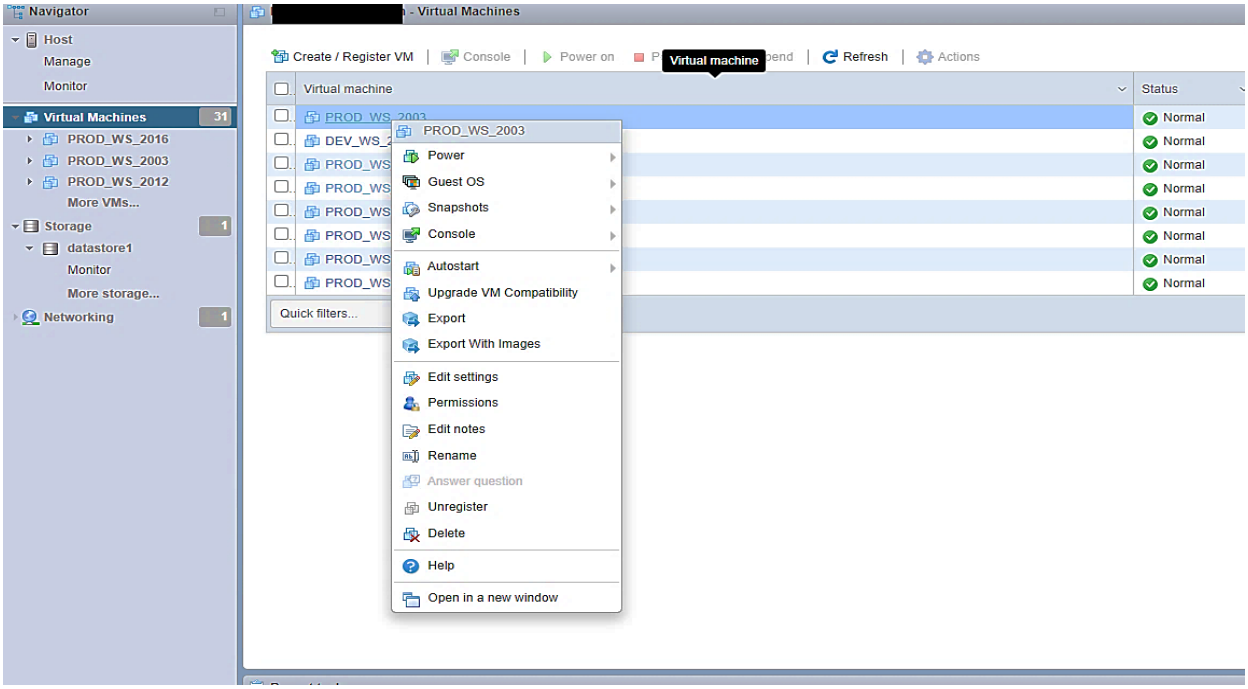

Fig. 20 ESXi tools

4.2. Discussion

Ali's research on the virtualization of servers for the optimization of resources indicates that the use of virtualization allowed the reduction of costs and the physical space of physical servers due to not having financing; in this research, it was verified that it is possible to reduce the physical space occupied by 31 servers to only one.

Rycaj's publication compares the different companies that offer virtualization and how Vmware leads this sector thanks to its solutions that converge with cloud computing, so in this research, it opted for its vSphere 6.7 solution that allows the virtualization of servers and groups multiple modules that allow taking the physical, technological infrastructure to virtual, and that they can make the next leap to integration with cloud computing.

Anbazhagu's research proposes the complementation of virtualization and cloud computing; in the research, this is affirmed since it is possible to manage virtualized teams remotely thanks to the web portal offered by ESXi.

5. Conclusion

In conclusion, it was possible to virtualize the physical servers of the data center of the Atarjea headquarters of Sedapal with the virtualization software Vmware vSphere 6.7. In addition, the prototype of the virtualized architecture was designed, which allows the virtual servers to be visibly structured and managed by ESXi. The design of a server virtualization plan allows for the reduction of physical spaces occupied by the servers, as well as the energy consumption and the power to provide high availability for the company through the creation of snapshots or export of vmdk files.

The waterfall methodology allowed to organize various stages sequentially so that it was possible to detail the series of steps to achieve the implementation of virtual servers with the VMware vSphere 6.7 virtualization software, which contains the ESXi platform capable of managing the new virtualized servers, from which they can be protected through snapshots.

However, the present research presents certain limitations, such as restricting other software functionalities in its free version, which would allow the management of virtual servers more efficiently. Also, the limited information collected from the company Sedapal due to the COVID-19 epidemic restricts the information on the current situation of the computer resources in the Atarjea headquarters. These limitations can be resolved with the purchase of the software and conducting a face-to-face interview at the facilities of the Sedapal data center by adopting biosecurity measures to avoid the spread of COVID-19.

In the same way, this research gives us an approach to virtualization technology and how companies like Vmware allow organizations to use this technology to reduce costs and grow in the long term. Likewise, the ESXi platform provides a virtual networking tool, which was not investigated given the scope of the project, but for future research, it is recommended as a research topic; in addition to all those interested in virtualization technology, the use of the other modules of the VMware vSphere software.

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