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Container Ecosystem and Docker Technology

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ABSTRACT

System resource use is a big problem in the field of informatics. Developers are constantly looking for new ways to solve this problem. Virtualization of data centers and moving to cloud environments are some of the solutions produced. In these methods, virtualized servers are used to run and publish applications in isolation. Servers used for dedicated software in cloud computing environments are still not used with the desired efficiency. For this purpose, container technology has been developed so that many applications can be run isolated from each other in the same server environments. With this method, CPU, memory, network and disk (volume) can be defined for more than one application on the same server. Today, cloud computing companies and technology companies are rapidly turning to container technology. In this study, the development of container technology, its types and common usage methods are explained.

KEYWORDS: *Virtualization, Container, Docker, Linux Container, Docker Container, Lxc*

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I. INTRODUCTION

Current problems trigger technological developments. Especially the problems encountered in the field of informatics have been the reason for many innovations and developments in this field. In recent years, virtualization platforms have been widely used in order to use system resources effectively in the field of informatics. Traditionally, companies run their own servers for specific tasks dedicated to them. DNS server, Active Directory server, E-mail server, dhcp server roles are some of the tasks that servers are dedicated to. With virtualization, a large number of servers with different roles can be run on one server. [1]. The operating system and applications are installed on virtual machines created on the hypervisor installed on the existing physical machine for virtualization [2]. System resources of the physical machine are shared with virtual machines hosted on the hypervisor. Today, most of the cloud providers actively use virtualization technology [3]. Container technology is a technology that has been popular in recent years. Container technology can be used alongside virtualization technology as well as to run isolated applications on physical machines without virtualization.

II. VIRTUALIZATION TECHNOLOGY

Today, virtualization technologies enable the simultaneous use of more than one computer on a machine [4]. With this technology, it is a system that allows the processor, memory, disk and network resources on the physical computer to be shared by many isolated operating systems [5]. In summary, it divides a physical structure into logical parts. It provides flexibility as well as reducing costs, preventing loss of labor, high efficiency. Virtualization at the operating system level is the most widely used method [6]. In addition, there are virtualization types that vary according to need, such as desktop virtualization, network virtualization, session virtualization, application virtualization, storage virtualization [7]. Virtualization platforms can be installed directly on hardware (Vmware ESX Server, Hyper-V Server) as seen in Figure 1, or they can be installed on an operating system (Hyper-V, Virtual Box, Vmware Workstation).

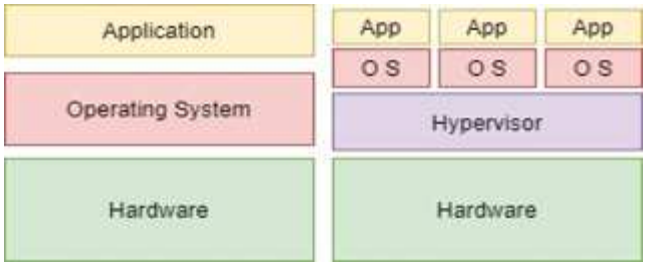

Figure 1 Comparison of traditional and virtual server architecture

According to a study conducted in 2019, 75% of institutions use virtualization technology. It is predicted that this rate will approach 100% in the following years. Server virtualization is the most preferred type with 92%, and network virtualization is the least preferred type with 30%. [8].

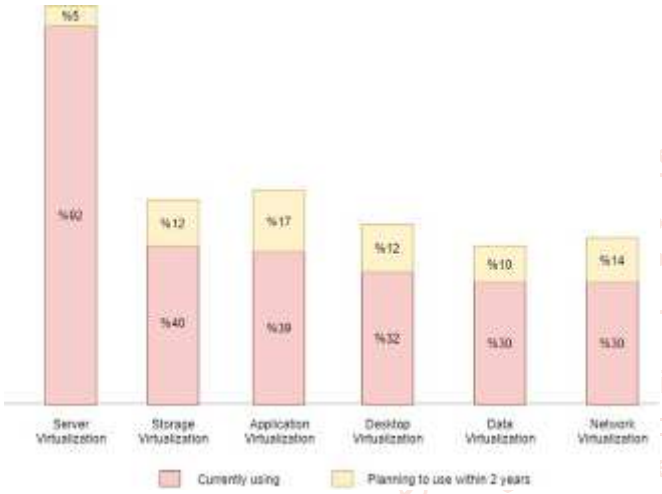

Figure 2 Types and usage rates of virtualization

As seen in Figure 2, although server virtualization has the highest usage rate, corporate users are looking for alternative solutions. 18% of IT decision makers prefer to use containers instead of virtual machines in some cases. 30% of businesses consider using containers instead of virtual machines [8].

III. CONTAINER TECHNOLOGY

Container technology is a technology that can run any application on a different machine in the desired operating system without the need for hypervisor software. On the basis of this technology, only executable files and libraries related to the application are used without being dependent on the operating system. This ensures effective use of system resources.

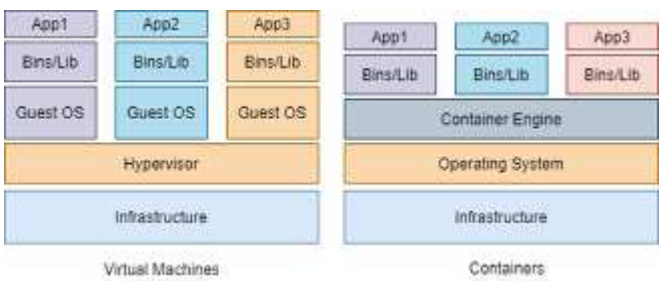

Figure 3 Comparison of virtualization and containerization

The Chroot feature, which was found in the Unix operating system in 1979, can be accepted as the beginning of the container technology. Thanks to this feature, it is possible to access another operating system file system and run commands through the Unix operating system. In 2000, the ability to create IP addresses, services and processes independent of the host machine with the Jail tool in the FreeBSD operating system contributed to the development of container technology.

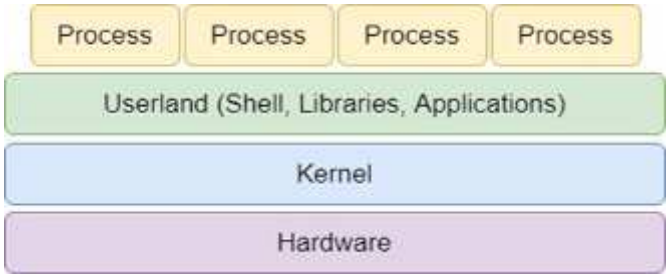

Figure 4 Jail system running programs in isolation

With the improvements made in the Linux operating system, container technology has reached a different level. After the kernel-based virtualization called Open VZ in Linux in 2005, a Linux kernel module called Process Containers was designed by Google engineers in 2006. This module could restrict the resource usage of processes running in the operating system. Container use was supported with LXC (Linux Containers) released in 2008.LXC does not require additional software to run on the Linux kernel and isolate applications. In this respect, LXC is similar to virtual machines. However, since LXC configuration is difficult, it has not been widely used by the end user.

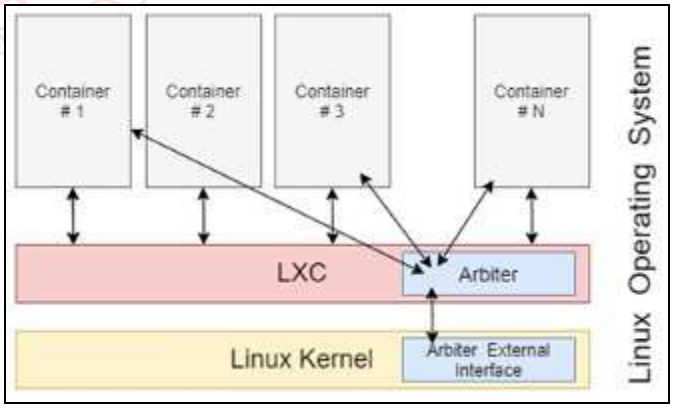

Figure 5 LXC architecture

In 2011, Cloud Foundry announced first LXC versions and then company-specific software with the project named Warden. Thus, the control of the containers running in the background over more than one machine has been ensured. After these developments, the container management platform called Docker was published in 2013. Container technology has been undergoing rapid change and

transformation since its emergence. The process is still ongoing. Problems that are important for institutions are solved quickly. The advantages of container technology can be listed as follows [9]:

- It saves resources. Small-sized software and big jobs can be done in small spaces. These things are done very quickly.
- It is low cost. It does not require extra investment for software and hardware.
- Deployment and configuration process is easy. The installation process takes place with simple commands. In case of problems, the process of stopping, restarting and destroying is easy, and additional containers can be run in case of overload. Cluster operations are simple.
- Provides a consistent testing environment. Container installations are made by following a certain route. Thus, a consistent path is followed from the creation of the code to the testing phase.

Today, there are container types developed by different companies. However, they all use the Linux namespaces and cgroups management mechanisms provided by the Linux operating system kernel. LXC, LXD, OpenVZ, Rkt, Docker, Kata and Podman are common container management platforms. The most widely used management mechanism today is Docker.

IV. DOCKER TECHNOLOGY

Docker is an open source platform that simplifies application development and execution using container technology. With the Docker platform, containers have become the industry standard. Thus, it can be easily transported to different machines. Because containers share the operating system core, it does not require a per-application operating system, increasing server efficiency and reducing costs. It is reliable due to its insulation feature.

The Docker platform is a solution that allows applications to be quickly built, tested, and deployed. It has a structure that packages and runs containers regardless of the operating system it is running on. Docker is easy to use from the enterprise level to the end user. It has facilitated the use of containers with its installation package that can run on different operating systems (Windows, Linux, Mac Os).

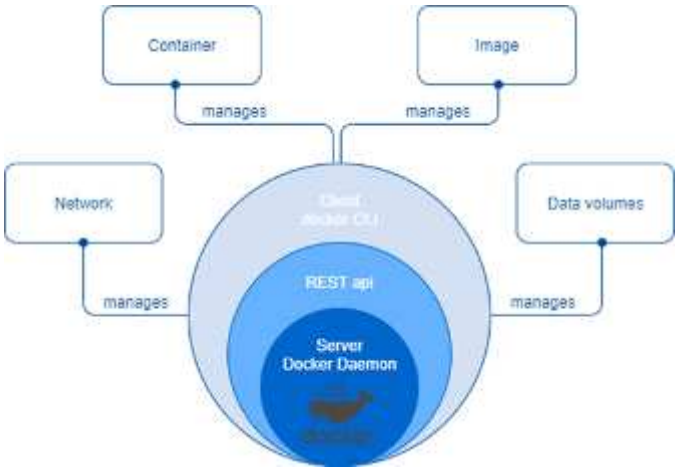

Figure 6 Logical design of docker server

As seen in Figure 6, containers on the Docker platform run on Docker Engine. Containers work in a virtual machine-like structure [10]. More than one container can run on the same machine. It can share the same processor core. It takes less space on the disk than the virtual machine. Container images are usually tens of megabytes in size.

In Docker architecture, clients and servers can run on the same machine as well as on different machines. Client requests running on the same machine are forwarded to Docker Daemon. Docker Daemon handles api requests, image, container operations.

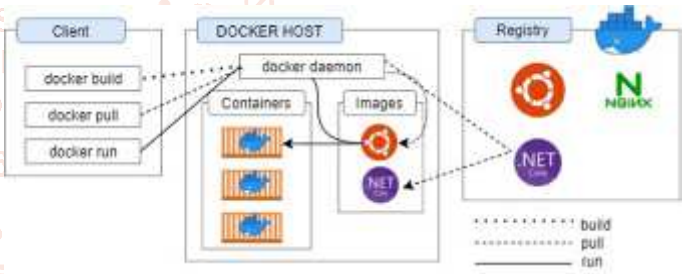

Figure 7 Docker container usage processes

As seen in Figure 7, Docker images are ready-made templates for containers. These templates are downloaded to the machine where the Docker platform is installed, a copy is created and this copy is run. Docker images contain the metadata required for the container to run [11]. Multiple containers can be run from the same Docker image. If the Docker image to run on the host is not found, the Docker Registry is searched. The found image is loaded onto the host and a copy is run. Docker images are stored in the Docker Registry (hub.docker.com) by default. Users can save the images they have created in a different recording medium if they wish. In addition, they can run images from different providers by uploading them.

Software that will use Docker container technology must be written in REST architecture for compatibility. REST (REpresentational State Transfer) is a distributed system that receives responses from the server with requests such as GET and POST using the HTTP protocol. Docker technology brings with it some concerns as well as the benefits it provides. Security concerns are the most important of them. In addition to the security of the physical environment where a top secret project will be run, the operating system to be used in the images where the application will be included, the vulnerabilities of the libraries can endanger sensitive projects. For this reason, it is necessary to carefully select the operating system core, database applications and add-ons that will be needed. While creating the container image, using official images and images published by reliable distributors will prevent possible problems.

V. RELATED WORKS

Virtualization and container technology are current issues in the IT industry. Thousands of studies have been done in this area and some of the recent studies are selected in this section. In a study on the performance of containerization platforms with virtualization, it is stated that under some conditions, containers can bring more processor load than the virtual machine, and containers running on virtual machines can reduce this load for certain applications. In addition, containers with many cores have lower overhead than containers with several cores [12].

In the study investigating the differences between virtualization and containerization for IaaS, PaaS and SaaS platforms used in cloud architecture, it was seen that container environments are much better in terms of PaaS, containers can process more threads per second in terms of SaaS, but the performance of the basic infrastructure is almost the same in terms of IaaS [13].

In another study, hypervisor-based virtualization and container-based virtualization application were compared for High Performance Computing applications. The study showed that Docker container imposes very low overhead compared to VMware virtualization environment [14]. In a study examining energy efficient approaches other than virtualization for modern data centers, the cumbersome structure of virtualization technology and the fast and light workload approach of container technology are explained. A hybrid cloud proposal is made for data centers planned to be established in the future [15].

In another study, which proposes container architecture for edge computing in smart homes, the processes of transforming deep learning models into containers in a smart home environment to overcome memory and computing constraints between smart devices were examined [16]. In another study, the issue of quality of service (QoS) in computing systems and dynamic scalability schemas and models for data centers with high performance were examined. Proposed a dynamic scaling model based on queuing theory to scale container virtual resources and meet customer service level agreements (SLAs) [17].

In a study on containerization for reproducible analysis, it was stated that in containerized analyzes reviewers can be safe for third-party code execution, containerization mechanics are easy, containers are a good solution for sharing codes easily [18]. Another article on container-based traffic generation for machine learning presents a new data generation framework based on Docker containers. Container technology can be used in every field besides virtualization technology, which is still widely used.

Along with the studies described above, there are potential areas in the literature where the concepts of docker and container can be applied. Potential areas include archive management systems [19], [20], distance education software platforms [21], fog or cloud computing applications in healthcare [22], and even the Internet of Things [23].

VI. CONCLUSION

Virtualization technology is actively used in institutions and cloud structures today. Virtualization technology is used at a rate of 92% for server virtualization, especially in cloud environments, and it is expected to grow by 5% in the coming years. Of the other virtualization methods, storage virtualization is used by 40% and application virtualization is used by 37%, and it is estimated that storage virtualization will grow by 12% and application virtualization will grow by 17%. This shows that virtualization technologies will be actively used at increasing rates in the near future.

Container-based virtualization, on the other hand, shows that its use has become widespread in small scale and experimental environments. According to studies, it is stated that container-based applications reduce the workload, increase performance and increase efficiency compared to traditional virtualization applications. In addition, no significant performance difference was observed between classical virtualization and container-based applications in IaaS (Infrastructure as a Service) applications.

Since container-based virtualization applications are still a new technology compared to classical

virtualization, it creates security concerns. However, since container technology is in a constantly evolving structure, solutions are produced for problems. Cloud providers offer users container-based solutions alongside existing virtualization solutions. This situation presents signs that container technology will be the technology of the near future.

Docker container technology is widely used because of the ease of installation and use it offers for the end user outside of the institutions. The fact that it can be used in different operating systems and is easy to access various container images increases its widespread effect.

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