Virtualization in Distributed System: A Brief Overview

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Abstract. Virtual machines are popular because of their efficiency, ease of use & flexibility. There has been a growing need for the development of a resilient distributed network in order to maximise system performance while lowering infrastructure costs. The creation of a robust distributed network has become more important in order to improve system performance while minimising infrastructure costs. The paper gives an overview of various types of virtualization techniques & their benefits. For eg: Server virtualization helps to create multiple server instances from one physical server. Such techniques will decrease the infrastructure cost, make the system more scalable & help in full utilization of available resources.

Keywords: Distributed system, virtualization, hypervisor, technology, virtual machine.

INTRODUCTION

The concept of virtual machines has been in the computing community since the early 1960s [8]. Virtualization technology has recently advanced, allowing for new options in service delivery & representing a strategic approach for IT managers to improve their organization’s performance. The virtualization technology provides a secure, isolated system that may be deployed in a variety of ways. These strategies increase the distributed systems’ dependability, scalability, & fault tolerance [11].

A distributed system, also known as distributed computing, is a system that consists of a collection of independent components that are situated on multiple machines & communicate & coordinate activities with one another over a network. All of the nodes in this network interact & coordinate with each other to complete tasks & it appears as a single coherent network to the end-user. The system is highly efficient as the workload is splitted & distributed to various nodes for fast completion. The task running in different nodes forms a common system where multiple machines can process the same function at the same time. Because each node performs computing independently, adding additional nodes & functionality as needed is straightforward, cost-effective, & fault-tolerant.

Virtualization is the process of creating virtual instances of a computer system abstracted from real resources like OS, storage device or network system. With it, multiple instances can run independently & simultaneously on a single system. Technology advancements have propelled virtualization to the spotlight of the IT sector. This technology encompasses a variety of mechanisms & techniques that addresses various problems such as performance, reliability, security, resource expenses which are the reasons for the rise of this technology.

Distributed virtualization is the process of transparently sharing resources from several users [15]. Each node is isolated & doesn’t interfere with each other. It helps the end user to access, store, analyze & organize the distributed system components. There are various types of virtualizations that can be used to increase the performance in distributed systems. Some of them are OS virtualization, storage virtualization, network virtualization. Each of them has their own paradigm that offers a reliable, secured & cost effective distributed system.

This article provides an overview of virtualization, including its types & advantages. The rest of the paper is organized as literature review in section “Literature Review”, different types of virtualization techniques & their benefits in section “Different Types of Virtualizations and Their Benefits” & final section with a conclusion note.

LITERATURE REVIEW

The paper [2] presents an x86 virtual machine monitor, Xen hypervisor that enables multiple operating systems to share conventional hardware in a secure &
The advantages of both, making it suitable for offering high-performance cloud services such as high-availability, replication, elasticity, load balancing, resource management, & process migration.

The paper [6] investigates container-based virtualization as a lightweight alternative to hypervisor-based virtualization that may be used on smart objects to improve IoT Cloud service provisioning. It is sometimes referred to as operating system level virtualization since it splits the actual machine’s resources, resulting in several separate user-space instances. It enables IoT Cloud providers to install & assess its performance on smart things in an IoT environment in terms of cloud service management & commercial potential. The two primary container usage models are Application Container, which runs a single application in the container, & System Container, which runs several isolated instances of user space at the same time, each with its own Init process, process space, file system, & network stack. This technology is also supported by SBC (Single Board Computer) devices equipped with a Linux Container Virtualization (LCV) layer. Docker, LXC, lxcmtf, & OpenVZ are some common container engine options. An experiment is carried out using a Raspberry Pi & the Docker container engine to evaluate the device’s response when no container & numerous containers run in various configurations that may be used in real-world use cases. The results show that the overhead of container virtualization is minimal when compared to the overhead of CoAP servers processing requests.

The paper Service Level Enforcement Discipline for Storage (SLEDS) system [7] gives statistical performance guarantees on a storage system constructed of commodity components. It is a distributed controller that controls client workloads in order to achieve QoS objectives. It guarantees that each client’s storage performance is good as if a subset of physical resources were dedicated to it & unaffected by the behavior of other clients. It does so by collecting performance samples on a regular basis & throttle (delaying) I/Os from overly-demanding clients whenever other clients suffer poor performance. It will shift resources away from apps that are receiving satisfactory QoS & toward those that are doing poorly. The reliability & performance of I/O service is maintained by decoupling the gateway from communications with the server & is based on a storage area network system for block-level storage service. They concluded from testing the prototype with heterogeneous clients that the system will facilitate both the consolidated & non-consolidated worlds, where applications will benefit from the reliability of high-end storage devices & will no longer suffer performance failures due to resource constraints.

The research [12] presents an architecture called Advanced Cloud Protection System (ACPS) for monitoring the integrity of guest virtual machines & cloud infrastructure components while being completely invisible to both the service user & the service provider. It demonstrates how virtualization might improve cloud
Table 1. Table representation of above-mentioned related work.

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Objective</th>
<th>Algorithm/Mechanism</th>
<th>Tools/Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barham et al.</td>
<td>2003</td>
<td>enable users to dynamically instantiate an operating system to execute whatever they desire</td>
<td>Borrowed Virtual Time (BVT) scheduling algorithm</td>
<td>2.4 GHz Xeon server with 2GB RAM, a Broadcom Tigon 3 Gigabit Ethernet NIC, and a single Hitachi DK32EJ 146GB 10k RPM SCSI disk.</td>
</tr>
<tr>
<td>Chambliss et al.</td>
<td>2003</td>
<td>statistical performance guarantees on a storage system and improve its effectiveness of the</td>
<td>Leaky bucket mechanism</td>
<td>IBM xSeries 345 servers, with a 2.4 GHz Intel Xeon processor and 512 MB (client)/2 GB (gateway) RAM, FC SAN fabric</td>
</tr>
<tr>
<td>Raj et al.</td>
<td>2007</td>
<td>investigate the implications of virtualization for the high-performance domain, virtualization of peripheral resources.</td>
<td>round-robin scheduling algorithm</td>
<td>XPF2400-based ethernet board</td>
</tr>
<tr>
<td>Lombardi et al.</td>
<td>2011</td>
<td>Identify the security issues of cloud computing and provide a solution to the issue.</td>
<td>Based on (KvmSec: A security extension and KvmSma: Security management architecture) for the Kernel Virtual Machines</td>
<td>Python, livibirt, Mysql, Turbogears</td>
</tr>
<tr>
<td>Celesti et al.</td>
<td>2016</td>
<td>Explores container virtualization to analyze its performance on smart objects from the perspective of a IoT scenario</td>
<td>Container based virtualization, Linux Container Virtualization (LCV)</td>
<td>Raspberry Pi and Docker container engine</td>
</tr>
<tr>
<td>Pessolani et al.</td>
<td>2019</td>
<td>integrates Virtualization and DOS technologies to take the benefits of both and making proposed system suitable to deliver provider-class Cloud service</td>
<td>load balancing, process migration, consensus, fault detection mechanism</td>
<td>POSIX APIs, RPC protocol</td>
</tr>
</tbody>
</table>

computing security. It protects the guest virtual machines from intruders & attacks such as worms & viruses. The paper highlights various issues of cloud computing such as user access, privacy, data segregation, recovery mechanism & develops a prototype to address those issues. The suggested ACPS prototype has been completely developed on two open-source solutions: Eucalyptus & OpenECP, & its efficacy & performance have been evaluated. The findings show that the system is resistant to attacks & incurs minimal overhead.

About mentioned reviews are mentioned in short in below table.

DIFFERENT TYPES OF VIRTUALIZATIONS & THEIR BENEFITS

Storage Virtualization

Storage virtualization is the technique of combining many physical storage arrays from a SAN & making them seem as a single virtual storage unit. The technique entails abstracting the discs & drives & presenting them as a single storage unit in order to simplify application & network-independent storage management. It collects information about the amount of storage capacity available across physical storage components, aggregates it, & makes it available to applications [5]. It provides better utilization & management of storage in heterogeneous environments. Storage virtualization helps to address this issue by making backup, archiving, & recovery processes easier & faster.

Some of the virtualizing storages are:

- **Simplicity:**
  It simplifies the IT environment as it eliminates complexities related to data centers by reducing the amount of hardware needed to run applications. It allows for dynamic storage use as well as virtual scalability of associated storage resources.

- **Affordable**
  It reduces costs related to hardware & other operational cost as it masks the complexities of managing infrastructure & resources in memory, networks, servers & storage.

- **Storage Utilization**
  It helps in properly partitioning the storage. The most frequently used data is kept in the best performing storage pool, whereas the least frequently used data is stored in the lowest performing storage pool. They may be recovered rapidly from virtual storage.

Operating System Virtualization

OS-level virtualization is a technique that splits the normal operating system to create many separate Virtual Machines (VM), allowing numerous users to execute various programmes on a single machine at the same time. An operating system’s kernel supports several isolated platform instances. Containers or virtualization engines are the names given to such instances. This approach is installed on an existing operating system, which is referred to as the host operating system [10]. The operating system in
OS-level virtualization is configured in such a way that it behaves like numerous other, independent systems. The virtualized environment allows instructions from several users running various apps on the same system without interfering with one another. It provides application-transparent virtualization to users by isolating apps from the OS & offers granular control for individual applications.

The advantages of operating system virtualization are as follows:
1. Save time & cost as the user does not require to install extra hardware support. Fewer machines mean minimal maintenance, less power, higher electrical saving, & less cooling systems requirement
2. As every instance of this system is virtual, no extra space is occupied by it.
3. It is not only compatible with small businesses but also useful for large businesses.
4. By integrating server hardware, OS Virtualization distributes resources across individual servers.

Network Virtualization

Network virtualization is the act of converting network services by combining available network resources to condense many physical networks into a single virtual, software-based network [16]. It abstracts network resources from underlying hardware & enables virtual network deployment. Each network is safe & independent of the others, & each network may be assigned to a specific server or device in real time. Every client has shared access to all network resources from a single machine. Internal virtualization, which gives software containers network-like capabilities to imitate the functionality of a single network server, & external virtualization, which merges numerous local networks into a single virtual unit, are the two forms of network virtualization. It intends to optimize network speed, improve productivity, manage network security of an organization.

Some of the benefit of network virtualization are:

- **Faster Delivery of Application:**
  Network virtualization automates network configuration which reduces the deployment time allowing for faster delivery of product rollouts or major application updates.

- **Enhances Security**
  Sensitive data is isolated from one virtual device to another. So, access to nodes is restricted making data more secure.

- **Improves Manageability**
  Functional grouping of nodes in a virtual network are eased. Virtual networks can share the same physical network which enhances the utilization of network resources & allows communication between nodes.

Application Virtualization

Application Virtualization also known as process-level virtualization is a technology which allows users to access & utilize an application from a computer or separate device other than the one on which it was installed as if it were installed on a user’s local device. It is useful when you simply want to virtualize only an application. The server-based technique is the most common method to virtualize applications [1]. Remote applications can be set up on a server by a service provider & are sent to an end user’s computer. The user’s instructions are sent back to the server to be executed. User experience is the same as that of an app installed on the real system.

Some of the benefits of virtualized application are:

- **Simplified Management**
  Instead of manually installing apps on each user’s workstation, IT administrators simply install an app once on a central server & then distribute it as required on user devices via app virtualization making it easier to manage & maintain application.

- **Scalability**
  Virtual applications can be deployed in any connected device regardless of that device’s operating system as the app is actually running on the centralized server. This will lower the organization hardware computing cost. As remote services, many companies also share application access. It results in reduction of software & infrastructure costs. Such cost reductions are obtained by reducing organizational needs for several servers, which benefits in decreased maintenance & power costs.

- **Security**
  Security is maintained across several users. The IT admin is responsible for managing resources & controlling user access to the particular application. If a user’s device is lost then the IT admin can revoke sensitive data through remote access.

Server Virtualization

Server virtualization is the technique of separating a single physical server into numerous distinct server instances, each with its own operating system. A slew of little virtual servers, each separated from the others. It is a cost-effective way to provide web hosting services & has boosted resource utilization to the fullest, without having to invest more in hardware. For creating virtual server instances, a virtualization software layer called hypervisor is added to a host machine [3]. Hypervisor separates host’s physical resources from virtual instances. Virtualization software may then be used to imitate the actual resources & construct a new virtual server on top of them.
Some of the server virtualization benefits are:

- **Server consolidation**
  Virtualization enables partition of a single server onto server servers. As a result, the overall number of servers in the company might be lowered. Server consolidation is the term for this procedure.

- **Cost reduction**
  By maximising the usage of existing resources, server consolidation reduces expenses. This minimises the amount of energy required to power the servers while also eliminating administration expenditures.

- **Saves Space**
  By hosting several virtual servers on fewer physical servers, we can possibly save a significant amount of physical space.

**CONCLUSION**

The paper presents an overview of virtualization in distributed systems. Various papers related to virtualization like Xen hypervisor, container-based virtualization, security of cloud computing, storage performance is discussed in this paper. Also, different types of virtualization techniques with its benefits are described. In conclusion, Virtualization in distributed systems enhances performance, reliability, fault tolerance, flexibility, scalability & minimizes infrastructure cost of an organization. As resources are shared transparently among the nodes, security, privacy & network management are some key concerns that need to be optimized to make the virtualization more secure & organized.

**REFERENCES**


