ADUSUMILLI GOPALAKRISHNAIAH & SUGARCANE GROWERS
SIDDHARTHA DEGREE COLLEGE OF ARTS & SCIENCE

Vuyyuru-521 165, Krishna District, Andhra Pradesh

An Autonomous College in the Jurisdiction of Krishna University

Accredited by NAAC with "A" Grade

VAD COURSE :: CLOUD COMPUTING

VAC CODE:CCVAC13

CLASS:III B.SC(MCCS)

DURATION :30 DAYS

DEPARTEMENT OF COMPUTER SCIENCE

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Vuyyuru-521165, Krishna District, Andhra Pradesh
(Managed by: Siddhartha Academy of General & Technical Education, Vijayawada-10)
An Autonomous College in the Jurisdiction of Krishna University
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DEPARTMENT OF COMPUTER SCIENCE

Value Added Course
Title: CLOUD COMPUTING

Name of the Lecturer	:	A. NAGA SRINIVASA RAO
Class	:	III B.SC (MCCS)
Duration of the Course	:	30 HOURS
VAC Code	:	CCVAC13

Title: CLOUD COMPUTING

Objectives :

1. Data Recovery: Cloud computing enables easy and reliable backup and restoration of data stored in the cloud.
2. Low-Cost Services: Cloud computing reduces the need for investing in expensive hardware and software, and offers pay-as-you-go pricing models.
3. Security: Cloud computing provides encryption, authentication, and access control mechanisms to protect data and applications from unauthorized access or cyberattacks.
4. Mobility: Cloud computing allows users to access data and applications from anywhere and any device, enhancing productivity and collaboration.

Methodology : Teacher - Centered method

Duration : 30 Hours

A.G. & S.G. Siddhartha Degree College of Arts & Science

Vuyyuru-521165, Krishna District, Andhra Pradesh

Value Added Course

Student Enrolment Sheet

Class : III B.SC (MCCS)

S. No	Roll No.	Name of the Student	Signature
1	20.701	Vemula Kavya Naga Sri	V. kavya naga sri
2	20.702	Dronadula Hemanjali	D. Hemanjali
3	20.703	Dekka Kavitha	D. Kavitha
4	20.704	Jujjuvarapu Venkateswara Rao	J. Venkateswara Rao
5	20.705	Mirza Hasan Abbas	M. Hassan Abbas.
6	20.706	Marepalli Venkata Naga Sai Pavan Kumar	M. V. N. Sai pavan kumar
7	20.707	Aluri Bhavya Sri	A. Bhavya Sri
8	20.708	Samayamanthula Sandeep	S. Sandeep
9	20.709	Kalapala Dinesh	K. Dinesh
10	20.710	Jogi Gowthami	J. Gowthami
11	20.711	Jonnalagadda Kusuma	J. Kusuma
12	20.712	Perlapudi Pranadeep	P. Pranadeep
13	20.713	Devabathina Satyadev	D. Satyadev
14	20.714	Somayajula S.M.K.Chaitanya	S.M.K. Chaitanya
15	20.715	Vukoti Naga Veera Sai	V. Naga Veera Sai
16	20.716	Surisetti Navya	S. Navya
17	20.717	Todeti Ajay Babu	T. Ajay Babu.
18	20.718	Yelivelu Venkata Jaya Ram	Y. Venkata jaya ram.

19	20.719	Pagolu Sri Lekha	P. Srilekha.
20	20.720	Darapu Vanitha	D. Vanitha
21	20.721	Kaitepalli Teja Sri	K. Teja Sri
22	20.722	Potluri Sravan Kumar	P. Sravan kumar
23	20.723	Tummala Akanksha	T. Akanksha
24	20.724	Tadepalli Anusha	T. Anusha
25	20.725	Chalapati Venkata Naga Lakshmi	Ch. Venkata Naga Lakshmi
26	20.726	Potturi Krishna Bhuvaneswari	P. Krishna Bhuvaneswari
27	20.727	Nunna Pedda Bala Siva Nagamani	N.P.B.S. Nagamani
28	20.728	Kagithala Durga Prasad	K. Durga Prasad.
29	20.729	Sangala Bhavana	S. Bhavana
30	20.730	Thota Lavanya	T. Lavanya
31	20.731	Gurrala Naga Sirisha	G. Naga Sirisha
32	20.732	Kunchala Bhargavi	K. Bhargavi
33	20.734	Nagarakanti Vujwala	N. Vujwala.
34	20.735	Rajulapati Bhavana	R. Bhavana
35	20.736	Derangula Durga Anjaneyulu	D. Durga Anjaneyulu
36	20.737	Kamodula Tulasi Ram	K. Tulasi Ram
37	20.738	Runku Sateesh	R. Sateesh
38	20.739	Konatham Siva Naga Pavani	K. Siva Naga Pavani
39	20.740	Peram Jyothiramai	P. Jyothiramai
40	20.741	Gopalajoshula Prasanna Sai	G. Prasanna sai
41	20.742	Ande Madhu Babu	A. Madhu Babu

42	20.743	Sheik Ayesha	SK. Ayesha
43	20.744	Mohammad Shaida Mansuri	M.d Shaida Mansuri
44	20.746	Mareedu Tejaswi	M. Tejaswi
45	20.747	Nalukurti Vinodh Babu	N. Vinodh Babu
46	20.748	Bandaru Abhilash	B. Abhilash
47	20.749	Ede Pavan Kumar	E. pavan kumar
48	20.750	Kolluri Manoj Kumar	K. Manoj Kumar

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Signature of Lecturer **Signature of HOD** **Signature of Principal**

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A.G. & S.G. Siddhartha Degree College of Arts & Science

Vuyyuru-521165, Krishna District, Andhra Pradesh

Value Added Course

Title: CLOUD COMPUTING

Date From 01/11/2022 to 09/02/2023

Content
Module I: INTRODUCTION TO VIRTUALIZATION Virtual Machines and Virtualization Middleware – Data Center Virtualization for Cloud Computing
Module II: Implementation Levels of Virtualization – Virtualization Structures/Tools and Mechanisms – Virtualization of CPU – Memory – I/O Devices
Module III: INTRODUCTION TO CLOUD COMPUTING System Models for Distributed and Cloud Computing – Software
Module IV: Clouds – Cloud Computing and Service Models – Public – Private – Hybrid Clouds

A.G. & S.G. Siddhartha Degree College of Arts & Science

Vuyyuru-521165, Krishna District, Andhra Pradesh

Value Added Course
Title: cloud computing
Module I:

Virtualization is a technique to divide the computer resources logically. It's achieved by abstracting away the underlying complexity of resource segregation. Although an old technology, it's still a popular technique and highly relevant in this era of cloud computing.

In this tutorial, we'll discuss various aspects of virtualization such as the concept, its types, and its workings.

What Is Virtualization?

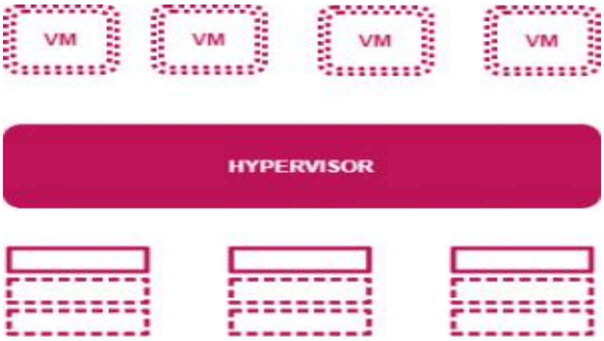
Virtualization helps us to create software-based or virtual versions of a computer resource. These computer resources can include computing devices, storage, networks, servers, or even applications.

It allows organizations to **partition a single physical computer or server into several virtual machines (VM)**. Each VM can then interact independently and run different operating systems or applications while sharing the resources of a single computer.

How Does Virtualization Work?

Hypervisor software facilitates virtualization. A hypervisor sits on top of an operating system but we can also have hypervisors that are installed directly onto the hardware. **Hypervisors take physical resources and divide them up so that virtual environments can use them**.

When a user or program issues an instruction to the VM that requires additional resources from the physical environment, the hypervisor relays the request to the physical system and caches the changes.



A virtual machine created by a hypervisor functions as a single data file, and we can move it from one computer to another, open it there, and it works the same as on any other machine. Thus, **it provides a lot of flexibility and portability**.

Types of Hypervisors

Hypervisors are available in two categories: Type 1 and Type 2.

4.1. Type 1 Hypervisors (Bare Metal)

A Type 1 hypervisor is installed directly on top of the physical machine. Type 1 hypervisors are also known as bare-metal hypervisors due to the nature of their installation type.

These categories of hypervisors are more popular and secure than the Type 2 hypervisors.

Type 1 hypervisors have a lower amount of latency and are the most used in the market. Some examples of these hypervisors are VMware ESXi, Microsoft Hyper-V, or open-source Kernel-based VMs (KVMs**)**.

4.2. Type 2 Hypervisors (Hosted)

On the other hand, **for Type 2 hypervisors, there is a layer of host OS that sits between the physical server and the hypervisor**. For this reason, we call these hypervisors "hosted hypervisors".

They are less common and mostly used for end-user virtualization.

They are known to have more latency compared to Type 1 due to their hosted nature. **Type 2 hypervisors include Oracle VirtualBox or VMware Workstation**.

5. Types of Virtualization

Virtualization is classified into several categories based on the resource we virtualize.

5.1. Data Virtualization

With data virtualization, the virtualization software **sits in front of multiple data sources and allows them to be treated as a single data source**. This facilitates delivering the required data in a specific format.

5.2. Desktop Virtualization

Desktop virtualization lets us deploy simulated desktop environments to many physical machines at once. Unlike traditional desktop environments that are physically installed, configured, and updated on each machine, desktop virtualization allows admins to perform mass configurations, updates, and security checks on all virtual desktops.

5.3. Server Virtualization

Servers are computers designed to process a high volume of specific tasks so that other computers such as laptops and desktops can do a variety of different jobs. Virtualizing a server lets it do more of those particular functions and involves partitioning it so that the components can serve multiple purposes.

5.4. OS Virtualization

Operating system virtualization happens at the OS kernel, and it’s a useful way to run multiple operating systems side-by-side. It reduces hardware costs, increases security, and limits software maintenance (update/patching) costs.

5.5. Network Functions Virtualization

Network functions virtualization separates the network functions such as IP configuration, file sharing, and directory services. Virtualizing networks helps to reduce the number of physical components such as switches, routers, servers, cables, and hubs.

6. Benefits of Virtualization

6.1. Cost Savings

The ability to run multiple virtual machines in one piece of physical infrastructure drastically reduces the footprint and the associated cost. Moreover, as this consolidation is done at the core, we don’t need to maintain as many servers. We also have a reduction in electricity consumption and the overall maintenance cost.

6.2. Agility and Speed

Spinning up a virtual machine is a straightforward and quick approach. It’s a lot simpler than provisioning entirely new infrastructure.
For instance, if we need a development/test region for a team, it’s much faster to provision a new VM for the system administrators. Besides, with an automated process in place, this task is swift and similar to other routine tasks.

Definition of Data Center Virtualization

Data center virtualization is a strategy wherein you transform your data center into a highly nimble, available, scalable, secure, and efficient IT infrastructure by applying virtualization heavily to all key resource components of the data center, i.e., compute, storage, and networking.

You can think of it as an extension of the more familiar concept of server virtualization. In server virtualization, a hypervisor abstracts and pools the underlying physical resources, i.e., CPU, memory, storage device(s), and network, from the software running on top of it. In data center virtualization, not only are servers virtualized, so are storage and network infrastructures.

Then what you get are vast resource pools of compute, storage, and network, which you can reallocate dynamically and automatically for your virtual machines, virtual networks, and virtual datastores.

Another key aspect of data center virtualization is the presence of a unified management framework for administering the components of the virtualized data center, regardless of whether they are located on-premises or in a public cloud. So, essentially, data center virtualization brings about a hybrid cloud.

The end result is a data center where administrators can quickly reconfigure and provision IT resources on demand. A lot of this reconfiguring and provisioning can be done programmatically and in a fully automated way, something that couldn't be accomplished easily (if ever) with a traditional, rigid data center.

Benefits of Virtualization

Virtualization has many benefits, including the ability to increase speed and flexibility; reduce costs, infrastructure, and real estate requirements; increase hosting bandwidth; and minimize downtime.

Increase Speed and Flexibility

One of the biggest benefits of data center virtualization is the amount of free time it unlocks for IT staff. In a highly virtualized data center, it's much easier for IT administrators to reallocate resources to applications that need them the most at any given time.

So, for example, if you're an IT administrator, and a department manager comes to you and says they need to test a newly acquired application that requires much higher CPU, memory, storage, or network bandwidth, you can simply reallocate whatever resources you have available—even resources used by a currently idle application. You couldn't do that as quickly in a non-virtualized environment.

Reduce Capital Costs

Because virtualization enables you to pool resources and share them among applications/users, you can maximize whatever resources you have fully and avoid unutilized capacity. Server consolidation, for example, allows you to run multiple virtual servers on one physical server and have those virtual servers share the same underlying resources on that physical server. With this capability, you no longer have to purchase as many physical servers, storage devices, and network components as you would with a traditional data center.

Reduce Infrastructure and Real Estate Requirements

As you reduce your overall physical infrastructure, you also reduce your physical space requirements. You can reduce these even more if your virtual data center makes heavy use of public cloud resources. Another offshoot of this benefit is the reduction of power consumption and carbon footprint, which is critical for organizations that favor environmentally friendly strategies.

Increase Hosting Bandwidth

When you virtualize servers and consolidate them into fewer physical servers, you also eliminate the amount of network traffic that would have gone to and from those discarded physical servers. This frees up your hosting bandwidth and improves your overall network performance.

Reduce or Eliminate Downtime

Virtual machines are much easier to duplicate and clone than physical servers. They're also easier to migrate. You can even transfer them over the network. Hence, it's much easier to create high availability clusters as well as offsite business continuity or disaster recovery environments. It's also faster to spin up a VM to replace one that has just failed.

Challenges of Virtualization

While virtualization has a lot of benefits, it's not devoid of issues. Some of the challenges experienced by organizations that adopt virtualization, especially at the start of their virtualization adoption journey, include excessive diversity, lack of proper resource distribution, and VM sprawl.

Too Much Diversity

Because they eliminate a lot of time-consuming tasks (e.g., server provisioning and deployment), highly virtualized environments breed innovation. While that's certainly a good thing, it can also encourage IT staff to try new software. That, too, is a good thing. But when you have a data center dotted with an assortment of operating systems (e.g., Windows and Linux), hypervisors (e.g., Hyper-V, ESXi, and KVM), network equipment, and so on, it could lead to inefficiencies and additional overhead costs.

Improper Resource Distribution

The ease of reallocating resources is susceptible to improper resource distribution that favors business units that consume resources more aggressively than others. For example, if left unchecked, business units that embark on big data projects or develop and test their own software could end up consuming more CPU and storage resources than those that just go about regular business operations.

VM Sprawl

Unlike physical servers that, depending on the number, may take days or weeks to provision and deploy, virtual machines require only minutes or hours for the same tasks. In fact, you could provision and deploy hundreds or thousands of VMs automatically in minutes or a few hours.

If IT administrators are nonchalant in spinning up VMs, they could cause what is known as VM sprawl. The consequence of VM sprawl is that you end up with too many virtual machines that consume resources much faster than you should, which holds them up even if you no longer need them. It also results in degraded performance, additional costs, and more attack surfaces to defend.

Data Center Virtualization Management

There are ways to avoid the pitfalls mentioned above. Some of the ways that you can better manage your virtual data center include adopting standardization, addressing sprawl, implementing proper administration tools, and verifying sufficient network storage.

Adopt Standardization

Diversity can be good for your organization, but not when applied to the components of your data center. Too much diversity can only make things unnecessarily complicated when you troubleshoot issues, track licenses, integrate systems, and so on. Standardize your IT infrastructure by dealing with as few vendors as possible.

Address Sprawl

VM sprawl can be minimized by establishing policies for VM creation, monitoring and auditing VMs, identifying idle as well as over- and under-allocated VMs, deleting unused VMs, and reconfiguring VMs so that they consume only resources that they need.

Implement Proper Administration and Management Tools

While major virtualization vendors such as Microsoft and VMware already have administrative tools that come with their products out of the box, there are smaller vendors that enable you to further enhance the capabilities of the products these major vendors provide. They also add a bunch of other features that take those products to the next level.

One example is Parallels® Remote Application Server (RAS), which builds on the Remote Desktop Services (RDS) capabilities of Windows Server to provide a more powerful, flexible way of delivering virtual desktops and applications. More about Parallels RAS below.

Module II:

What are the three ways that virtualization is implemented?

There are three ways to build virtual servers: full virtualization, para-virtualization, and OS-level virtualization.
They all experience a few common traits. The physical server is named the host, and the virtual servers are called guests.
Therefore, virtual servers act like physical machines. The specific system uses a distinctive approach to allocate physical server resources to virtual server requirements.

Full virtualization

- Full virtualization uses a specific software called a hypervisor. The hypervisor interacts straight with the physical server's CPU and disk space and serves as a virtual server's operating systems program.
- Hence, the hypervisor keeps each virtual server wholly independent and unaware of the separate virtual servers working on the physical machine.
- The hypervisor observes the physical server's resources. As virtual servers run applications, the hypervisor sends resources from the physical machine to the relevant virtual server.

Para-virtualization

- The para-virtualization program is a little different. Unlike the full virtualization technique, the guest servers in a para-virtualization system are aware of one another.
- Therefore, a para-virtualization hypervisor doesn't require as much processing power to control the guest operating systems.
- Each OS is already conscious of the demands the other operating systems are setting on the physical server. The entire system works collectively as a cohesive unit.

OS-level virtualization

- An OS-level virtualization program doesn't use a hypervisor at all. Instead, the virtualization ability is part of the host OS, which fulfills all the functions of a fully virtualized hypervisor.
- The most unusual limitation of this approach is that all the guest servers must work on the same OS. Hence, each virtual server remains free from all the others, but you can't mix-match operating systems between them.
- As all the guest operating systems must be the same, this is called a homogeneous environment.

Let us now explain different levels of virtualization in cloud computing.

Different Levels of Virtualization Implementation

It is not easy to set up virtualization. Your computer works on an operating system that gets configured on some specific hardware.

Thus, it is not feasible or straightforward to run a different operating system using the corresponding hardware.

To do this, one will need a hypervisor. Hence, the role of the hypervisor is to bridge between the hardware and the virtual operating system, which enables smooth functioning.

Meanwhile, talking of the Implementation levels of virtualization in cloud computing, five levels are commonly used. Let us now look firmly at each of these levels of virtualization implementation in cloud computing.

Instruction Set Architecture Level (ISA)

At the ISA level, virtualization can work via emulating a given ISA by the ISA of the host machine. For instance, MIPS binary code can operate on an x86-based host machine with the help of ISA emulation.

Thus, this strategy makes it possible to run a large volume of legacy binary code written for several processors on any provided different hardware host machine.

The first emulation method is through code interpretation. Therefore, an interpreter program defines the source instructions to target instructions one by one.

Activity happenings within the Instruction Set Architecture Level (ISA):

Instruction set

- The hardware on the physical server in cloud computing has its own instruction set that it will process.
- Hence, these instructions act as an interface between hardware and software. Therefore, by the instruction set, hardware immediately assigns its services to its upper layers.

VIRTUALIZATION STRUCTURES/TOOLS AND MECHANISMS

In general, there are three typical classes of VM architecture. Figure 3.1 showed the architectures of a machine before and after virtualization. Before virtualization, the operating system manages the hardware. After virtualization, a virtualization layer is inserted between the hardware and the operat-ing system. In such a case, the virtualization layer is responsible for converting portions of the real hardware into virtual hardware. Therefore, different operating systems such as Linux and Windows can run on the same physical machine, simultaneously. Depending on the position of the virtualiza-tion layer, there are several classes of VM architectures, namely the hypervisor architecture, para-virtualization, and host-based virtualization. The hypervisor is also known as the VMM (Virtual Machine Monitor). They both perform the same virtualization operations.

1. Hypervisor and Xen Architecture

The hypervisor supports hardware-level virtualization (see Figure 3.1(b)) on bare metal devices like CPU, memory, disk and network interfaces. The hypervisor software sits directly between the physi-cal hardware and its OS. This virtualization layer is referred to as either the VMM or the hypervisor. The hypervisor provides hypercalls for the guest OSes and applications. Depending on the functional-ity, a hypervisor can assume a micro-kernel architecture like the Microsoft Hyper-V. Or it can assume a monolithic hypervisor architecture like the VMware ESX for server virtualization.

A micro-kernel hypervisor includes only the basic and unchanging functions (such as physical memory management and processor scheduling). The device drivers and other changeable components are outside the hypervisor. A monolithic hypervisor implements all the aforementioned functions, including those of the device drivers. Therefore, the size of the hypervisor code of a micro-kernel hyper-visor is smaller than that of a monolithic hypervisor. Essentially, a hypervisor must be able to convert physical devices into virtual resources dedicated for the deployed VM to use.

1.1 The Xen Architecture

Xen is an open source hypervisor program developed by Cambridge University. Xen is a micro-kernel hypervisor, which separates the policy from the mechanism. The Xen hypervisor implements all the mechanisms, leaving the policy to be handled by Domain 0, as shown in Figure 3.5. Xen does not include any device drivers natively [7]. It just provides a mechanism by which a guest OS can have direct access to the physical devices. As a result, the size of the Xen hypervisor is kept rather small. Xen provides a virtual environment located between the hardware and the OS. A number of vendors are in the process of developing commercial Xen hypervisors, among them are Citrix XenServer [62] and Oracle VM [42].

The core components of a Xen system are the hypervisor, kernel, and applications. The organi-zation of the three components is important. Like other virtualization systems, many guest OSes can run on top of the hypervisor. However, not all guest OSes are created equal, and one in

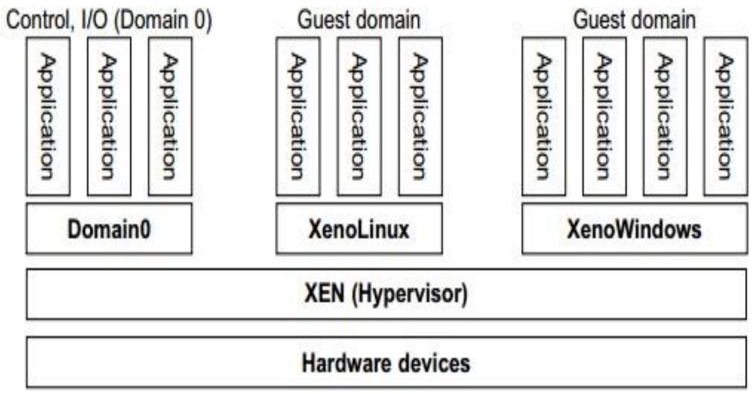


FIGURE 3.5

The Xen architecture's special domain 0 for control and I/O, and several guest domains for user applications.

particular controls the others. The guest OS, which has control ability, is called Domain 0, and the others are called Domain U. Domain 0 is a privileged guest OS of Xen. It is first loaded when Xen boots without any file system drivers being available. Domain 0 is designed to access hardware directly and manage devices. Therefore, one of the responsibilities of Domain 0 is to allocate and map hardware resources for the guest domains (the Domain U domains).

For example, Xen is based on Linux and its security level is C2. Its management VM is named Domain 0, which has the privilege to manage other VMs implemented on the same host. If Domain 0 is compromised, the hacker can control the entire system. So, in the VM system, security policies are needed to improve the security of Domain 0. Domain 0, behaving as a VMM, allows users to create, copy, save, read, modify, share, migrate, and roll back VMs as easily as manipulating a file, which flexibly provides tremendous benefits for users. Unfortunately, it also brings a series of security problems during the software life cycle and data lifetime.

Traditionally, a machine's lifetime can be envisioned as a straight line where the current state of the machine is a point that progresses monotonically as the software executes. During this time, con-figuration changes are made, software is installed, and patches are applied. In such an environment, the VM state is akin to a tree: At any point, execution can go into N different branches where multiple instances of a VM can exist at any point in this tree at any given time. VMs are allowed to roll back to previous states in their execution (e.g., to fix configuration errors) or rerun from the same point many times (e.g., as a means of distributing dynamic content or circulating a "live" system image).

2. Binary Translation with Full Virtualization

Depending on implementation technologies, hardware virtualization can be classified into two cate-gories: full virtualization and host-based virtualization. Full virtualization does not need to modify the host OS. It relies on binary translation to trap and to virtualize the execution of certain sensitive, nonvirtualizable instructions. The guest OSes and their applications consist of noncritical and critical instructions. In a host-based system, both a host OS and a guest OS are used. A virtuali-zation software layer is built between the host OS and guest OS. These two classes of VM architec-ture are introduced next.

2.1 Full Virtualization

With full virtualization, noncritical instructions run on the hardware directly while critical instructions are discovered and replaced with traps into the VMM to be emulated by software. Both the hypervisor and VMM approaches are considered full virtualization. Why are only critical instructions trapped into the VMM? This is because binary translation can incur a large performance overhead. Noncritical instructions do not control hardware or threaten the security of the system, but critical instructions do. Therefore, running noncritical instructions on hardware not only can promote efficiency, but also can ensure system security.

2.2 Binary Translation of Guest OS Requests Using a VMM

This approach was implemented by VMware and many other software companies. As shown in Figure 3.6, VMware puts the VMM at Ring 0 and the guest OS at Ring 1. The VMM scans the instruction stream and identifies the privileged, control- and behavior-sensitive instructions. When these instructions are identified, they are trapped into the VMM, which emulates the behavior of these instructions. The method used in this emulation is called binary translation. Therefore, full virtualization combines binary translation and direct execution. The guest OS is completely decoupled from the underlying hardware. Consequently, the guest OS is unaware that it is being virtualized.
The performance of full virtualization may not be ideal, because it involves binary translation which is rather time-consuming. In particular, the full virtualization of I/O-intensive applications is a really a big challenge. Binary translation employs a code cache to store translated hot instructions to improve performance, but it increases the cost of memory usage. At the time of this writing, the performance of full virtualization on the x86 architecture is typically 80 percent to 97 percent that of the host machine.

2.3 Host-Based Virtualization

An alternative VM architecture is to install a virtualization layer on top of the host OS. This host OS is still responsible for managing the hardware. The guest OSes are installed and run on top of the virtualization layer. Dedicated applications may run on the VMs. Certainly, some other applications

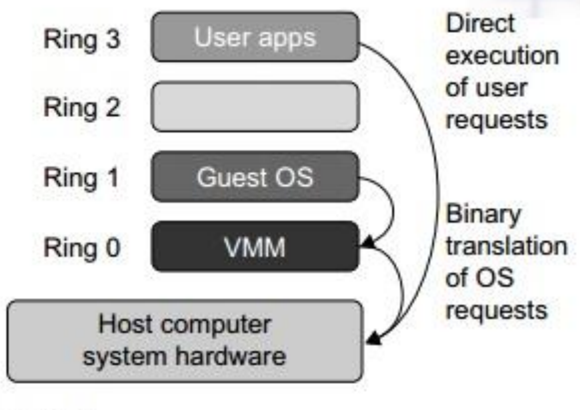


FIGURE 3.6

Indirect execution of complex instructions via binary translation of guest OS requests using the VMM plus direct execution of simple instructions on the same host.

can also run with the host OS directly. This host-based architecture has some distinct advantages, as enumerated next. First, the user can install this VM architecture without modifying the host OS. The virtualizing software can rely on the host OS to provide device drivers and other low-level services. This will simplify the VM design and ease its deployment.

Second, the host-based approach appeals to many host machine configurations. Compared to the hypervisor/VMM architecture, the performance of the host-based architecture may also be low. When an application requests hardware access, it involves four layers of mapping which downgrades performance significantly. When the ISA of a guest OS is different from the ISA of the underlying hardware, binary translation must be adopted. Although the host-based architecture has flexibility, the performance is too low to be useful in practice.

3. Para-Virtualization with Compiler Support

Para-virtualization needs to modify the guest operating systems. A para-virtualized VM provides special APIs requiring substantial OS modifications in user applications. Performance degradation is a critical issue of a virtualized system. No one wants to use a VM if it is much slower than using a physical machine. The virtualization layer can be inserted at different positions in a machine soft-ware stack. However, para-virtualization attempts to reduce the virtualization overhead, and thus improve performance by modifying only the guest OS kernel.

Figure 3.7 illustrates the concept of a paravirtualized VM architecture. The guest operating systems are para-virtualized. They are assisted by an intelligent compiler to replace the nonvirtualizable OS instructions by hypercalls as illustrated in Figure 3.8. The traditional x86 processor offers four instruction execution rings: Rings 0, 1, 2, and 3. The lower the ring number, the higher the privilege of instruction being executed. The OS is responsible for managing the hardware and the privileged instructions to execute at Ring 0, while user-level applications run at Ring 3. The best example of para-virtualization is the KVM to be described below.

3.1 Para-Virtualization Architecture

When the x86 processor is virtualized, a virtualization layer is inserted between the hardware and the OS. According to the x86 ring definition, the virtualization layer should also be installed at Ring 0. Different instructions at Ring 0 may cause some problems. In Figure 3.8, we show that para-virtualization replaces nonvirtualizable instructions with hypercalls that communicate directly with the hypervisor or VMM. However, when the guest OS kernel is modified for virtualization, it can no longer run on the hardware directly.

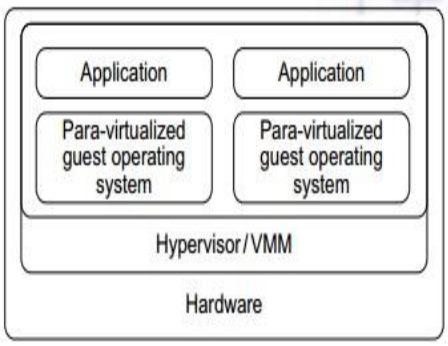


FIGURE 3.7

Para-virtualized VM architecture, which involves modifying the guest OS kernel to replace nonvirtualizable instructions with hypercalls for the hypervisor or the VMM to carry out the virtualization process (See Figure 3.8 for more details.)

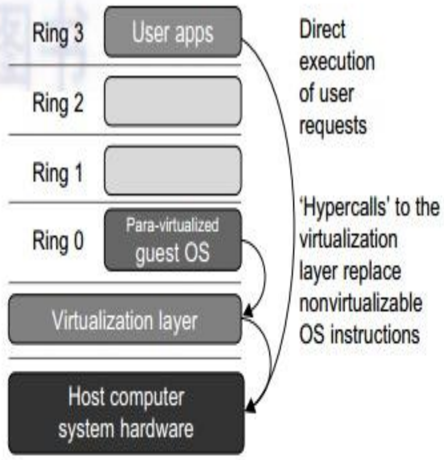


FIGURE 3.8

The use of a para-virtualized guest OS assisted by an intelligent compiler to replace nonvirtualizable OS instructions by hypercalls.

(*Courtesy of VMWare [71]*)

Although para-virtualization reduces the overhead, it has incurred other problems. First, its compatibility and portability may be in doubt, because it must support the unmodified OS as well. Second, the cost of maintaining para-virtualized OSes is high, because they may require deep OS kernel modifications. Finally, the performance advantage of para-virtualization varies greatly due to workload variations. Compared with full virtualization, para-virtualization is relatively easy and more practical. The main problem in full virtualization is its low performance in binary translation. To speed up binary translation is difficult. Therefore, many virtualization products employ the para-virtualization architecture. The popular Xen, KVM, and VMware ESX are good examples.

3.2 KVM (Kernel-Based VM)

This is a Linux para-virtualization system—a part of the Linux version 2.6.20 kernel. Memory management and scheduling activities are carried out by the existing Linux kernel. The KVM does the rest, which makes it simpler than the hypervisor that controls the entire machine. KVM is a hardware-assisted para-virtualization tool, which improves performance and supports unmodified guest OSes such as Windows, Linux, Solaris, and other UNIX variants.

3.3 Para-Virtualization with Compiler Suppor

Unlike the full virtualization architecture which intercepts and emulates privileged and sensitive instructions at runtime, para-virtualization handles these instructions at compile time. The guest OS kernel is modified to replace the privileged and sensitive instructions with hypercalls to the hypervi-sor or VMM. Xen assumes such a para-virtualization architecture.

The guest OS running in a guest domain may run at Ring 1 instead of at Ring 0. This implies that the guest OS may not be able to execute some privileged and sensitive instructions. The privileged instructions are implemented by hypercalls to the hypervisor. After replacing the instructions with hypercalls, the modified guest OS emulates the behavior of the original guest OS. On an UNIX system, a system call involves an interrupt or service routine. The hypercalls apply a dedicated service routine in Xen.

*****VIRTUALIZATION OF CPU, MEMORY, AND I/O DEVICES

To support virtualization, processors such as the x86 employ a special running mode and instructions, known as hardware-assisted virtualization. In this way, the VMM and guest OS run in different modes and all sensitive instructions of the guest OS and its applications are trapped in the VMM. To save processor states, mode switching is completed by hardware. For the x86 architecture, Intel and AMD have proprietary technologies for hardware-assisted virtualization.

1. Hardware Support for Virtualization

Modern operating systems and processors permit multiple processes to run simultaneously. If there is no protection mechanism in a processor, all instructions from different processes will access the hardware directly and cause a system crash. Therefore, all processors have at least two modes, user mode and supervisor mode, to ensure controlled access of critical hardware. Instructions running in supervisor mode are called privileged instructions. Other instructions are unprivileged instructions. In a virtualized environment, it is more difficult to make OSes and applications run correctly because there are more layers in the machine stack. Example 3.4 discusses Intel's hardware support approach.
At the time of this writing, many hardware virtualization products were available. The VMware Workstation is a VM software suite for x86 and x86-64 computers. This software suite allows users to set up multiple x86 and x86-64 virtual computers and to use one or more of these VMs simultaneously with the host operating system. The VMware Workstation assumes the host-based virtualization. Xen is a hypervisor for use in IA-32, x86-64, Itanium, and PowerPC 970 hosts. Actually, Xen modifies Linux as the lowest and most privileged layer, or a hypervisor.
One or more guest OS can run on top of the hypervisor. KVM (Kernel-based Virtual Machine) is a Linux kernel virtualization infrastructure. KVM can support hardware-assisted virtualization and paravirtualization by using the Intel VT-x or AMD-v and VirtIO framework, respectively. The VirtIO framework includes a paravirtual Ethernet card, a disk I/O controller, a balloon device for adjusting guest memory usage, and a VGA graphics interface using VMware drivers.

Example 3.4 Hardware Support for Virtualization in the Intel x86 Processor

Since software-based virtualization techniques are complicated and incur performance overhead, Intel provides a hardware-assist technique to make virtualization easy and improve performance. Figure 3.10 provides an overview of Intel's full virtualization techniques. For processor virtualization, Intel offers the VT-x or VT-i technique. VT-x adds a privileged mode (VMX Root Mode) and some instructions to processors. This enhancement traps all sensitive instructions in the VMM automatically. For memory virtualization, Intel offers the EPT, which translates the virtual address to the machine's physical addresses to improve performance. For I/O virtualization, Intel implements VT-d and VT-c to support this.

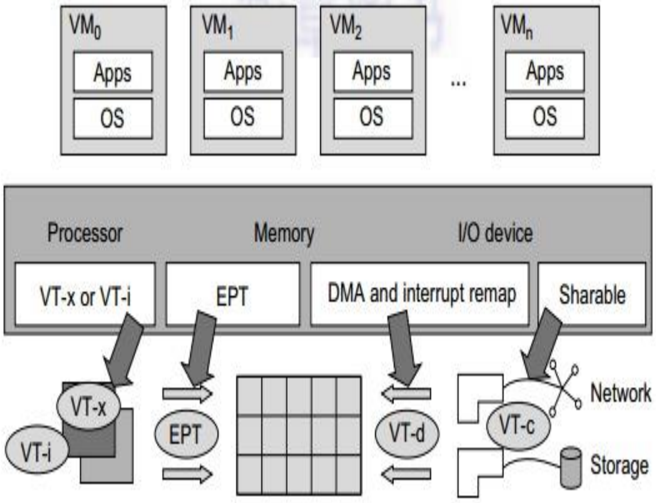


FIGURE 3.10

Intel hardware support for virtualization of processor, memory, and I/O devices.

2. CPU Virtualization

A VM is a duplicate of an existing computer system in which a majority of the VM instructions are executed on the host processor in native mode. Thus, unprivileged instructions of VMs run directly on the host machine for higher efficiency. Other critical instructions should be handled carefully for correctness and stability. The critical instructions are divided into three categories: privileged instructions, control-sensitive instructions, and behavior-sensitive instructions. Privileged instructions execute in a privileged mode and will be trapped if executed outside this mode. Control-sensitive instructions attempt to change the configuration of resources used. Behavior-sensitive instructions have different behaviors depending on the configuration of resources, including the load and store operations over the virtual memory.

A CPU architecture is virtualizable if it supports the ability to run the VM's privileged and unprivileged instructions in the CPU's user mode while the VMM runs in supervisor mode. When the privileged instructions including control- and behavior-sensitive instructions of a VM are exe-cuted, they are trapped in the VMM. In this case, the VMM acts as a unified mediator for hardware access from different VMs to guarantee the correctness and stability of the whole system. However, not all CPU architectures are virtualizable. RISC CPU architectures can be naturally virtualized because all control- and behavior-sensitive instructions are privileged instructions. On the contrary, x86 CPU architectures are not primarily designed to support virtualization. This is because about 10 sensitive instructions, such as SGDT and SMSW, are not privileged instructions. When these instruc-tions execute in virtualization, they cannot be trapped in the VMM.

On a native UNIX-like system, a system call triggers the 80h interrupt and passes control to the OS kernel. The interrupt handler in the kernel is then invoked to process the system call. On a para-virtualization system such as Xen, a system call in the guest OS first triggers the 80h interrupt nor-mally. Almost at the same time, the 82h interrupt in the hypervisor is triggered. Incidentally, control is passed on to the hypervisor as well. When the hypervisor completes its task for the guest OS system call, it passes control back to the guest OS kernel. Certainly, the guest OS kernel may also invoke the hypercall while it's running. Although paravirtualization of a CPU lets unmodified applications run in the VM, it causes a small performance penalty.

2.1 Hardware-Assisted CPU Virtualization

This technique attempts to simplify virtualization because full or paravirtualization is complicated. Intel and AMD add an additional mode called privilege mode level (some people call it Ring-1) to x86 processors. Therefore, operating systems can still run at Ring 0 and the hypervisor can run at Ring -1. All the privileged and sensitive instructions are trapped in the hypervisor automatically. This technique removes the difficulty of implementing binary translation of full virtualization. It also lets the operating system run in VMs without modification.

Example 3.5 Intel Hardware-Assisted CPU Virtualization

Although x86 processors are not virtualizable primarily, great effort is taken to virtualize themThey are used widely in comparing RISC processors that the bulk of x86-based legacy systems cannot discard easily. Virtuali-zation of x86 processors is detailed in the following sections. Intel's VT-x technology is an example of hardware-assisted virtualization, as shown in Figure

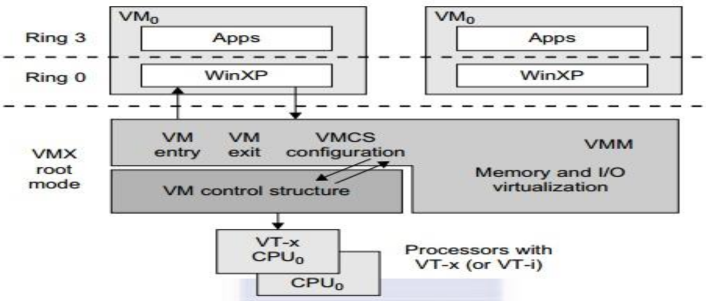


FIGURE 3.11
Intel hardware-assisted CPU virtualization.

CPU state for VMs, a set of additional instructions is added. At the time of this writing, Xen, VMware, and the Microsoft Virtual PC all implement their hypervisors by using the VT-x technology.

Generally, hardware-assisted virtualization should have high efficiency. However, since the transition from the hypervisor to the guest OS incurs high overhead switches between processor modes, it sometimes cannot outperform binary translation. Hence, virtualization systems such as VMware now use a hybrid approach, in which a few tasks are offloaded to the hardware but the rest is still done in software. In addition, para-virtualization and hardware-assisted virtualization can be combined to improve the performance further.

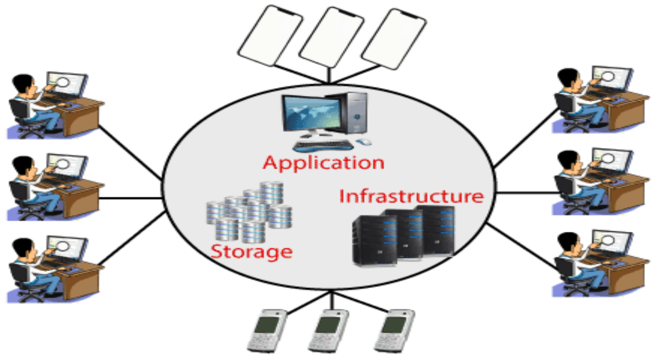
Memory Virtualization

Virtual memory virtualization is similar to the virtual memory support provided by modern operat-ing systems. In a traditional execution environment, the operating system maintains mappings of virtual memory to machine memory using page tables, which is a one-stage mapping from virtual memory to machine memory. All modern x86 CPUs include a memory management unit (MMU) and a translation lookaside buffer (TLB)

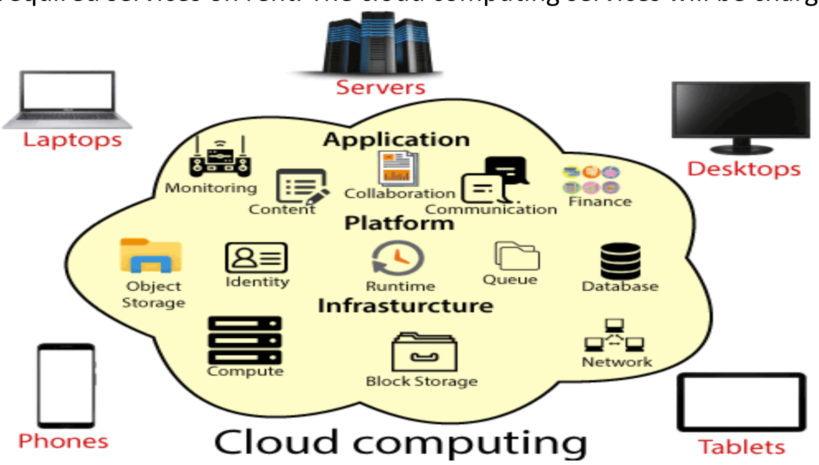
Module III

Introduction to Cloud Computing

Cloud Computing is the delivery of computing services such as servers, storage, databases, networking, software, analytics, intelligence, and more, over the Cloud (Internet).



Cloud Computing provides an alternative to the on-premises datacentre. With an on-premises datacentre, we have to manage everything, such as purchasing and installing hardware, virtualization, installing the operating system, and any other required applications, setting up the network, configuring the firewall, and setting up storage for data. After doing all the set-up, we become responsible for maintaining it through its entire lifecycle.
But if we choose Cloud Computing, a cloud vendor is responsible for the hardware purchase and maintenance. They also provide a wide variety of software and platform as a service. We can take any required services on rent. The cloud computing services will be charged based on usage.

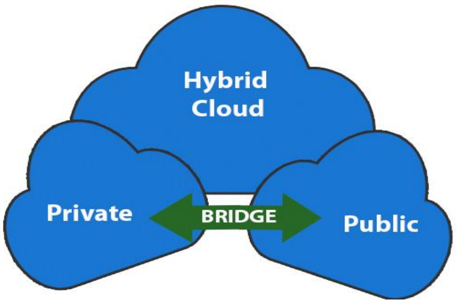


The cloud environment provides an easily accessible online portal that makes handy for the user to manage the compute, storage, network, and application resources. Some cloud service providers are in the following figure

Advantages of cloud computing

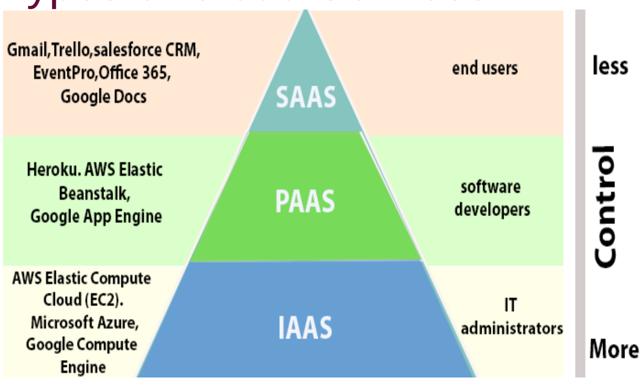
- **Cost:** It reduces the huge capital costs of buying hardware and software.
- **Speed:** Resources can be accessed in minutes, typically within a few clicks.
- **Scalability:** We can increase or decrease the requirement of resources according to the business requirements.
- **Productivity:** While using cloud computing, we put less operational effort. We do not need to apply patching, as well as no need to maintain hardware and software. So, in this way, the IT team can be more productive and focus on achieving business goals.
- **Reliability:** Backup and recovery of data are less expensive and very fast for business continuity.
- **Security:** Many cloud vendors offer a broad set of policies, technologies, and controls that strengthen our data security.

Types of Cloud Computing

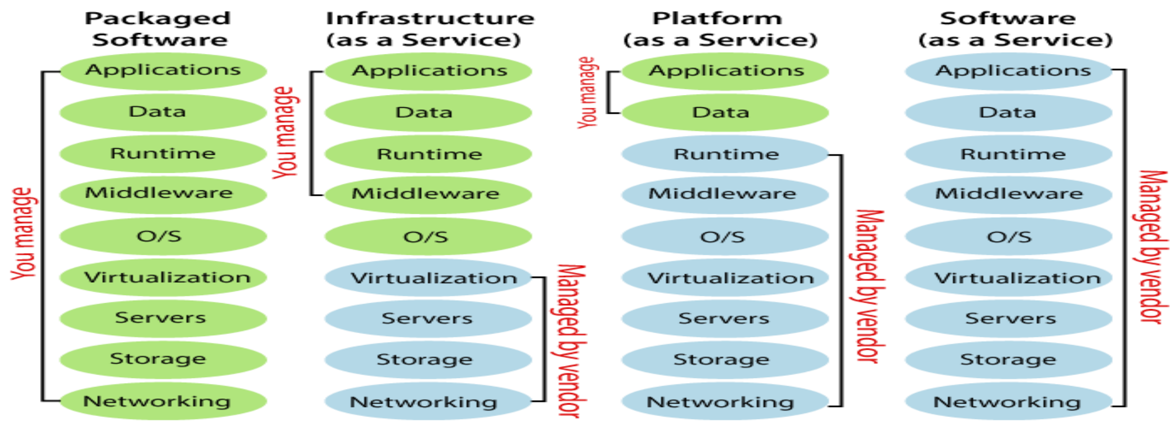


- **Public Cloud:** The cloud resources that are owned and operated by a third-party cloud service provider are termed as public clouds. It delivers computing resources such as servers, software, and storage over the internet
- **Private Cloud:** The cloud computing resources that are exclusively used inside a single business or organization are termed as a private cloud. A private cloud may physically be located on the company's on-site datacentre or hosted by a third-party service provider.
- **Hybrid Cloud:** It is the combination of public and private clouds, which is bounded together by technology that allows data applications to be shared between them. Hybrid cloud provides flexibility and more deployment options to the business.

Types of Cloud Services



1. **Infrastructure as a Service (IaaS):** In IaaS, we can rent IT infrastructures like servers and virtual machines (VMs), storage, networks, operating systems from a cloud service vendor. We can create VM running Windows or Linux and install anything we want on it. Using IaaS, we don't need to care about the hardware or virtualization software, but other than that, we do have to manage everything else. Using IaaS, we get maximum flexibility, but still, we need to put more effort into maintenance.
2. **Platform as a Service (PaaS):** This service provides an on-demand environment for developing, testing, delivering, and managing software applications. The developer is responsible for the application, and the PaaS vendor provides the ability to deploy and run it. Using PaaS, the flexibility gets reduce, but the management of the environment is taken care of by the cloud vendors.
3. **Software as a Service (SaaS):** It provides a centrally hosted and managed software services to the end-users. It delivers software over the internet, on-demand, and typically on a subscription basis. E.g., Microsoft One Drive, Dropbox, WordPress, Office 365, and Amazon Kindle. SaaS is used to minimize the operational cost to the maximum extent.



******Difference between Cloud Computing and Distributed Computing

1. Cloud Computing :
Cloud computing refers to providing on demand IT resources/services like server, storage, database, networking, analytics, software etc. over internet. It is a computing technique that delivers hosted services over the internet to its users/customers. Cloud computing provides services such as hardware, software, networking resources through internet. Some characteristics Public Cloud

- Private Cloud
- Community Cloud
- Hybrid Cloud

2. Distributed Computing :
Distributed computing refers to solve a problem over distributed autonomous computers and they communicate between them over a network. It is a computing technique which allows to multiple computers to communicate and work to solve a single problem. Distributed computing helps to achieve computational tasks more faster than using a single computer as it takes a lot of time. Some characteristics of distributed computing are distributing a single task among computers to progress

the work at same time, Remote Procedure calls and Remote Method Invocation for distributed computations.
It is classified into 3 different types such as

- Distributed Computing Systems
- Distributed Information Systems
- Distributed Pervasive Systems

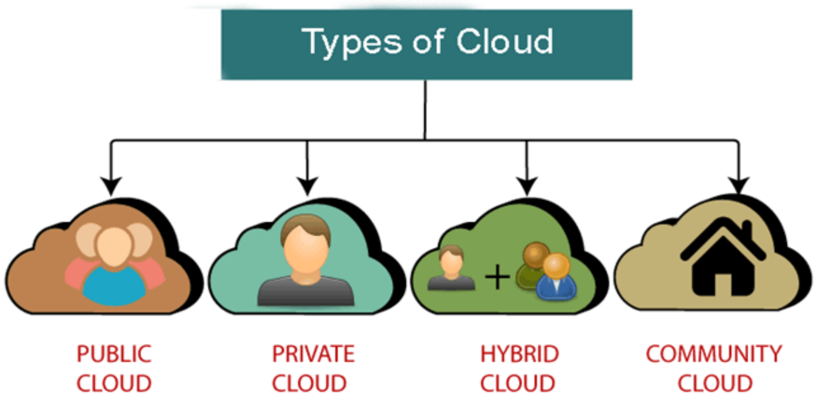
Difference between Cloud Computing and Distributed Computing :

S.No.	CLOUD COMPUTING	DISTRIBUTED COMPUTING
01.	Cloud computing refers to providing on demand IT resources/services like server, storage, database, networking, analytics, software etc. over internet.	Distributed computing refers to solve a problem over distributed autonomous computers and they communicate between them over a network.
02.	In simple cloud computing can be said as a computing technique that delivers hosted services over the internet to its users/customers.	In simple distributed computing can be said as a computing technique which allows to multiple computers to communicate and work to solve a single problem.
03.	It is classified into 4 different types such as Public Cloud, Private Cloud, Community Cloud and Hybrid Cloud.	It is classified into 3 different types such as Distributed Computing Systems, Distributed Information Systems and Distributed Pervasive Systems.
04.	There are many benefits of cloud computing like cost effective, elasticity and reliable, economies of Scale, access to the global market etc.	There are many benefits of distributed computing like flexibility, reliability, improved performance etc.
05.	Cloud computing provides services such as hardware, software, networking resources through internet.	Distributed computing helps to achieve computational tasks more faster than using a single computer as it takes a lot of time.
06.	The goal of cloud computing is to provide on demand computing services over internet on pay per use model.	The goal of distributed computing is to distribute a single task among multiple computers and to solve it quickly by maintaining coordination between them.

MODULE-IV

Types of Cloud

There are the following 4 types of cloud that you can deploy according to the organization's needs-



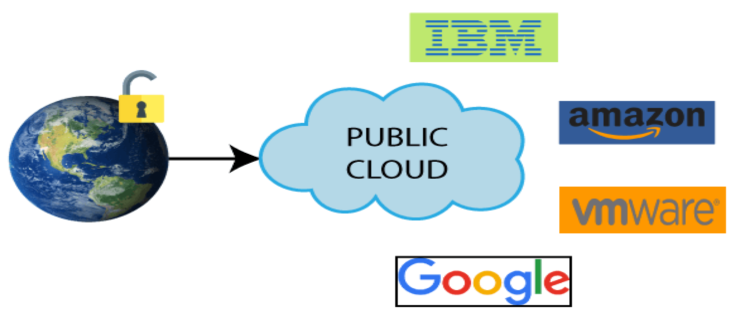
- Public Cloud
- Private Cloud
- Hybrid Cloud
- Community Cloud

Public Cloud

Public cloud is **open to all** to store and access information via the Internet using the pay-per-usage method.

In public cloud, computing resources are managed and operated by the Cloud Service Provider (CSP).

Example: Amazon elastic compute cloud (EC2), IBM SmartCloud Enterprise, Microsoft, Google App Engine, Windows Azure Services Platform.



Advantages of Public Cloud

There are the following advantages of Public Cloud -

- Public cloud is owned at a lower cost than the private and hybrid cloud.

- Public cloud is maintained by the cloud service provider, so do not need to worry about the maintenance.
- Public cloud is easier to integrate. Hence it offers a better flexibility approach to consumers.
- Public cloud is location independent because its services are delivered through the internet.
- Public cloud is highly scalable as per the requirement of computing resources.
- It is accessible by the general public, so there is no limit to the number of users.

Disadvantages of Public Cloud

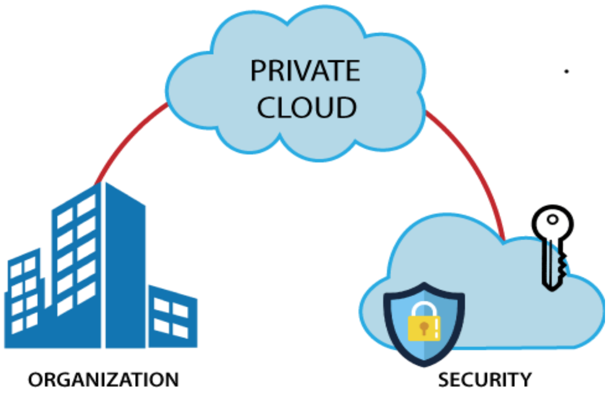
- Public Cloud is less secure because resources are shared publicly.
- Performance depends upon the high-speed internet network link to the cloud provider.
- The Client has no control of data.

Private Cloud

Private cloud is also known as an **internal cloud** or **corporate cloud**. It is used by organizations to build and manage their own data centers internally or by the third party. It can be deployed using Opensource tools such as Openstack and Eucalyptus.

Based on the location and management, National Institute of Standards and Technology (NIST) divide private cloud into the following two parts-

- On-premise private cloud
- Outsourced private cloud



Advantages of Private Cloud

There are the following advantages of the Private Cloud -

- Private cloud provides a high level of security and privacy to the users.
- Private cloud offers better performance with improved speed and space capacity.
- It allows the IT team to quickly allocate and deliver on-demand IT resources.

- The organization has full control over the cloud because it is managed by the organization itself. So, there is no need for the organization to depends on anybody.
- It is suitable for organizations that require a separate cloud for their personal use and data security is the first priority.

Disadvantages of Private Cloud

- Skilled people are required to manage and operate cloud services.
- Private cloud is accessible within the organization, so the area of operations is limited.
- Private cloud is not suitable for organizations that have a high user base, and organizations that do not have the prebuilt infrastructure, sufficient manpower to maintain and manage the cloud.

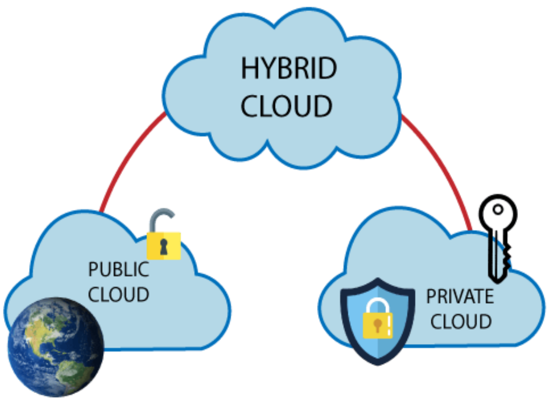
Hybrid Cloud

Hybrid Cloud is a combination of the public cloud and the private cloud. we can say:

Hybrid Cloud = Public Cloud + Private Cloud

Hybrid cloud is partially secure because the services which are running on the public cloud can be accessed by anyone, while the services which are running on a private cloud can be accessed only by the organization's users.

Example: Google Application Suite (Gmail, Google Apps, and Google Drive), Office 365 (MS Office on the Web and One Drive), Amazon Web Services.



Advantages of Hybrid Cloud

There are the following advantages of Hybrid Cloud -

- Hybrid cloud is suitable for organizations that require more security than the public cloud.
- Hybrid cloud helps you to deliver new products and services more quickly.
- Hybrid cloud provides an excellent way to reduce the risk.
- Hybrid cloud offers flexible resources because of the public cloud and secure resources because of the private cloud.

Disadvantages of Hybrid Cloud

- In Hybrid Cloud, security feature is not as good as the private cloud.
- Managing a hybrid cloud is complex because it is difficult to manage more than one type of deployment model.
- In the hybrid cloud, the reliability of the services depends on cloud service providers.

Community Cloud

Community cloud allows systems and services to be accessible by a group of several organizations to share the information between the organization and a specific community. It is owned, managed, and operated by one or more organizations in the community, a third party, or a combination of them.

Example: Health Care community cloud

Advantages of Community Cloud

There are the following advantages of Community Cloud -

- Community cloud is cost-effective because the whole cloud is being shared by several organizations or communities.
- Community cloud is suitable for organizations that want to have a collaborative cloud with more security features than the public cloud.
- It provides better security than the public cloud.
- It provdes collaborative and distributive environment.
- Community cloud allows us to share cloud resources, infrastructure, and other capabilities among various organizations.

Disadvantages of Community Cloud

- Community cloud is not a good choice for every organization.
- Security features are not as good as the private cloud.
- It is not suitable if there is no collaboration.

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Test Exercise:

1.Which of the following type of virtualization is also characteristic of cloud computing?

a) Storage
b) Application
c) CPU
d) All of the mentioned

2. The technology used to distribute service requests to resources is referred to as _____________

a) load performing
b) load scheduling
c) load balancing
d) all of the mentioned

3. What type of computing technology refers to services and applications that typically run on a distributed network through virtualized resources?

a. Distributed Computing
b. Cloud Computing
c. Soft Computing
d. Parallel Computing

4) Which one of the following options can be considered as the Cloud?

a. Hadoop
b. Intranet
c. Web Applications
d. All of the mentioned

5) Which one of the following refers to the non-functional requirements like disaster recovery, security, reliability, etc.

a. Service Development
b. Quality of service
c. Plan Development
d. Technical Service

6) Which of the model involves the special types of services that users can access on a Cloud Computing platform?

a. Service
b. Planning
c. Deployment
d. Application

7) In how many parts we can broadly divide the architecture of the Cloud?

a. 4
b. 3
c. 2

d. 5

8) The Foce.com and windows Azure are examples of which of the following?

a. IaaS
b. PaaS
c. SaaS
d. Both A and B

9) Which one of the following a technology works behind the cloud computing platform?

a. Virtualization
b. SOA
c. Grid Computing
d. All of the above

10) Which one of the following is also known as a Hypervisor?

a. VMA
b. VMM
c. VMS
d. VMR

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Key:

1. All of the mentioned
2. load balancing
3. Cloud Computing
4. Hadoop
5. Quality of service
6. Service
7. 2
8. PaaS
9. All of the above
10. VMM

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Class: III B.SC (MCCS)

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1	20.701	Vemula Kavya Naga Sri	9
2	20.702	Dronadula Hemanjali	10
3	20.703	Dekka Kavitha	10
4	20.704	Jujjuvarapu Venkateswara Rao	8
5	20.705	Mirza Hasan Abbas	9
6	20.706	Marepalli Venkata Naga Sai Pavan Kumar	9
7	20.707	Aluri Bhavya Sri	9
8	20.708	Samayamanthula Sandeep	7
9	20.709	Kalapala Dinesh	9
10	20.710	Jogi Gowthami	10
11	20.711	Jonnalagadda Kusuma	10
12	20.712	Perlapudi Pranadeep	10
13	20.713	Devabathina Satyadev	8
14	20.714	Somayajula S.M.K.Chaitanya	9
15	20.715	Vukoti Naga Veera Sai	7

16	20.716	Surisetti Navya	10
17	20.717	Todeti Ajay Babu	9
18	20.718	Yelivelu Venkata Jaya Ram	9
19	20.719	Pagolu Sri Lekha	9
20	20.720	Darapu Vanitha	8
21	20.721	Kaitepalli Teja Sri	7
22	20.722	Potluri Sravan Kumar	10
23	20.723	Tummala Akanksha	10
24	20.724	Tadepalli Anusha	9
25	20.725	Chalapati Venkata Naga Lakshmi	9
26	20.726	Potturi Krishna Bhuvaneswari	10
27	20.727	Nunna Pedda Bala Siva Nagamani	10
28	20.728	Kagithala Durga Prasad	9
29	20.729	Sangala Bhavana	9
30	20.730	Thota Lavanya	10
31	20.731	Gurrala Naga Sirisha	10
32	20.732	Kunchala Bhargavi	9
33	20.734	Nagarakanti Vujwala	10
34	20.735	Rajulapati Bhavana	9
35	20.736	Derangula Durga Anjaneyulu	10
36	20.737	Kamodula Tulasi Ram	8
37	20.738	Runku Sateesh	9
38	20.739	Konatham Siva Naga Pavani	9

39	20.740	Peram Jyothiramai	10
40	20.741	Gopalajoshula Prasanna Sai	10
41	20.742	Ande Madhu Babu	8
42	20.743	Sheik Ayesha	9
43	20.744	Mohammad Shaida Mansuri	8
44	20.746	Mareedu Tejaswi	10
45	20.747	Nalukurti Vinodh Babu	9
46	20.748	Bandaru Abhilash	8
47	20.749	Ede Pavan Kumar	8
48	20.750	Kolluri Manoj Kumar	7

A. Naga Srinivasa Rao.

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Feed Back Form

1. Is the programme interested to you (Yes/No)
2. Have you attended all the session (Yes/No)
3. Is the content of the program is adequate (Yes/No)
4. Have the teacher covered the entire syllabus? (Yes/No)
5. Is the number of hours adequate? (Yes/No)
6. Do you have any suggestions for enhancing or reducing the number of weeks designed for the program? (Yes/No)
7. On the whole, is the program useful in terms of enriching your knowledge? (Yes/No)
8. Do you have any suggestions on the program? (Yes/No)

R. Sateesh
20.738

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8. Do you have any suggestions on the program? (Yes/No)

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20.750.

A.G. & S.G. Siddhartha Degree College of Arts & Science

Vuyyuru-521165, Krishna District, Andhra Pradesh

Value Added Course / Certificate Course - Attendance Register

Class / Section: III B.Sc (MCCS) Year : 2022-23 Department of: Computer Science Paper: Cloud Computing Lecturer: A. Naga Srinivasa Rao

Sl. No	Roll No	Student Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1	20.701	Vemula Kavya Naga Sri	P	P	P	P	P	P	P	A	P	P	P	P	P	P	P	
2	20.702	Dronadula Hemanjali	P	P	P	P	P	P	P	P	P	P	P	A	A	P	P	
3	20.703	Dekka Kavitha	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
4	20.704	Jujjuvarapu Venkateswara Rao	P	A	P	P	P	P	P	P	P	P	P	P	P	P	P	
5	20.705	Mirza Hasan Abbas	P	P	P	P	P	P	P	P	P	P	P	P	A	P	P	
6	20.706	Marepalli Venkata Naga Sai Pavan Kumar	P	P	P	P	A	P	P	P	P	P	P	P	P	P	P	
7	20.707	Aluri Bhavya Sri	P	P	P	A	P	P	P	P	P	P	P	P	P	P	P	
8	20.708	Samayamanthula Sandeep	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
9	20.709	Kalapala Dinesh	P	P	P	P	P	P	A	P	P	P	P	P	P	P	P	
10	20.710	Jogi Gowthami	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
11	20.711	Jonnalagadda Kusuma	A	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
12	20.712	Perlapudi Pranadeep	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
13	20.713	Devabathina Satyadev	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
14	20.714	Somayajula S.M.K.Chaitanya	A	P	P	P	P	P	P	P	P	P	P	P	P	P	A	
15	20.715	Vukoti Naga Veera Sai	P	P	P	P	P	P	P	P	P	P	P	P	A	P	P	
16	20.716	Surisetti Navya	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	

17	20.717	Todeti Ajay Babu	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
18	20.718	Yelivelu Venkata Jaya Ram	P	A	P	P	P	P	P	P	P	P	P	P	P	P	P	
19	20.719	Pagolu Sri Lekha	P	P	P	P	P	P	P	P	P	P	A	P	P	P	P	
20	20.720	Darapu Vanitha	P	P	P	P	P	P	P	P	A	P	P	P	P	P	P	
21	20.721	Kaitepalli Teja Sri	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
22	20.722	Potluri Sravan Kumar	P	P	P	P	P	P	P	P	P	P	P	A	P	P	P	
23	20.723	Tummala Akanksha	P	P	P	P	P	A	P	P	P	P	P	P	P	P	P	
24	20.724	Tadepalli Anusha	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
25	20.725	Chalapati Venkata Naga Lakshmi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
26	20.726	Potturi Krishna Bhuvaneswari	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
27	20.727	Nunna Pedda Bala Siva Nagamani	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
28	20.728	Kagithala Durga Prasad	P	P	P	P	P	A	P	P	P	P	P	P	P	P	P	
29	20.729	Sangala Bhavana	P	P	P	P	P	P	P	P	P	P	A	P	P	P	P	
30	20.730	Thota Lavanya	P	P	P	P	A	P	P	P	P	P	P	P	P	P	P	
31	20.731	Gurrala Naga Sirisha	P	P	P	P	A	P	P	P	P	P	P	P	P	P	P	
32	20.732	Kunchala Bhargavi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
33	20.734	Nagarakanti Vujwala	P	P	P	P	P	P	P	P	P	P	P	P	A	P	P	
34	20.735	Rajulapati Bhavana	P	P	P	P	P	P	P	P	P	P	A	P	P	P	P	
35	20.736	Derangula Durga Anjaneyulu	P	P	A	P	P	P	P	P	P	P	P	P	P	P	P	
36	20.737	Kamodula Tulasi Ram	P	P	P	P	P	P	P	P	P	P	P	P	A	P	P	
37	20.738	Runku Sateesh	P	P	P	P	P	A	P	P	P	P	P	P	P	P	P	

38	20.739	Konatham Siva Naga Pavani	P	P	P	P	P	P	P	P	A	P	P	P	P	P	P	
39	20.740	Peram Jyothiramai	P	P	P	A	P	P	P	P	P	P	P	P	P	P	P	
40	20.741	Gopalajoshula Prasanna Sai	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
41	20.742	Ande Madhu Babu	P	P	P	P	P	A	P	P	P	P	P	P	P	P	A	
42	20.743	Sheik Ayesha	P	A	P	P	P	P	P	P	P	P	P	P	P	P	P	
43	20.744	Mohammad Shaida Mansuri	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
44	20.746	Mareedu Tejaswi	P	P	P	P	P	P	P	P	A	P	P	P	P	P	P	
45	20.747	Nalukurti Vinodh Babu	P	P	P	A	P	P	P	P	P	P	P	P	P	P	P	
46	20.748	Bandaru Abhilash	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
47	20.749	Ede Pavan Kumar	P	A	P	P	P	P	P	P	P	P	P	P	P	P	P	
48	20.750	Kolluri Manoj Kumar	P	P	P	P	P	P	P	P	P	P	P	A	P	P	P	

A. Naga Srinivasa Rao.
Signature of Lecturer

Signature of HOD
Head of the Department of Computers
AG & SG Siddhartha Degree College
VUYYURU - 521 165

Signature of Principal
PRINCIPAL
AG & SG Siddhartha Degree College of Arts&Science (Autonomous), Vuyyuru

A.G. & S.G. Siddhartha Degree College of Arts & Science

Vuyyuru-521165, Krishna District, Andhra Pradesh

Value Added Course / Certificate Course - Attendance Register

Class / Section: III B.Sc (MCCS) Year : 2022-23 Department of: Computer Science Paper: Cloud Computing Lecturer: A. Naga Srinivasa Rao.

Sl. No	Roll No	Student Name	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Total
1	20.701	Vemula Kavya Naga Sri	P	P	P	A	P	P	P	P	P	P	P	P	P	P	A	
2	20.702	Dronadula Hemanjali	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
3	20.703	Dekka Kavitha	P	A	P	P	P	P	P	P	P	P	P	P	P	P	P	
4	20.704	Jujjuvarapu Venkateswara Rao	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
5	20.705	Mirza Hasan Abbas	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
6	20.706	Marepalli Venkata Naga Sai Pavan Kumar	P	P	A	P	P	P	P	P	P	P	P	P	P	P	P	
7	20.707	Aluri Bhavya Sri	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
8	20.708	Samayamanthula Sandeep	P	A	P	P	P	P	P	P	P	P	P	P	P	P	P	
9	20.709	Kalapala Dinesh	P	P	P	A	P	P	P	P	P	P	P	P	P	P	P	
10	20.710	Jogi Gowthami	P	P	P	P	P	P	A	P	P	P	P	P	P	P	P	
11	20.711	Jonnalagadda Kusuma	P	P	P	P	P	P	P	P	P	P	P	P	P	A	P	
12	20.712	Perlapudi Pranadeep	P	P	P	P	A	P	P	P	P	P	P	P	P	P	P	
13	20.713	Devabathina Satyadev	P	P	P	P	P	P	A	P	P	P	P	P	P	P	A	
14	20.714	Somayajula S.M.K.Chaitanya	P	P	A	P	P	P	P	P	P	P	P	P	P	P	P	
15	20.715	Vukoti Naga Veera Sai	P	P	P	P	P	P	P	P	P	P	P	P	P	A	P	

16	20.716	Surisetti Navya	P	P	P	A	P	P	P	P	P	P	P	P	P	P	P	
17	20.717	Todeti Ajay Babu	P	P	P	P	P	A	P	P	P	P	P	P	P	P	P	
18	20.718	Yelivelu Venkata Jaya Ram	P	P	P	P	P	P	P	P	P	P	P	P	A	P	P	
19	20.719	Pagolu Sri Lekha	P	P	P	A	P	P	P	P	P	P	P	P	P	P	P	
20	20.720	Darapu Vanitha	P	P	P	P	P	P	P	P	P	P	P	P	P	A	P	
21	20.721	Kaitepalli Teja Sri	P	P	P	P	P	P	P	P	P	P	P	A	P	P	P	
22	20.722	Potluri Sravan Kumar	P	P	P	P	P	P	P	A	P	P	P	P	P	P	P	
23	20.723	Tummala Akanksha	P	P	P	P	P	P	P	P	P	P	P	P	A	P	P	
24	20.724	Tadepalli Anusha	P	P	P	P	P	P	P	A	P	P	P	P	P	P	P	
25	20.725	Chalapati Venkata Naga Lakshmi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
26	20.726	Potturi Krishna Bhuvaneswari	P	P	P	P	P	P	P	P	A	P	P	P	P	P	P	
27	20.727	Nunna Pedda Bala Siva Nagamani	P	P	P	P	P	A	P	P	P	P	P	P	P	P	P	
28	20.728	Kagithala Durga Prasad	P	P	P	P	P	P	P	P	P	P	P	P	P	P	A	
29	20.729	Sangala Bhavana	P	P	P	P	P	P	A	P	P	P	P	P	P	P	P	
30	20.730	Thota Lavanya	P	P	P	P	A	P	P	P	P	P	P	P	P	P	P	
31	20.731	Gurrala Naga Sirisha	A	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
32	20.732	Kunchala Bhargavi	P	P	P	P	P	P	P	P	P	P	P	A	P	P	P	
33	20.734	Nagarakanti Vujwala	P	P	P	P	P	P	P	P	A	P	P	P	P	P	P	
34	20.735	Rajulapati Bhavana	P	P	P	A	P	P	P	P	P	A	P	P	P	P	P	
35	20.736	Derangula Durga Anjaneyulu	P	P	P	P	P	P	P	A	P	P	P	P	P	P	P	
36	20.737	Kamodula Tulasi Ram	P	A	P	P	P	P	P	P	P	P	P	P	P	P	P	

37	20.738	Runku Sateesh	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
38	20.739	Konatham Siva Naga Pavani	P	A	P	P	P	P	P	P	P	P	P	P	P	P	P	
39	20.740	Peram Jyothiramai	P	P	A	P	P	P	P	P	P	P	P	P	P	P	P	
40	20.741	Gopalajoshula Prasanna Sai	P	P	P	P	P	P	P	A	P	P	P	P	P	P	P	
41	20.742	Ande Madhu Babu	P	A	P	P	P	P	P	P	P	P	P	P	A	P	P	
42	20.743	Sheik Ayesha	P	P	P	P	P	P	P	P	P	A	P	P	P	P	A	
43	20.744	Mohammad Shaida Mansuri	P	P	P	P	A	P	P	P	P	P	P	P	A	P	P	
44	20.746	Mareedu Tejaswi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	A	
45	20.747	Nalukurti Vinodh Babu	P	P	P	P	P	P	P	P	A	P	P	P	P	P	P	
46	20.748	Bandaru Abhilash	A	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
47	20.749	Ede Pavan Kumar	P	P	A	P	P	P	P	P	P	P	P	P	P	P	P	
48	20.750	Kolluri Manoj Kumar	P	P	P	P	A	P	P	P	P	P	P	P	P	P	P	

A. Naga Srinivasa Rao .

Signature of Lecturer

Signature of HOD

Head of the Department of Computers
A G & S G Siddhartha Degree College
VUYYURU - 521 165

Signature of Principal

PRINCIPAL
AG & SG Siddhartha Degree College of
Arts&Science (Autonomous),Vuyyuru

ADUSUMILLI GOPALAKRISHNAIAH & SUGARCANE GROWERS
SIDDHARTHA DEGREE COLLEGE OF ARTS & SCIENCE
Vuyyuru-521 165, Krishna District, Andhra Pradesh
An Autonomous College in the Jurisdiction of Krishna University
Accredited by NAAC with "A" Grade

DEPARTMENT OF COMPUTER SCIENCE

VALUE ADDED COURSE:CLOUD COMPUTING

VAC CODE:CCVAC13

CERTIFICATE

This is to Certify that Son /Daughter of shri/Smt has Successfully completed value added course in CLOUD COMPUTING Conducted by the Department of COMPUTER SCIENCE from 01-11-2022 to 09-02-2023 We wish him /her bright future

Co-ordinator **Head of Department** **Principal**