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Subject Name: Cloud computing Lab (CCL)

Class/Sem: T.E. / SEM-VI

Year: 2021-2022



COMPUTER ENGINEERING DEPARTMENT

Subject: Cloud Computing Lab

Class/Sem: TE/VI

Name of the Laboratory: SDC LAB

Year: 2021-2022

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H/W Requirement	P I and above, RAM 128MB, Printer, Cartridges.
S/W Requirement	VirtualBox Machine, Ubuntu, AWS/Azure account, Docker.

Prof. Hemlata Gosavi
Subject In-charge

Prof. Sujata Bhairnallykar
HOD

Experiment No. 1

Aim: To understand concept of Cloud Computing.

Theory:

What is cloud computing?

Cloud computing is the delivery of computing services—including servers, storage, databases, networking, software, analytics, and intelligence—over the Internet (“the cloud”) to offer faster innovation, flexible resources, and economies of scale. You typically pay only for cloud services you use, helping lower your operating costs, run your infrastructure more efficiently and scale as your business needs change.

Cloud Computing Architecture

The Architecture of Cloud computing contains many different components. It includes Client infrastructure, applications, services, runtime clouds, storage spaces, management, and security. These are all the parts of a Cloud computing architecture.

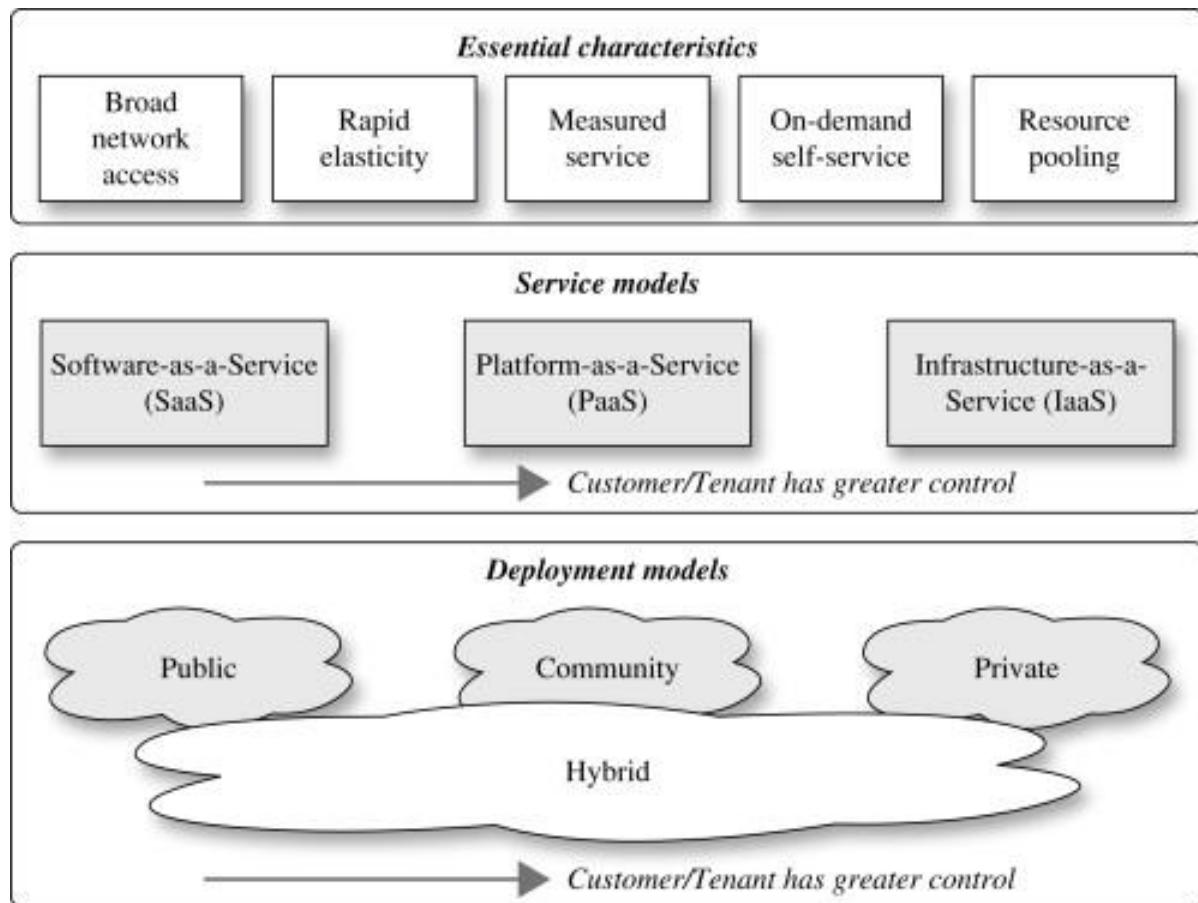
- **Front End:** The client uses the front end, which contains a client-side interface and application. Both of these components are important to access the Cloud computing platform. The front end includes web servers (Chrome, Firefox, Opera, etc.), clients, and mobile devices.
- **Back End:** The backend part helps you manage all the resources needed to provide Cloud computing services. This Cloud architecture part includes a security mechanism, a large amount of data storage, servers, virtual machines, traffic control mechanisms, etc.

Virtualization and Cloud Computing

The main enabling technology for Cloud Computing is Virtualization. Virtualization is the partitioning of a single physical server into multiple logical servers. Once the physical server is divided, each logical server behaves like a physical server and can run an operating system and applications independently. Many popular companies like VMware and Microsoft provide virtualization services. Instead of using your PC for storage and computation, you can use their virtual servers. They are fast, cost-effective, and less time-consuming.

For software developers and testers, virtualization comes in very handy. It allows developers to write code that runs in many different environments for testing.

Virtualization is mainly used for three main purposes: 1) Network Virtualization, 2) Server Virtualization, and 3) Storage Virtualization



Cloud Deployment Models

NIST defines four cloud deployment models: public clouds, private clouds, community clouds, and hybrid clouds. A cloud deployment model is defined according to where the infrastructure for the deployment resides and who has control over that infrastructure. Deciding which deployment model you will go with is one of the most important cloud deployment decisions you will make.

Each cloud deployment model satisfies different organizational needs, so it's important that you choose a model that will satisfy the needs of your organization. Perhaps even more important is the fact that each cloud deployment model has a different value proposition and different costs associated with it. Therefore, in many cases, your choice of a cloud deployment model may simply come down to money. In any case, to be able to make an informed decision, you need to be aware of the characteristics of each environment.

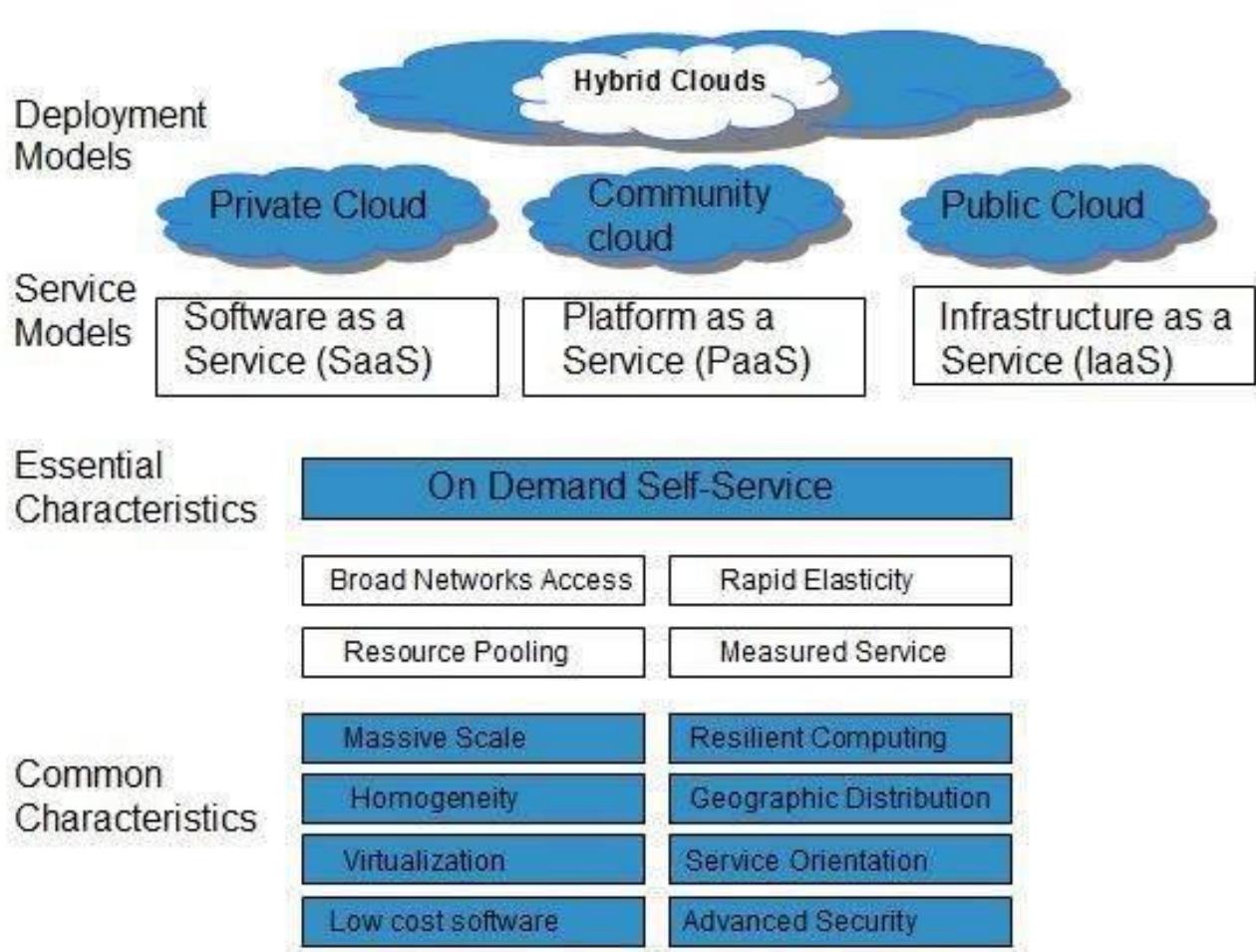
The four Cloud Deployment models:

- **Private cloud:** The cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on premise or off premise.
- **Community cloud:** The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise.
- **Public cloud:** The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services.
- **Hybrid cloud:** The cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load-balancing between clouds).

These four deployment models can see significant variation depending on other factors that we will discuss in the next section, but they serve to address the broad questions as to how one can deploy pooled cloud resources. It is important to make two points about the NIST Cloud Model:

A customer or tenant can have greater security control over more resources as one moves from SaaS to PaaS and again from PaaS to the IaaS service model.

A customer or tenant can achieve greater security control over more resources when moving from a Public cloud to a community cloud and again from a community cloud to a Private cloud.



Cloud Service models

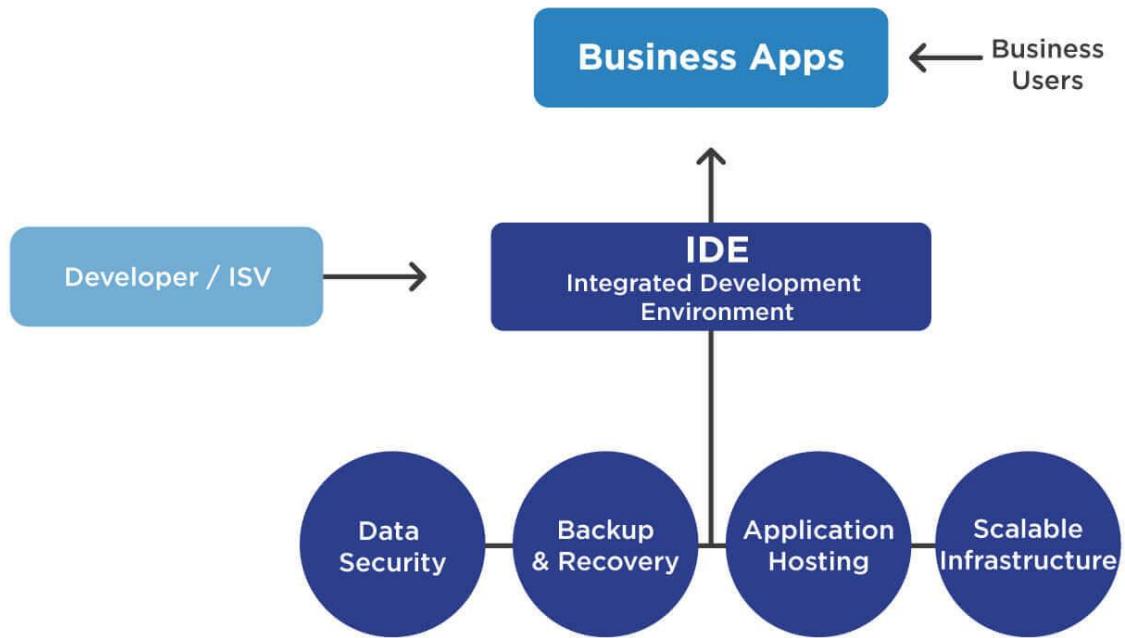
Software as a Service: Software as a Service, also known as SaaS, is essentially a web platform that provides users access to cloud computing on a subscription basis. Instead of purchasing the solution one time, as if it would be a product, the software is delivered continuously — like a service. SaaS services provide companies with data storage and management features. Often, these are services for process automation, marketing, collaboration, and data organization. Development environments can also be done as SaaS — software developers receive access to the platform where they can build, test, and deploy a product, configure its functionality and interface with built-in tools and templates.



Examples of SaaS:

- **Google's G Suite:** top cloud service provides businesses with access to management, communication, and organization tools and uses cloud for data computing. Gmail, Google Drive, Google Docs, Google Planner, Hangouts — these are all SaaS tools that can be accessed anytime and anywhere.
- **Microsoft Office 365:** the series of web services that provide business owners and individuals with access to Microsoft Office main tools directly from their browsers. Users can access Microsoft editing tools, business email, communication instruments, and documentation software.
- **Salesforce:** the most popular CRM on the market that unites marketing, communication, e-commerce. Salesforce uses cloud computing benefits to provide access to its services and internal data. Business owners can keep track of their sales, client relations, communications, and relevant tasks from any device. Salesforce can be integrated into the website — the information about incoming leads will be sent to the platform automatically.
- **Platform as a Service:** Platform as a Service is software that provides access to development tools, APIs, and deployment instruments. Users receive access to virtual

development environments and Cloud storage, where they can build, test, and run applications. In PaaS, users are billed only for the platforms that they use for the time when the services were used. There is no need to pay for excessive functionality, like in desktop solutions.

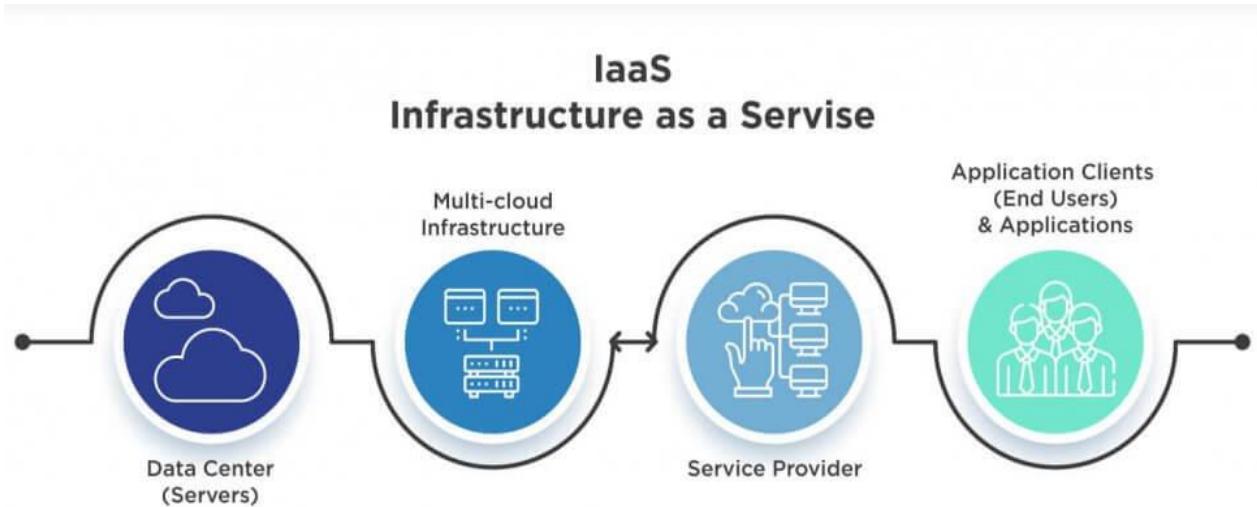


Examples of PaaS:

- **AWS Elastic Beanstalk:** a web platform for software deployment and management, powered by the AWS Cloud. Users upload their applications to the service, and it automatically monitors the performance, load capacity, and checks for deployment errors.
- **Apache Stratos:** the Cloud computing platform for arranging PHP and MySQL. The PaaS provides users with ready-to-use tools for database development and testing, performance monitoring, integration, and billing.
- **Magento Commerce Cloud:** Magento Cloud offers tools for e-commerce development, testing, deployment, and maintenance. The Cloud environment

allows accessing the store settings anytime and anywhere as well as automates the key processes.

- **Infrastructure as a service:** IaaS provides businesses with ready-to-use IT infrastructure: development environment, private networks, secure data storage, instruments for software development and testing, functionality monitoring, etc. The enterprises don't need to build and secure their own IT infrastructure — they fully power the development process with third-party servers and cloud backup storage.



Examples of IaaS:

- **Amazon Web Services:** a public cloud that offers subscribers access to virtual servers for product deployment, Cloud storage, tools for development, testing, and analytics. The application provides a ready-to-use environment to develop and test the product and offers the full cloud infrastructure for its deployment and maintenance.
- **Microsoft Azure:** the combination of IaaS and platform as a service, the software offers 100+ services for software development, administration, and deployment, provides tools for working with innovative technologies (big data, machine learning, Internet of Things), etc.

- **IBM Infrastructure:** IBM uses its in-house services to store the data of infrastructure users, enabling remote data access via Cloud computing. IBM servers support AI, block chain, and the Internet of Things. The infrastructure also provides Cloud storage and virtual development environments, enabled on the subscription basis.
- **Google Cloud Infrastructure:** the large network of international servers that provides users access to remote Cloud data centres. Companies can store their information in Asia, Europe, and Latin America, which minimizes the risk of a security breach.

Advantages of Cloud

- **Cost:** Cloud computing eliminates the capital expense of buying hardware and software and setting up and running on-site datacentres—the racks of servers, the round-the-clock electricity for power and cooling, the IT experts for managing the infrastructure. It adds up fast.
- **Global scale:** The benefits of cloud computing services include the ability to scale elastically. In cloud speak, that means delivering the right amount of IT resources—for example, more or less computing power, storage, bandwidth—right when it is needed and from the right geographic location.
- **Performance:** The biggest cloud computing services run on a worldwide network of secure datacentres, which are regularly upgraded to the latest generation of fast and efficient computing hardware. This offers several benefits over a single corporate datacentre, including reduced network latency for applications and greater economies of scale.

- **Security:** Many cloud providers offer a broad set of policies, technologies and controls that strengthen your security posture overall, helping protect your data, apps and infrastructure from potential threats.
- **Speed:** Most cloud computing services are provided self service and on demand, so even vast amounts of computing resources can be provisioned in minutes, typically with just a few mouse clicks, giving businesses a lot of flexibility and taking the pressure off capacity planning.
- **Productivity:** On-site datacentres typically require a lot of “racking and stacking”—hardware setup, software patching, and other time-consuming IT management chores. Cloud computing removes the need for many of these tasks, so IT teams can spend time on achieving more important business goals.
- **Reliability:** Cloud computing makes data backup, disaster recovery and business continuity easier and less expensive because data can be mirrored at multiple redundant sites on the cloud provider’s network.

Disadvantages of cloud computing

- **Downtime:** Downtime is often cited as one of the biggest disadvantages of cloud computing. Since cloud computing systems are internet-based, service outages are always an unfortunate possibility and can occur for any reason.
- **Security and privacy:** Although cloud service providers implement the best security standards and industry certifications, storing data and important files on external service providers always opens up risks. Any discussion involving data must address security and privacy, especially when it comes to managing sensitive data. We must not forget what happened at Code Space and the hacking of their AWS EC2 console, which led

to data deletion and the eventual shutdown of the company. Their dependence on remote cloud-based infrastructure meant taking on the risks of outsourcing everything.

- **Vulnerability to attack:** In cloud computing, every component is online, which exposes potential vulnerabilities. Even the best teams suffer severe attacks and security breaches from time to time. Since cloud computing is built as a public service, it's easy to run before you learn to walk. After all, no one at a cloud vendor checks your administration skills before granting you an account: all it takes to get started is generally a valid credit card.
- **Limited control and flexibility:** Since the cloud infrastructure is entirely owned, managed, and monitored by the service provider, it transfers minimal control over to the customer. To varying degrees (depending on the particular service), cloud users may find they have less control over the function and execution of services within a cloud-hosted infrastructure. A cloud provider's end-user license agreement (EULA) and management policies might impose limits on what customers can do with their deployments. Customers retain control of their applications, data, and services, but may not have the same level of control over their backend infrastructure.
- **Vendor lock-in:** Vendor lock-in is another perceived disadvantage of cloud computing. Easy switching between cloud services is a service that hasn't yet completely evolved, and organizations may find it difficult to migrate their services from one vendor to another. Differences between vendor platforms may create difficulties in migrating from one cloud platform to another, which could equate to additional costs and configuration complexities. Gaps or compromises made during migration could also expose your data to additional security and privacy vulnerabilities.

Applications of Cloud Computing

- **Online Data Storage:** Organizations have a lot of data to store and with time the size of this data increases. This data can be in any format like text, image, audio, or video. Now, in order to store and maintain this huge amount of data, organizations are no longer needed to set physical storage systems. They can use Clouds to store their data. The whole data of an organization can be categorized into two types – current data and historical data. Data that is used very frequently in order to perform some day-to-day operations is known as current data. On the other hand, data that is not operational but is of value and needs to be stored is known as historical data. So, in order to store these two types of data separately, we have two storage options available:
 - Hot Storage: The data which needs to be accessed right away or very frequently, is stored in this storage.
 - Cold Storage: The data which does not require fast access or frequent access is stored in cold storage.

- Cloud storage of data also makes it easily accessible because now you can access it from anywhere in the world with just an internet connection.
- **Backup and Recovery:** Cloud service providers offer a lot of options for data recovery. They offer various recovery plans at different costs. The cloud provider gives the option for data redundancy, i.e., a copy of data is stored at different places. It can be a different server or data centre or even a different geographic location. The reason for this redundant storage option is to provide safety against data and to provide flexibility in accessing the data. Suppose, at the primary location data becomes inaccessible somehow, then it can be easily accessed from other storage locations. Some data redundancy options available are:
 - Locally redundant storage (LRS)

- Zone-redundant storage (ZRS)
 - Geo-redundant storage (GRS)
 - Geo-zone-redundant storage (GZRS)
- **Testing and Development:** After the development of a product, testing plays a major role in finalizing it for deployment. Before the final delivery, a product needs to be tested properly. It must be tested on different machines with different infrastructures because the end-user of that product can be anywhere. It also must be tested for load balancing. Load balancing- How the performance of a product affects when a large number of users use it simultaneously. To accomplish such tasks testing requires different IT resources and different computer infrastructures. Now, A cloud can provide these testing features at one place. Organizations can easily test the performance of their product on the cloud against a large number of users.
 - **Cloud Computing in Medical Fields:** In the medical field also, cloud computing is doing wonders. It is used to store data of patients and helps to access it over the internet without any need of the physical computer set up to trace the previous records, or even doesn't need the paperwork. In case of emergencies, the patient's data can be accessed remotely from anywhere rather than waiting till they get access to information from the hospital computer.
 - **Big Data analysis:** Big Data analysis involves dealing with huge amounts of data having sizes from terabytes to zettabytes (known as big data). Now for any traditional database management system, it is very difficult to maintain this amount of data. Cloud Computing allows us to store large data sets that include structured, and unstructured data, from different sources, and in different sizes from terabytes to zettabytes. Not only the storage, it also provides us various tools in order to do the analysis on this big data.

Because the main purpose of storing big data is to derive something out of it. The flexibility of the cloud makes it a good choice for big data analytics. Organizations will have a major financial advantage by using the cloud because it is much cheaper than the traditional large-scale big data resources. Now they do not need to maintain large data centres. Moreover, the cloud also makes data integration from different resources much easier for organizations.

- **Entertainment Applications:** Today we get a lot of entertainment content on the internet, let it be Netflix web series episodes, online games, or YouTube videos. This data is widely used by users from almost all parts of the world. It is also very necessary to provide a great customer experience. So that this content is available on-demand. For this, the entertainment companies reach their customers through a multi-cloud strategy. With the help of the cloud, the entertainment industry is reaching new heights.
- **Social Network Platforms:** Social network platforms play an important role in day-to-day life. They have changed the way of communication and interaction. These platforms have a large number of users across the globe and this makes them ideal candidates for cloud computing adaptation. Social media sites contain heavy multimedia content like images and videos and they are capable of making the whole network slow, here cloud storage comes into play. Cloud storage helps social media applications to run smoothly. Apart from data storage, cloud services also offer cost-effective analytics for these sites. Another advantage of cloud computing is data backup and recovery in case of any disaster. Social media sites store the personal data of their users and therefore they cannot afford to lose even a small part of it. If the data is only stored in one central location it can be insecure. If something happens there, it is almost impossible to recover the data. But through cloud security services they remain accessible through shared resources across the globe.

- **Anti-virus Applications:** Nowadays we have cloud-based antivirus solutions which perform better than traditional antivirus software. The main reason behind this is – Cloud-based antivirus stores malware information on the cloud rather than on the user system. Traditional antivirus software is used to store malware information on the user system itself which can adversely affect the performance of the user's system.
- **Accounting Application:** Cloud-based accounting applications help an organization to manage their business accounting and finances in less time, effort, expense, and labour. It allows businesses to manage their finances from anywhere in the world without compromising on the security of data. Cloud-based accounting applications or software are scalable because now companies can expand their workforce without investing in the infrastructure. Cloud makes this software easy to upgrade because now we do not have to worry about our system specifications and resources.
- **Management Applications:** Management Application like 'Evernote' is cloud-based application. It helps to save, format, and share notes over the cloud. Evernote uses cloud computing's storage service to store the data of the users. Because of being in the cloud storage, the data can be accessed at any time, from anywhere, and on any device. The security service of the cloud helps to keep the data secure. Also, there are no chances of data loss because of the redundant storage service that Evernote uses in Cloud Computing.

Conclusion: We have successfully understand the concept of cloud computing, NIST Architecture and Infrastructure of cloud computing, various Deployment models of cloud computing and when to use specific or combination of Deployment model, different Services models and their level of access, Advantages and Disadvantages of cloud computing and whereas areas where it can be implemented and how it can be implemented.

Experiment No. 2

Aim: To create and run virtual machines on Hosted **Hypervisor** like **KVM** (Kernel Based Virtual Machine) and **Virtual Box**.

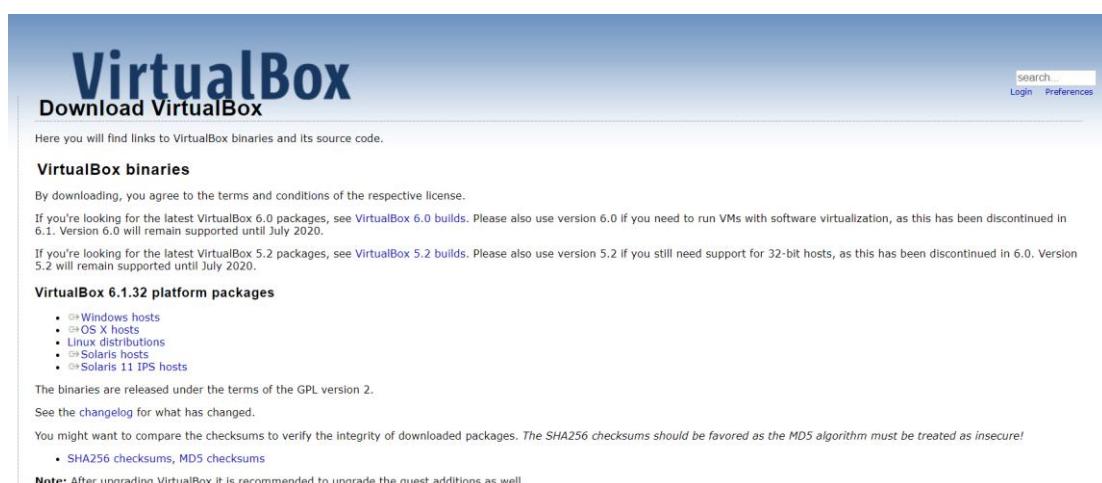
Requirements: Windows/Linux O.S for **Virtual Box** and Linux O.S for **KVM** with compatible hardware.

Theory:

Hypervisor: A **hypervisor**, also known as a virtual machine monitor or **VMM**, is software that creates and runs virtual machines (VMs). A hypervisor allows one host computer to support multiple guest VMs by virtually sharing its resources, such as memory and processing. There are two main hypervisor types, referred to as “Type 1” (or “bare metal”) and “Type 2” (or “hosted”). A **type 1 hypervisor** acts like a lightweight operating system and runs directly on the host’s hardware, while a **type 2 hypervisor** runs as a software layer on an operating system, like other computer programs. **Oracle Virtual Box** is type 2 hypervisor and **KVM** is type 2 hypervisor.

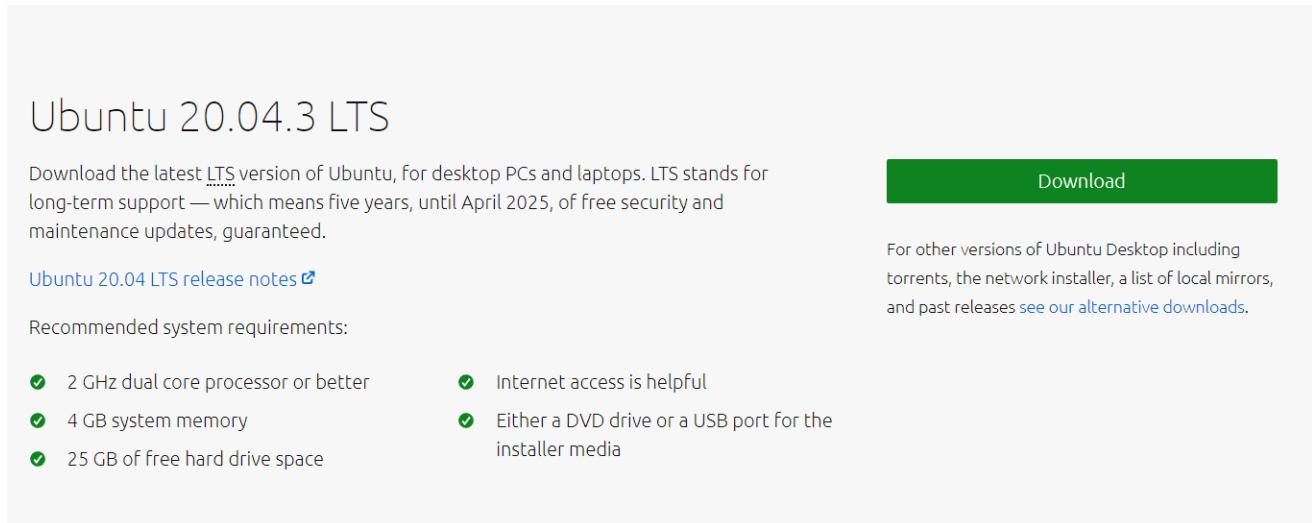
1. Implementing virtual machine on Oracle Virtual Box:

Step 1: Download Oracle Virtual Box compatible for your O.S from <https://www.virtualbox.org/wiki/Downloads>

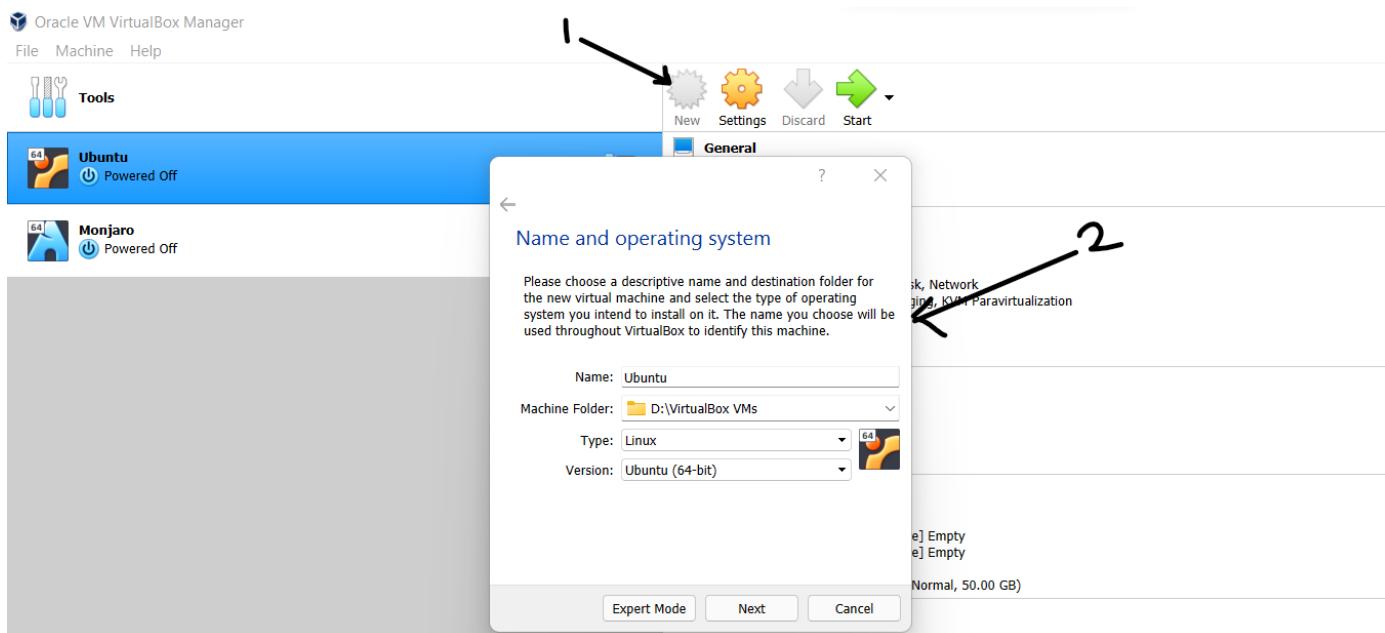


Step 2: Download Disc Image of Ubuntu (Linux) from <https://ubuntu.com/download/desktop>

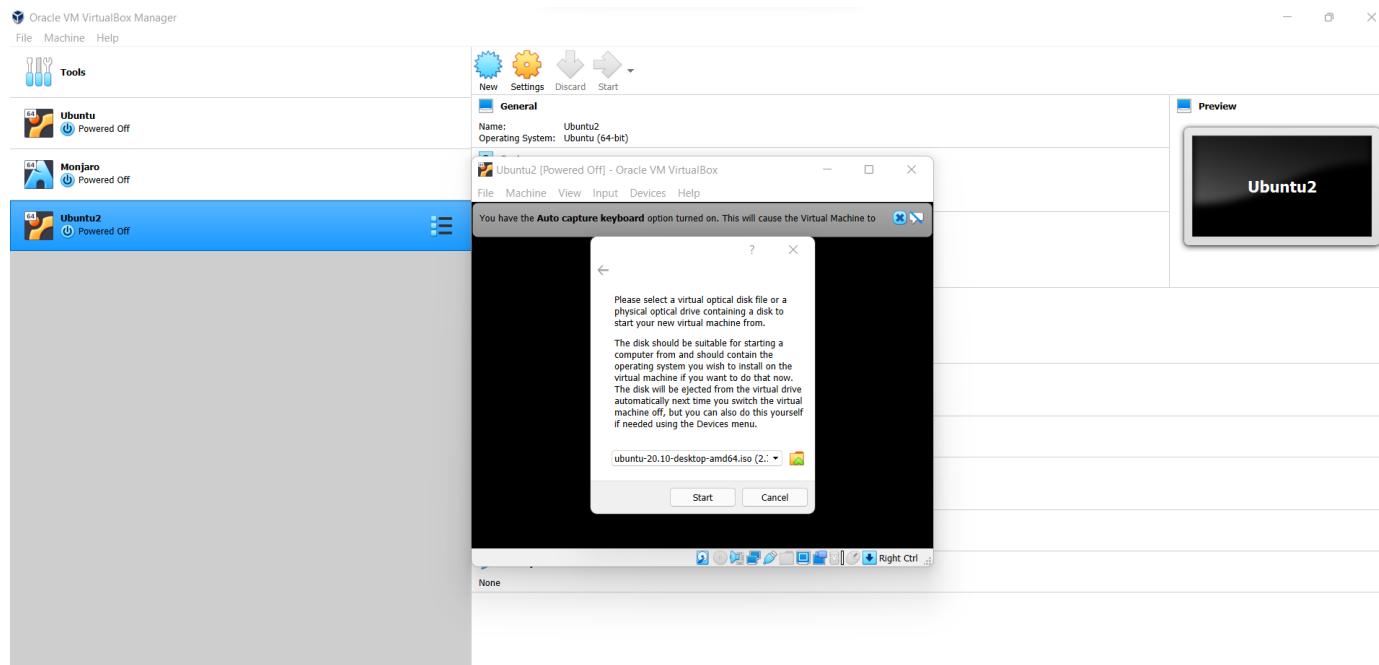
Download Ubuntu Desktop



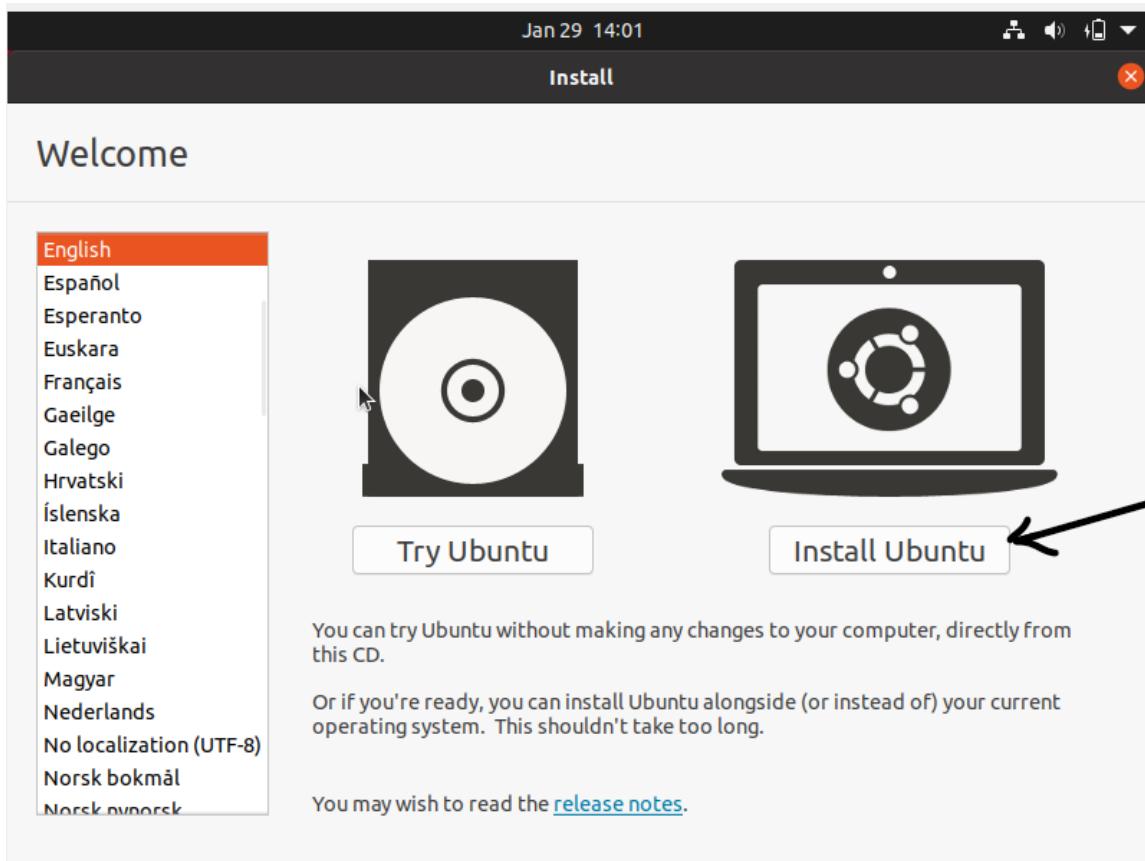
Step 3: Open Virtual Box and click on New and give a desired name and select type Linux and version Ubuntu and Click on next setup hardware specifications.



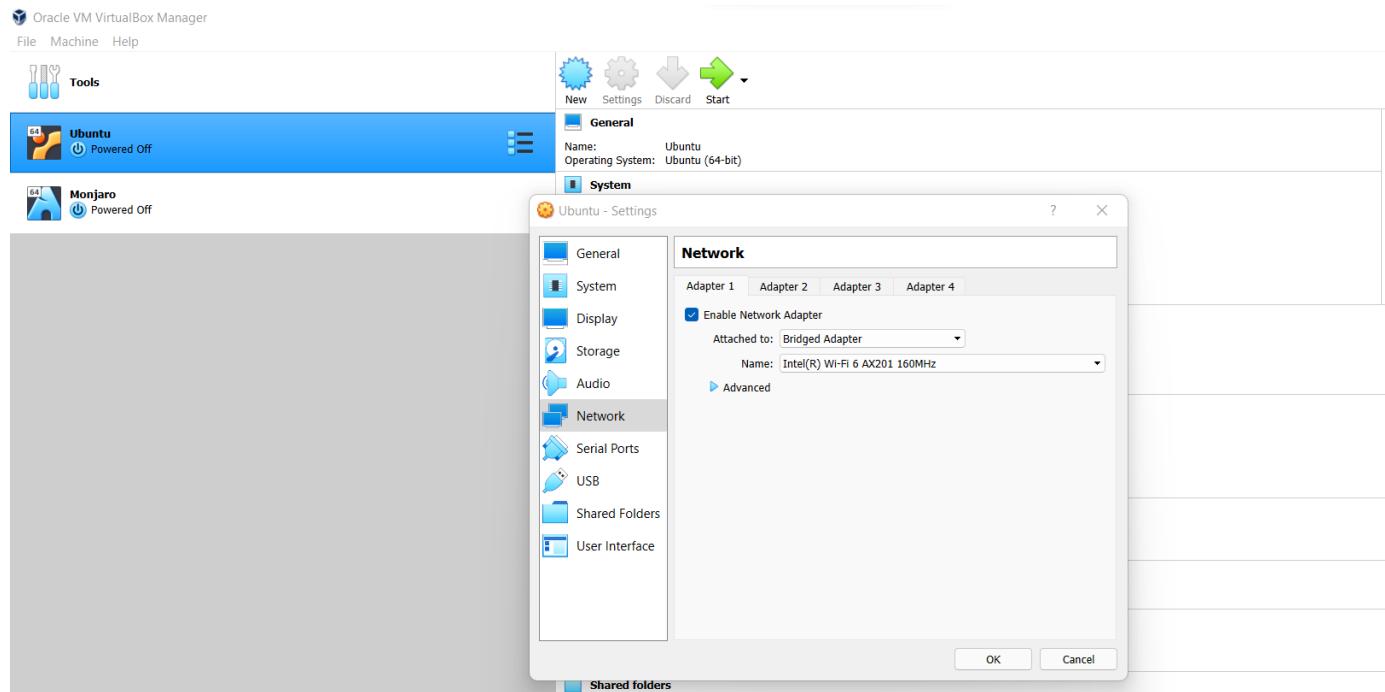
Step 4: After completion of **Step 3** click on Start button, after clicking on Start it will ask for disc image (.iso) select the Ubuntu disc image downloaded in **Step 2** and click on start.



Step 5: Select Safe Graphical Install if you graphical installation then it will show you option Try Ubuntu and Install Ubuntu click on Install Ubuntu and wait for Installation process to complete.



Step 6: After completion of installation enable change network mode to Bridge Adapter for Ubuntu virtual machine which is by default set to NAT by **Oracle Virtual Box**.



2. Implementing virtual machine on KVM:

Step 1: Before you begin with installing KVM, check if your CPU supports hardware virtualization. Command: **egrep -c '(vmx|svm)' /proc/cpuinfo**

```
marko@test-machine:~$ egrep -c '(vmx|svm)' /proc/cpuinfo
2
marko@test-machine:~$
```

If the command returns a value of **0**, your processor is not capable of running KVM. On the other hand, any other number means you can proceed with the installation.

Step 2: Install essential KVM packages with the following command:

```
sudo apt install qemu-kvm libvirt-daemon-system libvirt-clients bridge-utils
```

```
marko@test-machine:~$ sudo apt install qemu-kvm libvirt-daemon-system libvirt-clients b
ridge-utils
Reading package lists... Done
Building dependency tree
Reading state information... Done
Need to get 25.6 MB of archives.
After this operation, 108 MB of additional disk space will be used.
Do you want to continue? [Y/n]
```

Step 3: Only members of the libvirt and kvm user groups can run virtual machines. Add a user to the libvirt and kvm group by typing commands:

1. **sudo adduser ‘username’ libvirt**

2. **sudo adduser ‘username’ kvm**

```
marko@test-machine:~$ sudo adduser 'marko' libvirt
Adding user `marko' to group `libvirt' ...
Adding user marko to group libvirt
Done.
marko@test-machine:~$
```

```
marko@test-machine:~$ sudo adduser 'marko' kvm
Adding user `marko' to group `kvm' ...
Adding user marko to group kvm
Done.
marko@test-machine:~$
```

Note: If user is not created you can create user using following command: **sudo adduser ‘username’**

Step 4: Confirm the installation was successful by using the **virsh** command: **virsh list –all**

```
marko@test-machine:~$ virsh list --all
 Id  Name   State
 -----
marko@test-machine:~$
```

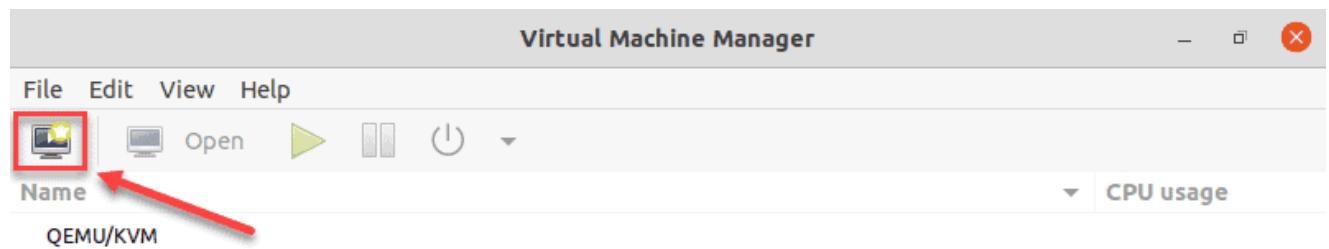
Step 5: use the systemctl command to check the status of libvирtd: **sudo systemctl status libvирtd**

```
marko@test-machine:~$ sudo systemctl status libvирtd
● libvирtd.service - Virtualization daemon
   Loaded: loaded (/lib/systemd/system/libvирtd.service; enabled; vendor preset: enabled)
   Active: active (running) since Fri 2020-11-27 09:36:04 EST; 44min ago
     TriggeredBy: ● libvирtd-ro.socket
                  ● libvирtd-admin.socket
                  ● libvирtd.socket
   Docs: man:libvирtd(8)
         https://libvirt.org
 Main PID: 18166 (libvирtd)
    Tasks: 19 (limit: 32768)
   Memory: 14.2M
      CGroup: /system.slice/libvирtd.service
              └─18166 /usr/sbin/libvирtd
                  ├─18301 /usr/sbin/dnsmasq --conf-file=/var/lib/libvирт/dnsmasq/default.conf
                  ├─18302 /usr/sbin/dnsmasq --conf-file=/var/lib/libvирт/dnsmasq/default.conf
```

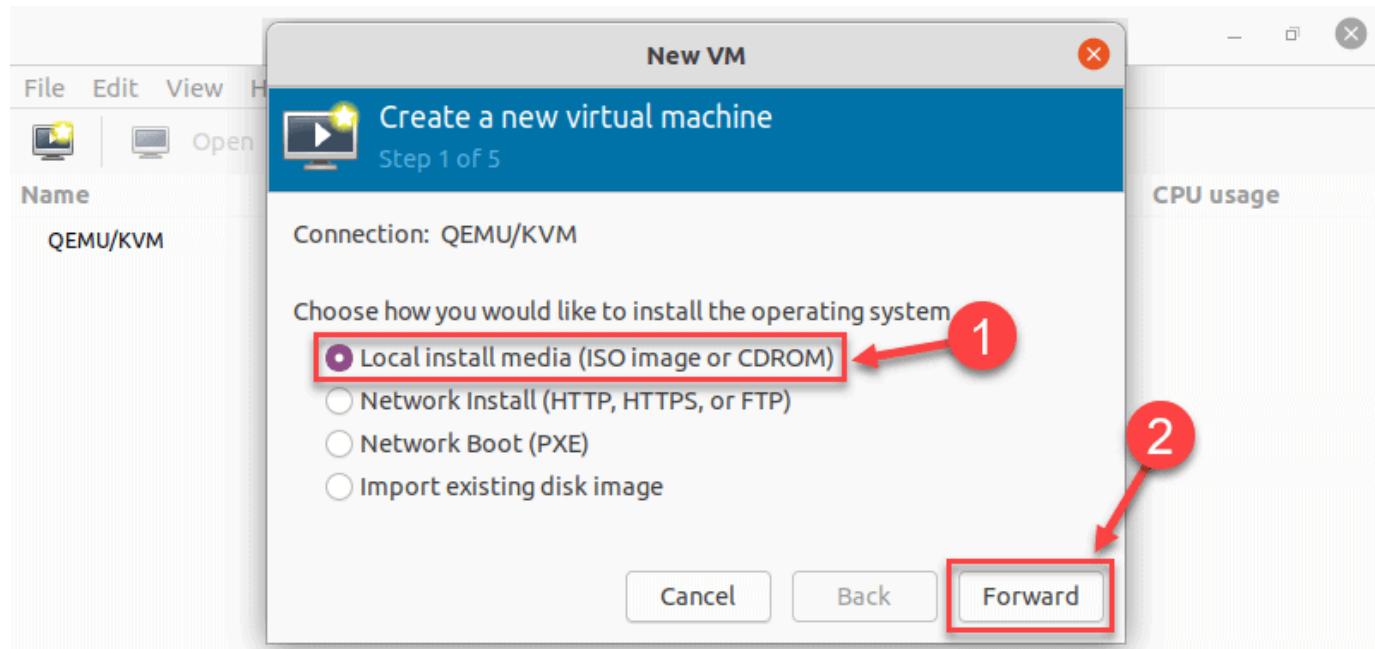
Step 6: Install virt-manager, a tool for creating and managing VMs: **sudo apt install virt-manager**

```
marko@test-machine:~$ sudo apt install virt-manager
[sudo] password for marko:
Reading package lists... Done
Building dependency tree
Reading state information... Done
0 upgraded, 33 newly installed, 0 to remove and 74 not upgraded.
Need to get 7,987 kB of archives.
After this operation, 62.5 MB of additional disk space will be used.
Do you want to continue? [Y/n] ■
```

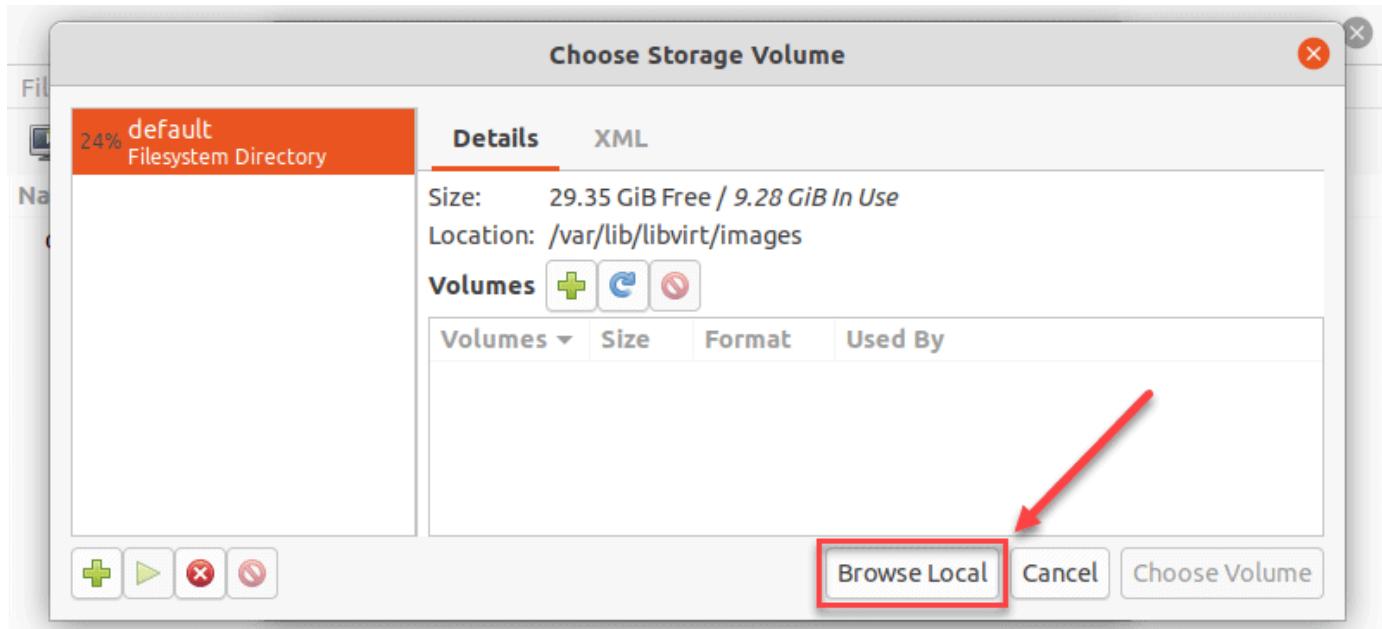
Step 7: Start virt-manager with: **sudo virt-manager** and then click the computer icon in the upper-left corner.



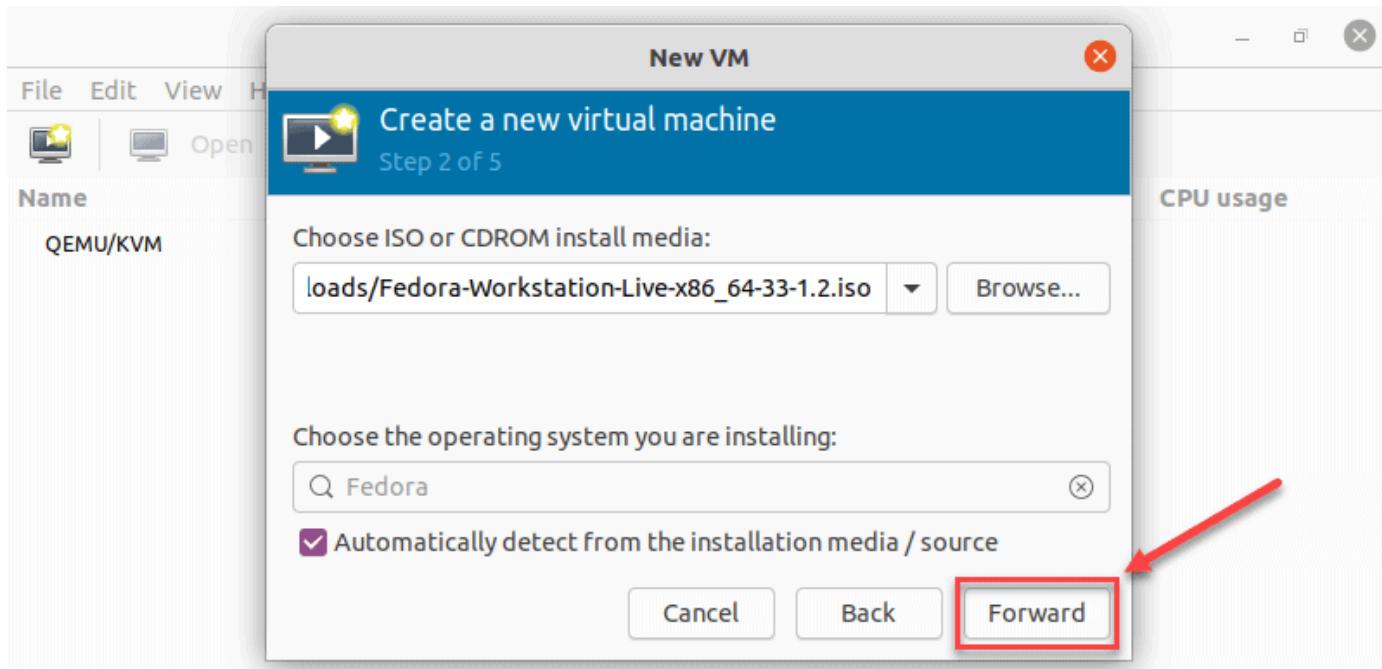
Step 8: In the dialogue box that opens, select the option to install the VM using an ISO image. Then click Forward.



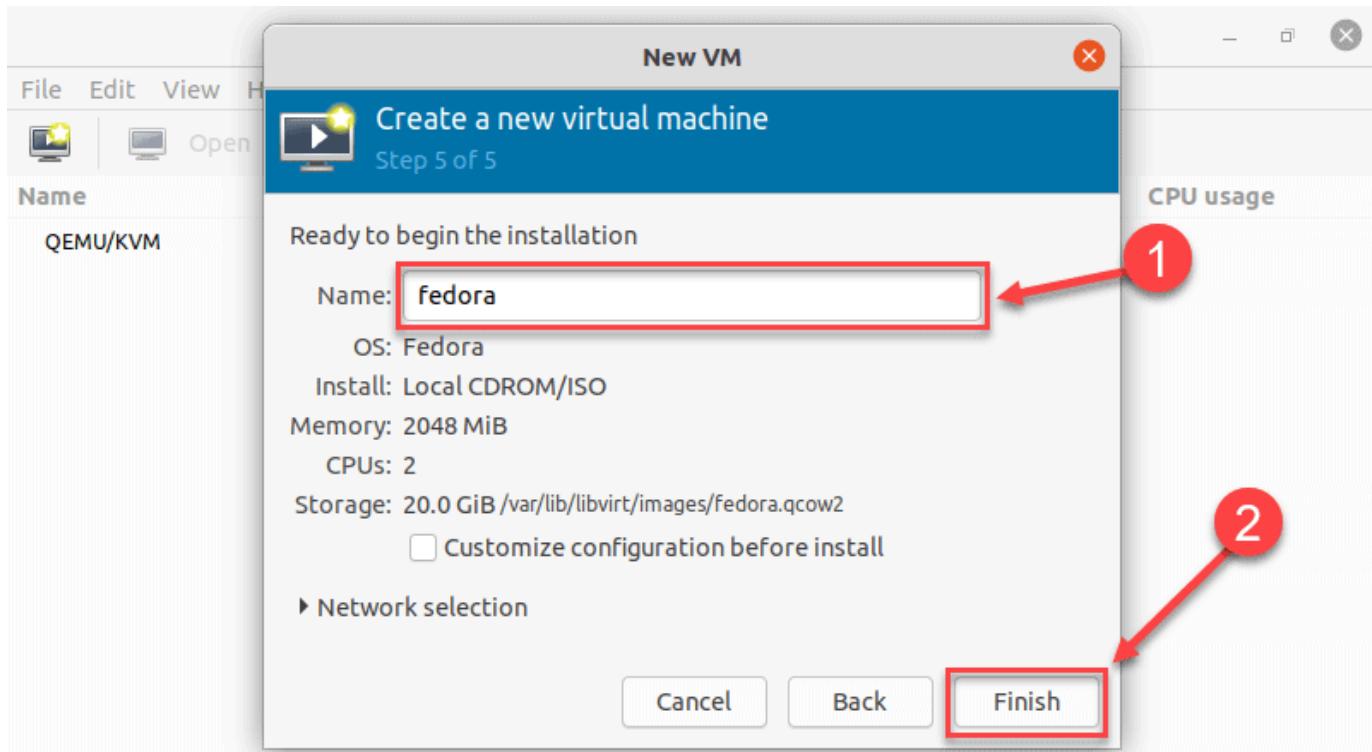
Step 8: Click Browse Local and navigate to the path where you stored the ISO you wish to install.



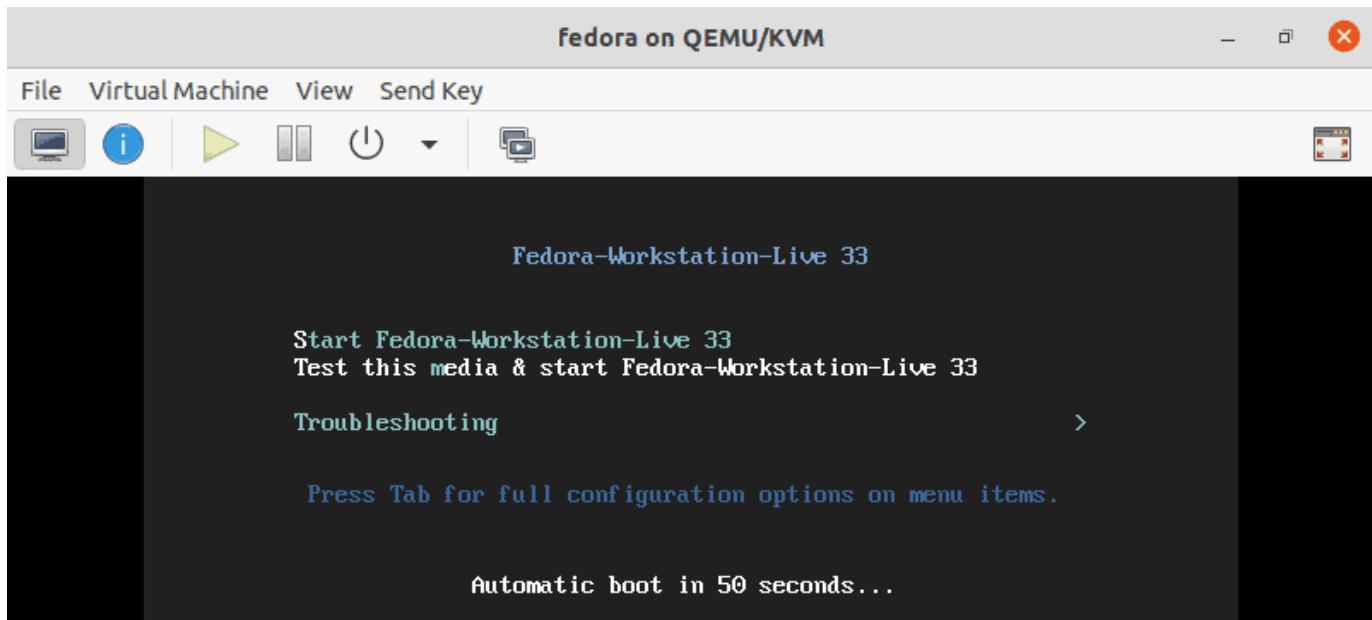
Step 9: Choose ISO file of virtual system (Here, I used Fedora because it is light weighted) and click on forward and then select hardware specification.



Step 10: Specify the name for your VM and click Finish to complete the setup.



Step 11: The VM starts automatically, prompting you to start installing the OS that's on the ISO file, now you only need to follow installation process of OS.



Conclusion: In this practical we successfully created and run **VM** on Hosted **Hypervisor** type 1 **Virtual Box** and type 2 **KVM**.

Experiment No. 3

Aim: To study and Implement Bare-metal Virtualization using Xen, HyperV or VMware Esxi.

Requirements: Xenserver.

Theory:

The Xen Hypervisor

The Xen hypervisor forms the core of all Xen-based virtualization platforms and, like VMware ESXi and Microsoft Hyper-V, is a “bare metal” hypervisor. This means that the first code that starts on the machine is the hypervisor and that a general-purpose operating system isn’t required to manage the system.

Originally designed at the University of Cambridge in Cambridge, England, Xen forms the core hypervisor in not only XenServer but also Oracle VM and can be used as an optional hypervisor within major Linux distributions such as CentOS, Debian, and SUSE Linux Enterprise Server. Additionally, Xen has been heavily used with what is arguably the most famous deployment at Amazon: providing the basis of its Amazon Web Services product offering.

Xen is actively developed under stewardship within the Xen Project: a Linux Foundation Collaborative Project, where it benefits from the active participation and contributions of well over a dozen organizations. This breadth of development ensures that the Xen hypervisor technology keeps pace with changing trends in data center operations while remaining focused on delivering hypervisor services.

Along with the depth of development put into the Xen hypervisor, it’s important to note that each Xen-based product chooses which version of the Xen hypervisor to support and which

features of that version to integrate. As such, it's common for some hypervisor features present in Xen to not be utilized in other packaged solutions.

Software architecture

Xen Project runs in a more privileged CPU state than any other software on the machine, except for Firmware.

Responsibilities of the hypervisor include memory management and CPU scheduling of all virtual machines ("domains"), and for launching the most privileged domain ("dom0") - the only virtual machine which by default has direct access to hardware. From the dom0 the hypervisor can be managed and unprivileged domains ("domU") can be launched.

The dom0 domain is typically a version of Linux or BSD. User domains may either be traditional operating systems, such as Microsoft Windows under which privileged instructions are provided by hardware virtualization instructions (if the host processor supports x86 virtualization, e.g., Intel VT-x and AMD-V), or paravirtualized operating systems whereby the operating system is aware that it is running inside a virtual machine, and so makes hypercalls directly, rather than issuing privileged instructions.

Xen Project boots from a bootloader such as GNU GRUB, and then usually loads a paravirtualized host operating system into the host domain (dom0).

Output:

Step 1: Install Xen Server

Step i: Insert Bootable Xen Server CD into CDROM and Make first boot device as a CDROM from BIOS

Step ii: press F2 to see the advanced options, otherwise press Enter to start installation

Step iii -: Select Keyboard Layout

Step iv: Press Enter to load Device Drivers

Step v: Press Enter to Accept End user license Agreement

Step vi: Select Appropriate disk on which you want to install

Xenserver

Step vii: Select appropriate installation Media (LOCAL Media)

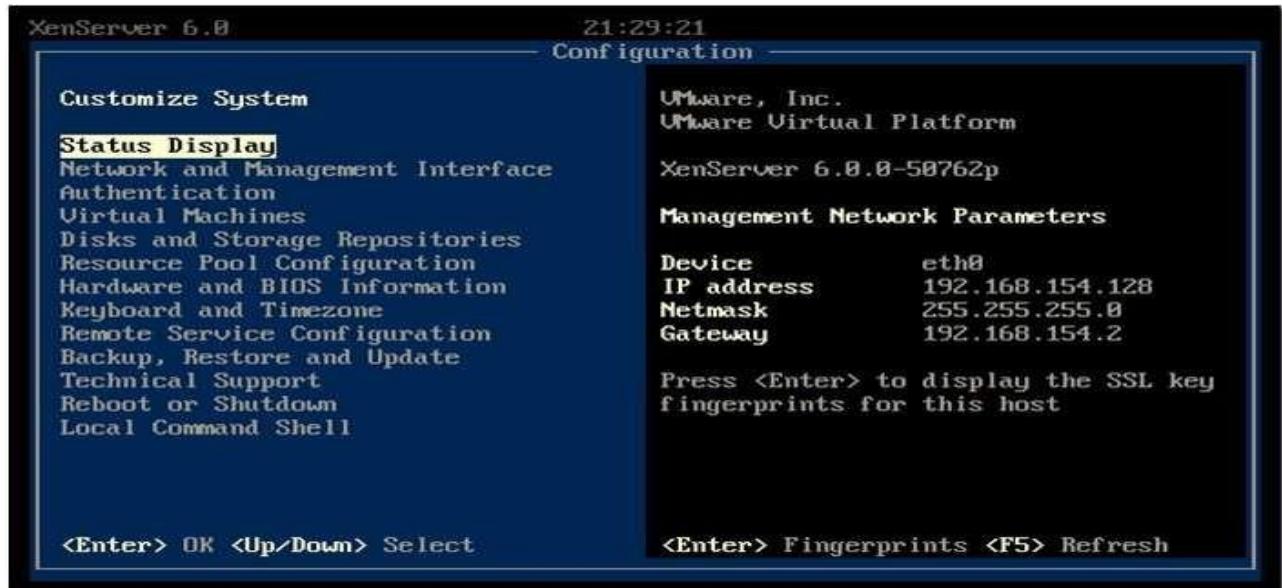
Step viii: Select Additional Packages for installation

Step ix: Specify Root password

Step x: Specify IP Address to Xenserver

Step xi: Select Time Zone

Step xii: Specify NTP Servers address or use manual time entry then start installation. Once installation is done you will see the final screen shown below.

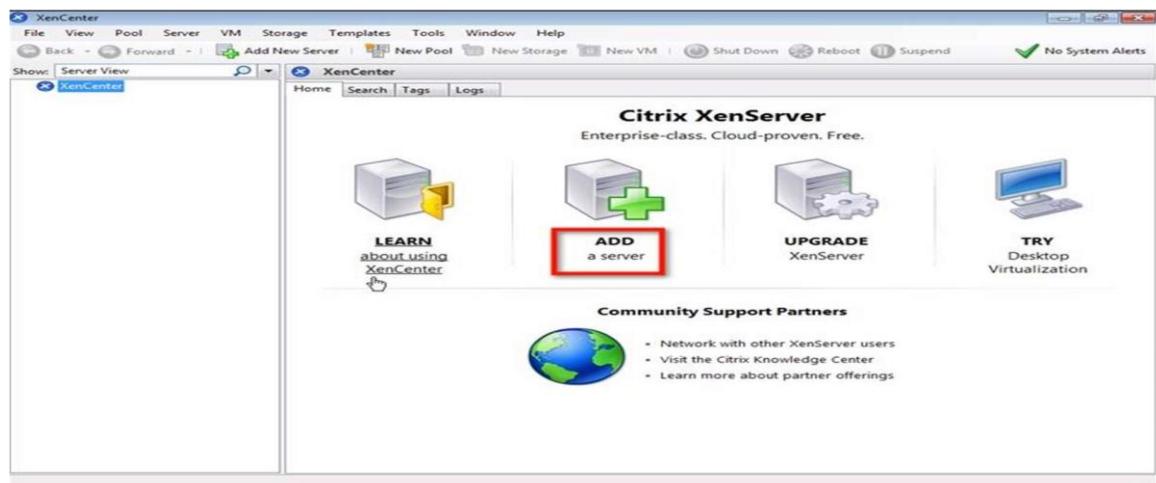


Step 2: Connect Xen Server to Xen Center

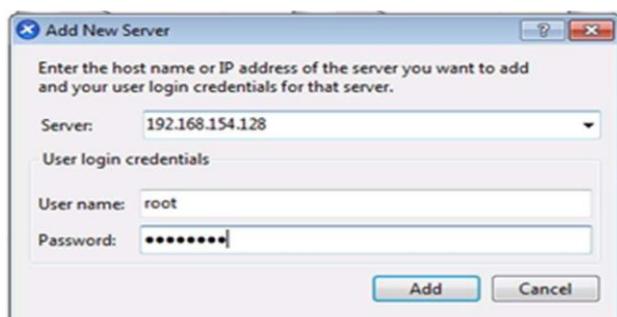
Firstly, download the xen center a management utily from xen server by opening the xen severs IP address as a URL on browser. Once Xen center is downloaded, install it. Open Xencenter from start menu of Windows.



To connect to the XenServer host you configured earlier, click Add a server.



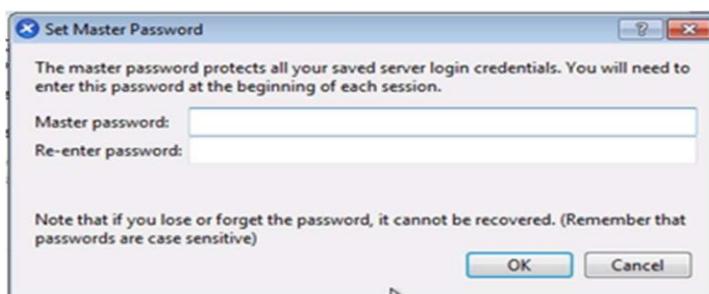
Enter the IP address I asked you to take note of earlier. Also enter the password you assigned for your root account. Click Add.



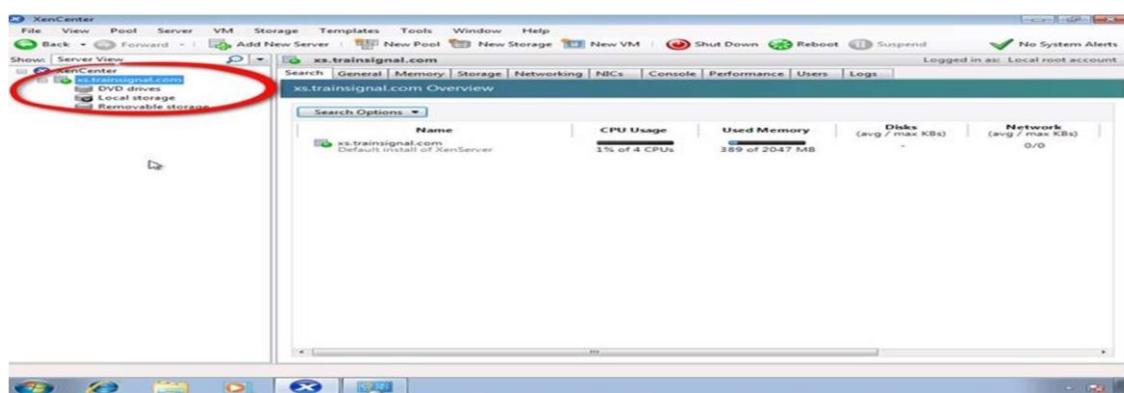
One of the first things you want to make sure as you're adding a new XenServer to XenCenter is to save and restore the server connection state on startup. Check the box that will do just that.



Once you do that, you will be allowed to configure a master password for all the XenServers you'll be associating with this XenCenter. Click the 'Require a master password' checkbox if that's what you want to do, and then enter your desired master password in the fields provided.

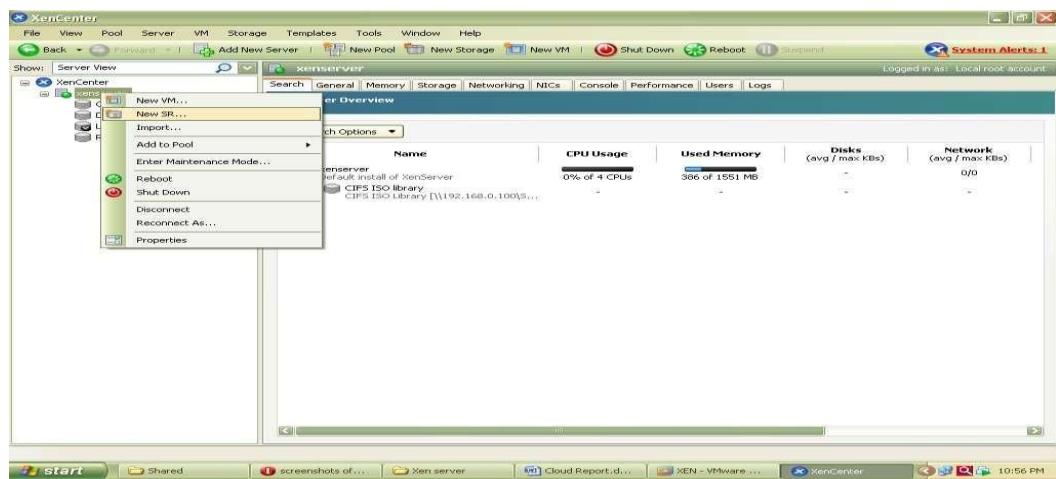


After you click OK, you'll be brought back to the main screen, where you'll see your XenServer already added to XenCenter.

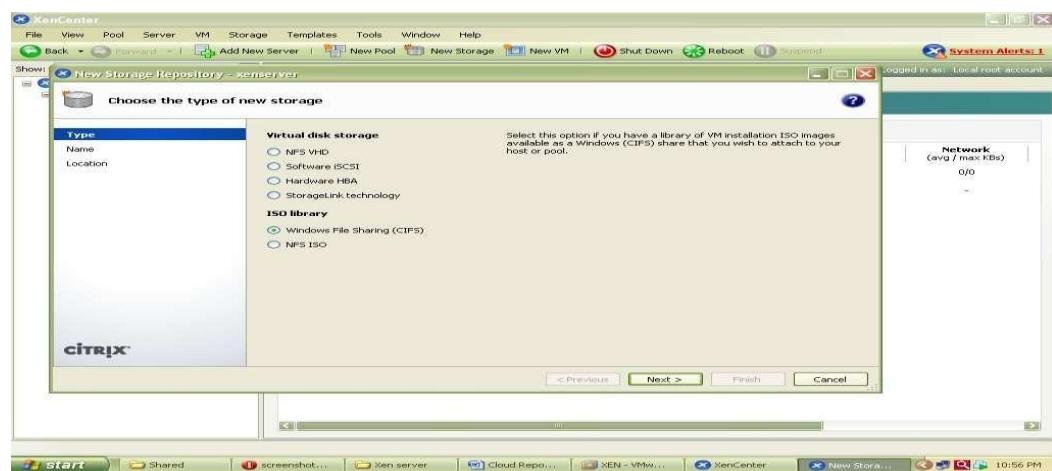


Step 3: Create Storage Repository and Installing VM

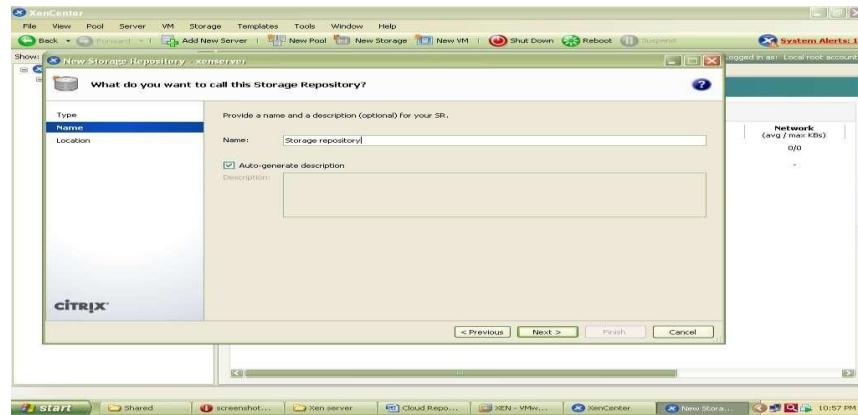
Now Before Creating VM we have to Create Storage Repository first which is nothing but shared directory on Xen Center which holds all iso files and which is required to install Operating system on Xen Server its steps are as follows.Right click on Xenserver icon on xencenter and click on New SR



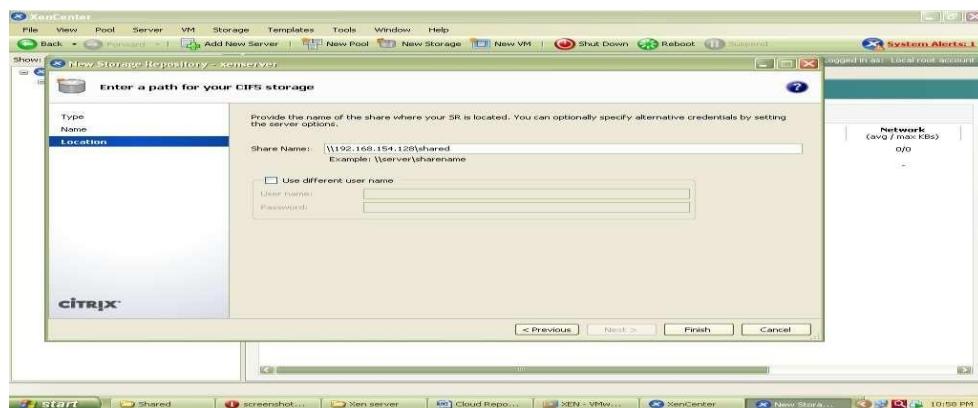
Now Select Windows CIFS library



Specify Storage Repository Name



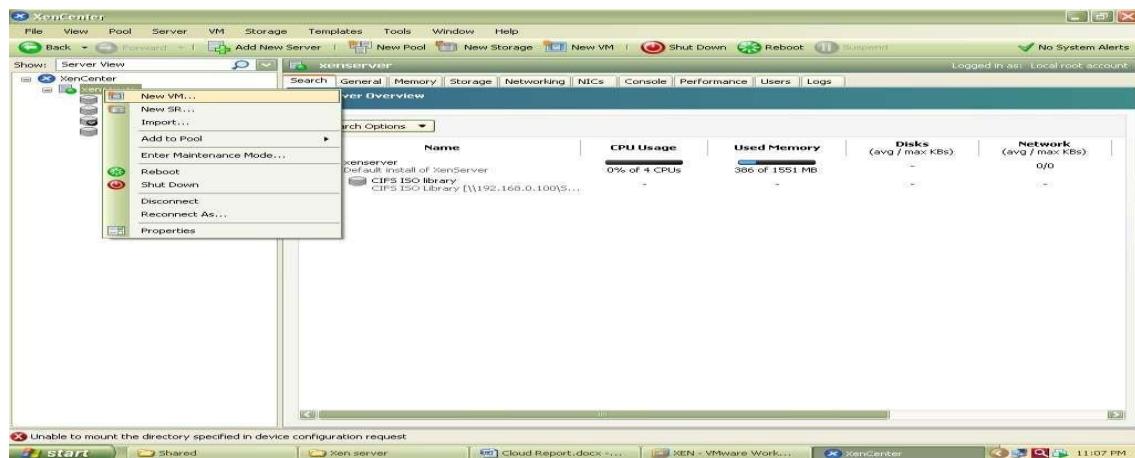
Now specify path of shared folder at client side which holds all iso files of os or VM which we are going to install on Xen Server.



At the end Click on finish to create SR. To check all iso files click on CIFS library and select storage this will show you all iso files.

Installation of UBUNTU Server on Xen Server

Step 1 :- Right click on Xenserver icon on xen center and select New VM



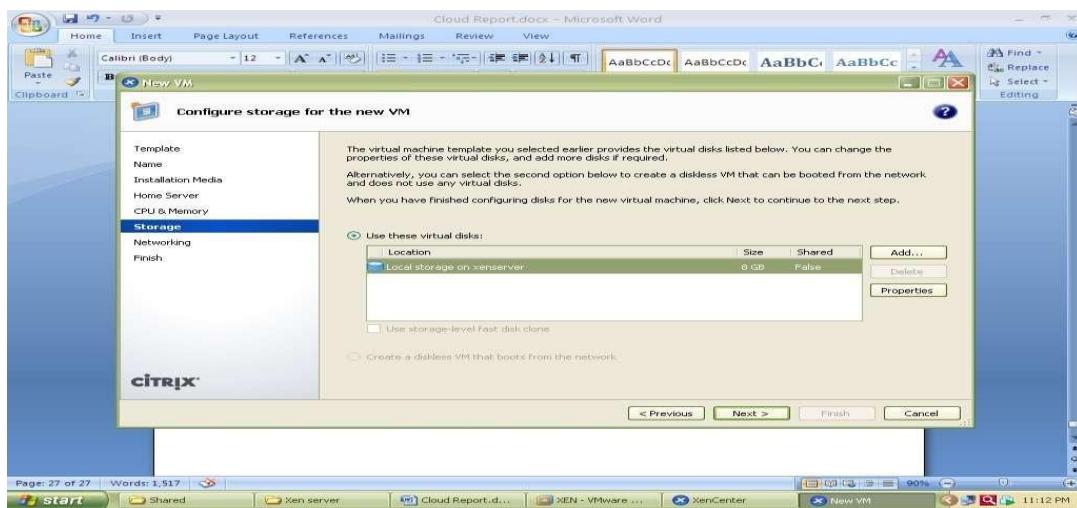
Now select an Operating System to be install here select Ubuntu Lucid Lynx and click on next

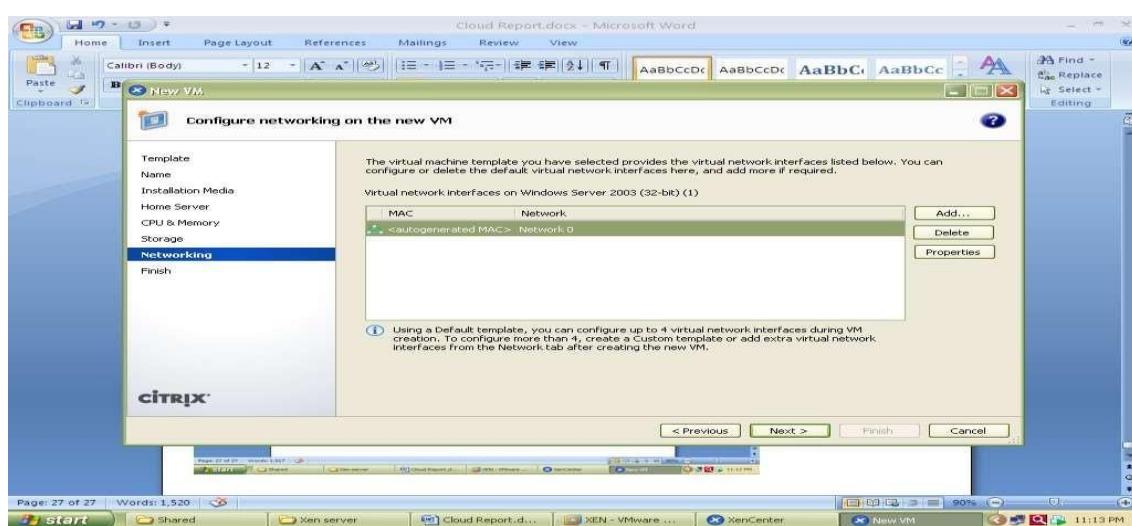
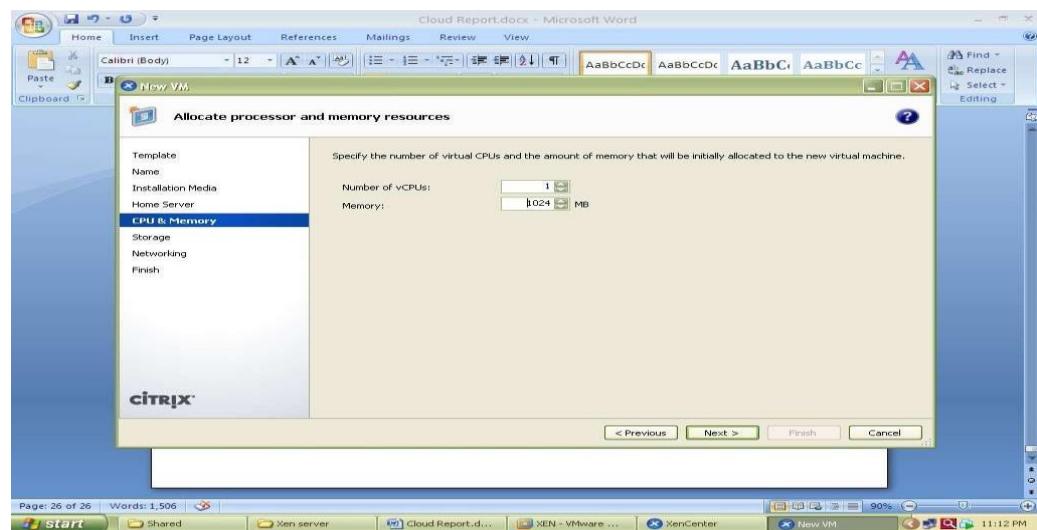
Now specify Instance Name as ubuntu server Select iso file of Ubuntu server 10.10 to be install

Now select hardware for vm i.e. no. of cpu's and memory Select local storage

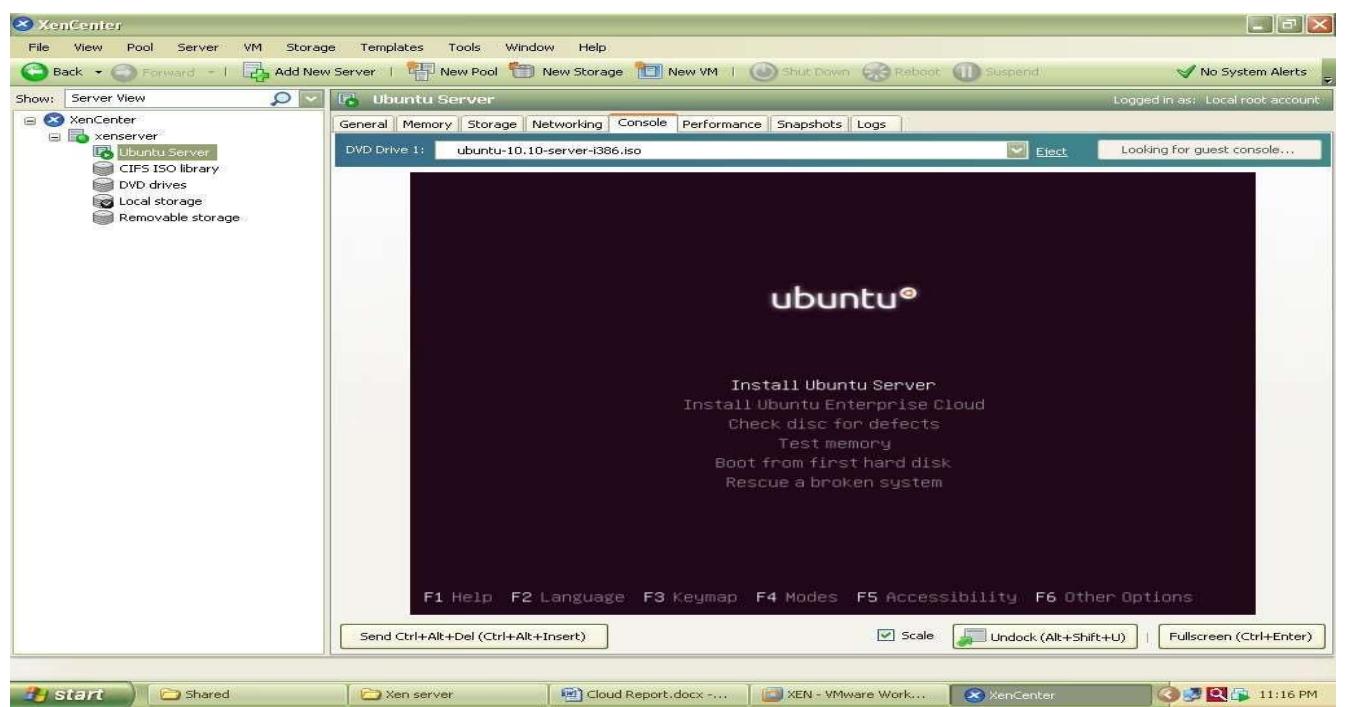
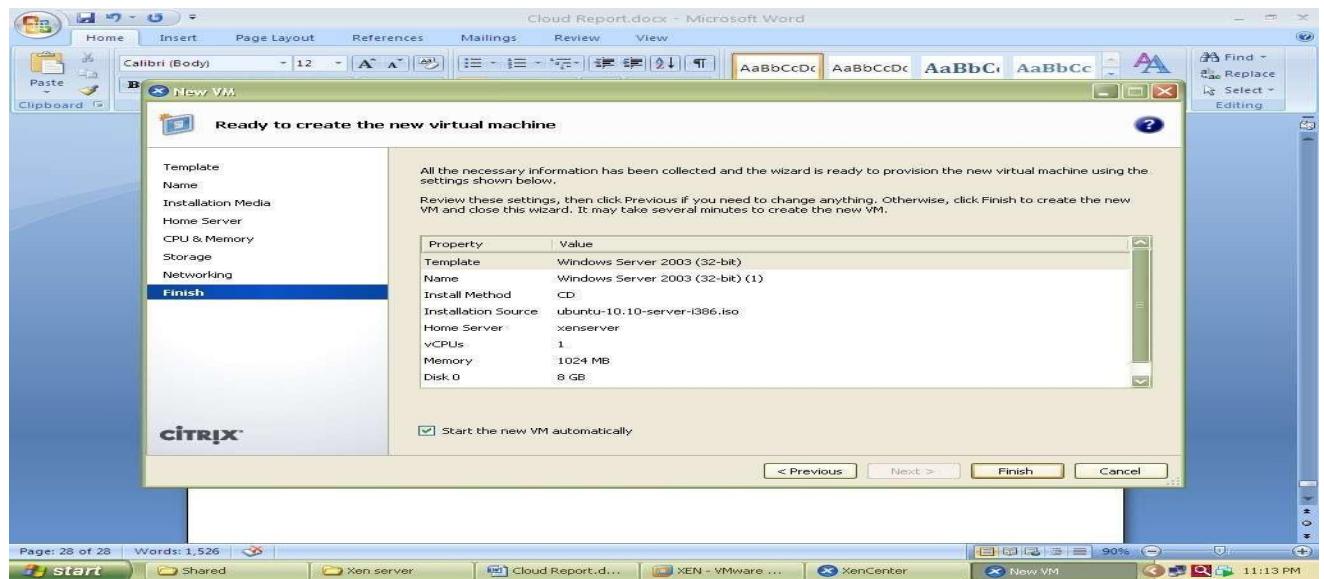
Select network And click on finish

Now go to Console tab to install ubuntu and follow installation Steps.

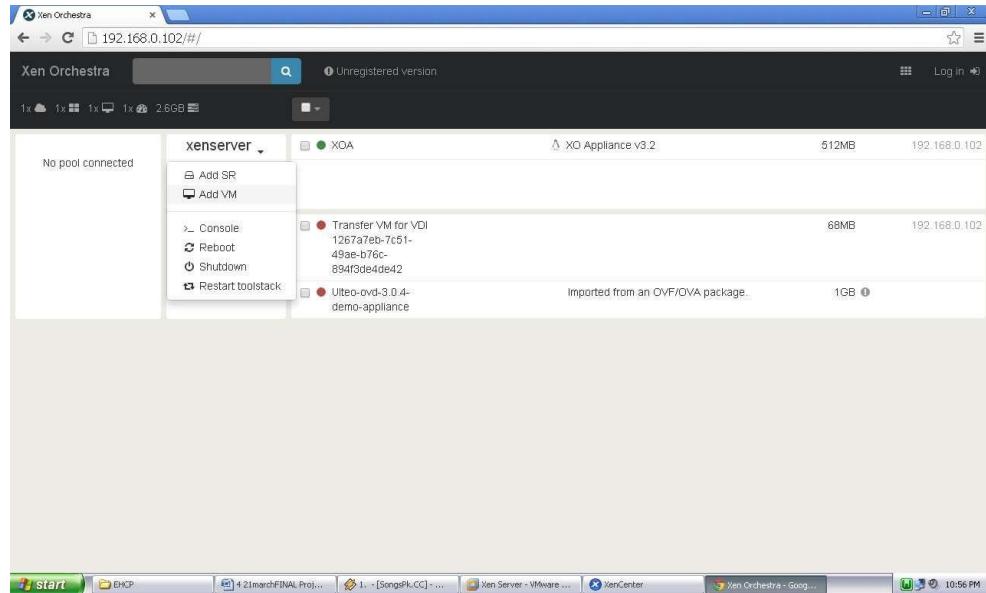




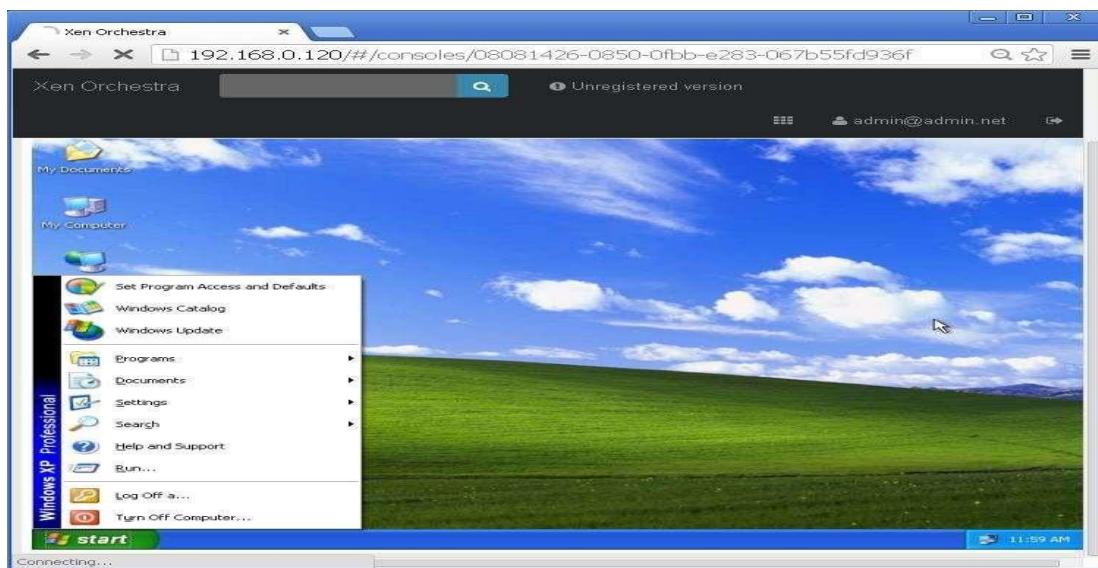
76_Adnan Shaikh



The Xen orchestra provides web based functionality of Xen Center.it provides access to all the VMs with their lifecycle management which are installed over Xen Server shown in figure Xen Orchestra (XOA) Portal.



The Windows XP image running on Xen Orchestra over Google chrome web browser is shown in following screenshot



Conclusion: We have successfully implemented Bar-metal Metal virtualization using Xen.

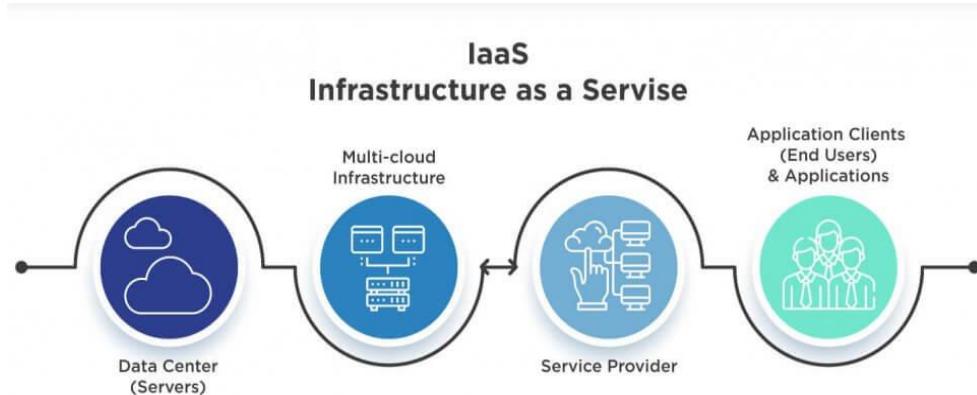
Experiment No. 4

Aim: To study and Implement Infrastructure as a Service using AWS/Microsoft Azure.

Requirements: Windows/Mac/Linux O.S, AWS/Azure account and Remmina for Linux.

Theory:

Infrastructure as a service: IaaS provides businesses with ready-to-use IT infrastructure: development environment, private networks, secure data storage, instruments for software development and testing, functionality monitoring, etc. The enterprises don't need to build and secure their own IT infrastructure — they fully power the development process with third-party servers and cloud backup storage.



Examples of IaaS:

Amazon Web Services: a public cloud that offers subscribers access to virtual servers for product deployment, Cloud storage, tools for development, testing, and analytics. The application provides a ready-to-use environment to develop and test the product and offers the full cloud infrastructure for its deployment and maintenance.

Microsoft Azure: the combination of IaaS and platform as a service, the software offers 100+ services for software development, administration, and deployment, provides tools for working with innovative technologies (big data, machine learning, Internet of Things), etc.

IBM Infrastructure: IBM uses its in-house services to store the data of infrastructure users, enabling remote data access via Cloud computing. IBM servers support AI, block chain, and the Internet of Things. The infrastructure also provides Cloud storage and virtual development environments, enabled on the subscription basis.

Google Cloud Infrastructure: the large network of international servers that provides users access to remote Cloud data centres. Companies can store their information in Asia, Europe, and Latin America, which minimizes the risk of a security breach.

Implementation:

1. Creating Virtual Machine in Azure:

i) Basics

ii) Disks

iii) Network

iv) Management

v) Tags

The screenshot shows the Microsoft Azure portal interface for creating a new virtual machine. The current step is 'Tags'. A single tag named 'cc1' with the value 'testing' is selected. The interface includes tabs for Basics, Disks, Networking, Management, Advanced, Tags, Review + create, and a note about tag synchronization.

vi) Creating

The screenshot shows the Microsoft Azure portal interface for creating a new virtual machine. The current step is 'Review + create'. The validation status is 'Validation passed'. The 'PRODUCT DETAILS' section shows a 1 X Standard D2s v3 by Microsoft at 7.5648 INR/hr. The 'TERMS' section contains legal disclaimers. The 'Basics' section displays configuration details: Subscription (Azure for Students), Resource group (CCL), Virtual machine name (adnan), Region (Central India), Availability options (No infrastructure redundancy required), Security type (Standard), Image (Windows 10 Pro, version 20H2 - Gen2), and Size (Standard D2s v3 (2 vcpus, 8 GiB memory)). Buttons for 'Create', 'Previous', 'Next', and 'Download a template for automation' are present at the bottom.

vii) Deployment complete

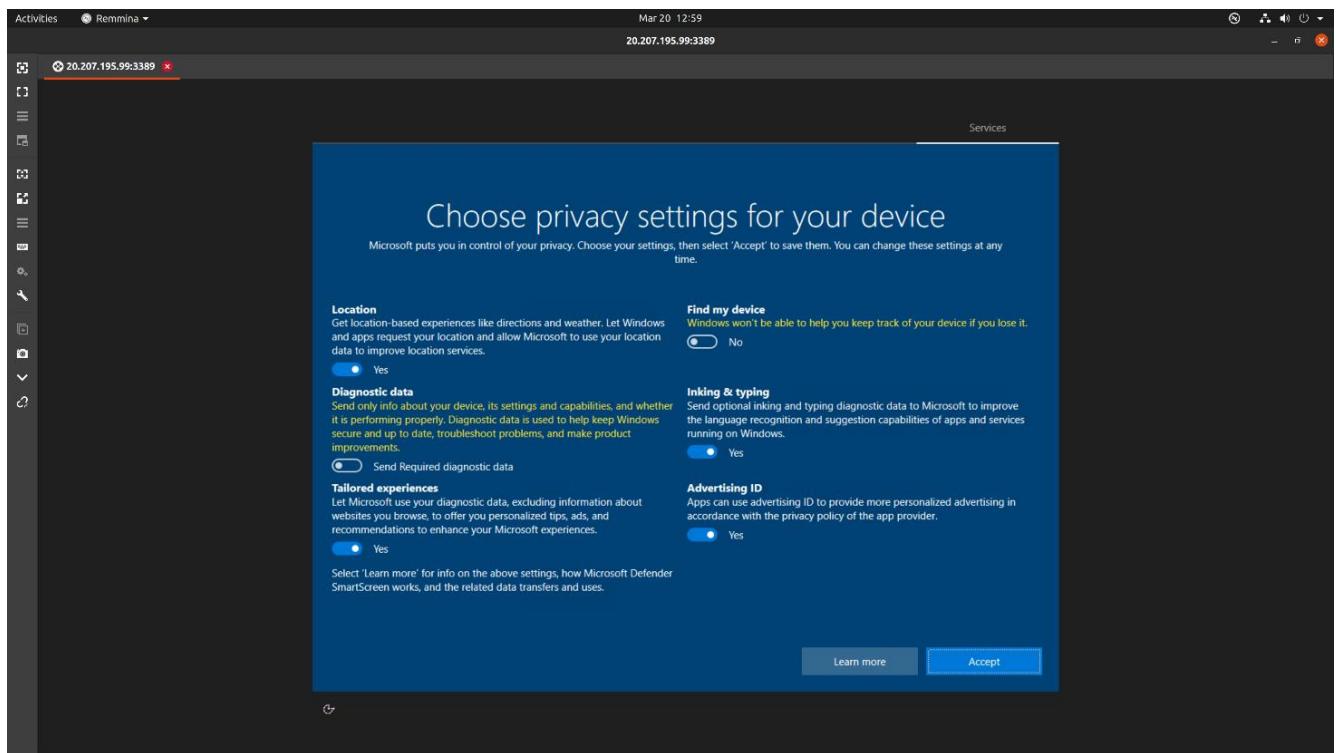
The screenshot shows the Microsoft Azure portal interface. The main title bar indicates "Mar 20 12:55". The left sidebar shows "Activities" and "CreateVm-MicrosoftWindowsDesktop.Windows-10-20h2--20220320125023 | Overview". The main content area displays a green checkmark icon and the message "Your deployment is complete". It provides deployment details: Deployment name: CreateVm-MicrosoftWindowsDesktop.Windows..., Start time: 3/20/2022, 12:55:19 PM, Subscription: Azure for Students, Correlation ID: 747a84b0-81ab-4d53-b64c-1c6cf7f25b08, Resource group: CCL. Below this, there are sections for "Deployment details" (with a download link), "Next steps" (including "Setup auto-shutdown: Recommended", "Monitor VM health, performance and network dependencies: Recommended", and "Run a script inside the virtual machine: Recommended"), and buttons for "Go to resource" and "Create another VM". On the right side, there are promotional banners for "Cost Management", "Microsoft Defender for Cloud", and "Free Microsoft tutorials". At the bottom, there is a file download bar showing "template.zip".

2) RDP connection:

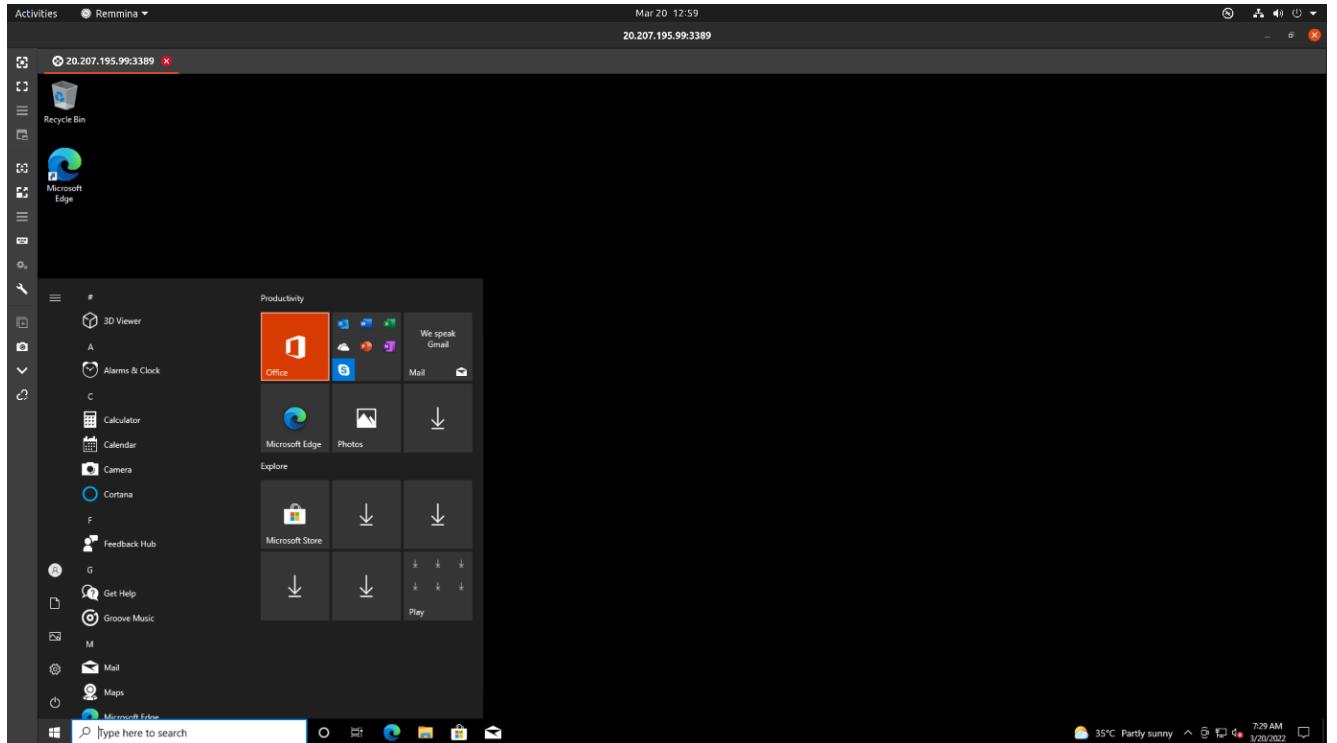
i) Configuring and downloading RDP file

The screenshot shows the Microsoft Azure portal interface for connecting to a virtual machine named "adnan". The left sidebar shows "adnan | Connect" under the "Virtual machine" section. The main content area has a warning message: "To improve security, enable just-in-time access on this VM." Below this, there are tabs for "RDP", "SSH", and "Bastion", with "RDP" selected. The "Connect with RDP" section contains fields for "IP address" (set to "Public IP address (20.207.195.99)") and "Port number" (set to "3389"). A blue "Download RDP File" button is visible. Below the connection fields, there are links for "Can't connect?", "Test your connection", "Troubleshoot RDP connectivity issues", and "Tell us about your RDP experience". The bottom of the screen shows a file download bar for "template.zip".

ii) Connecting through Remmina



3) Result:



Conclusion: We have successfully implemented infrastructure as a service using Azure.

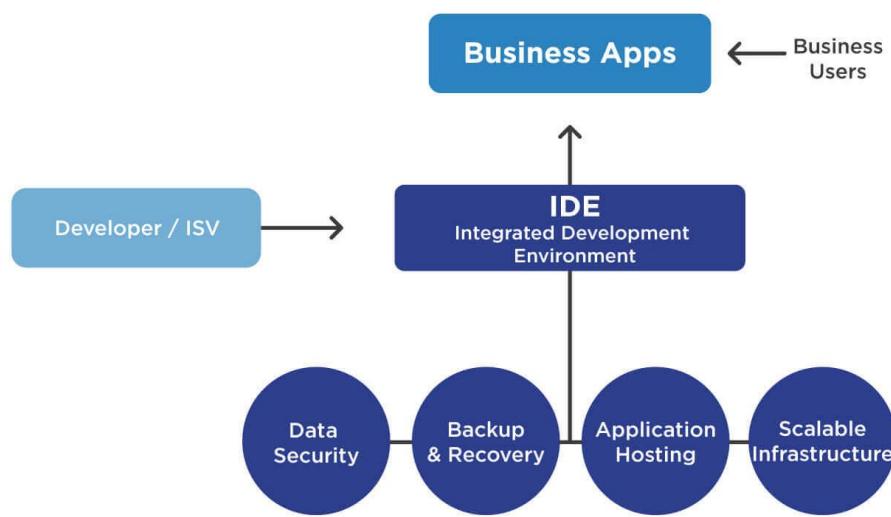
Experiment No. 5

Aim: To study and Implement Platform as a Service using AWS Elastic Beanstalk/ Microsoft Azure App Service.

Requirements: Windows/Mac/Linux O.S, AWS/Azure account and compatible version of python.

Theory:

Platform as a Service: Platform as a Service is software that provides access to development tools, APIs, and deployment instruments. Users receive access to virtual development environments and Cloud storage, where they can build, test, and run applications. In PaaS, users are billed only for the platforms that they use for the time when the services were used. There is no need to pay for excessive functionality, like in desktop solutions.



Examples of PaaS:

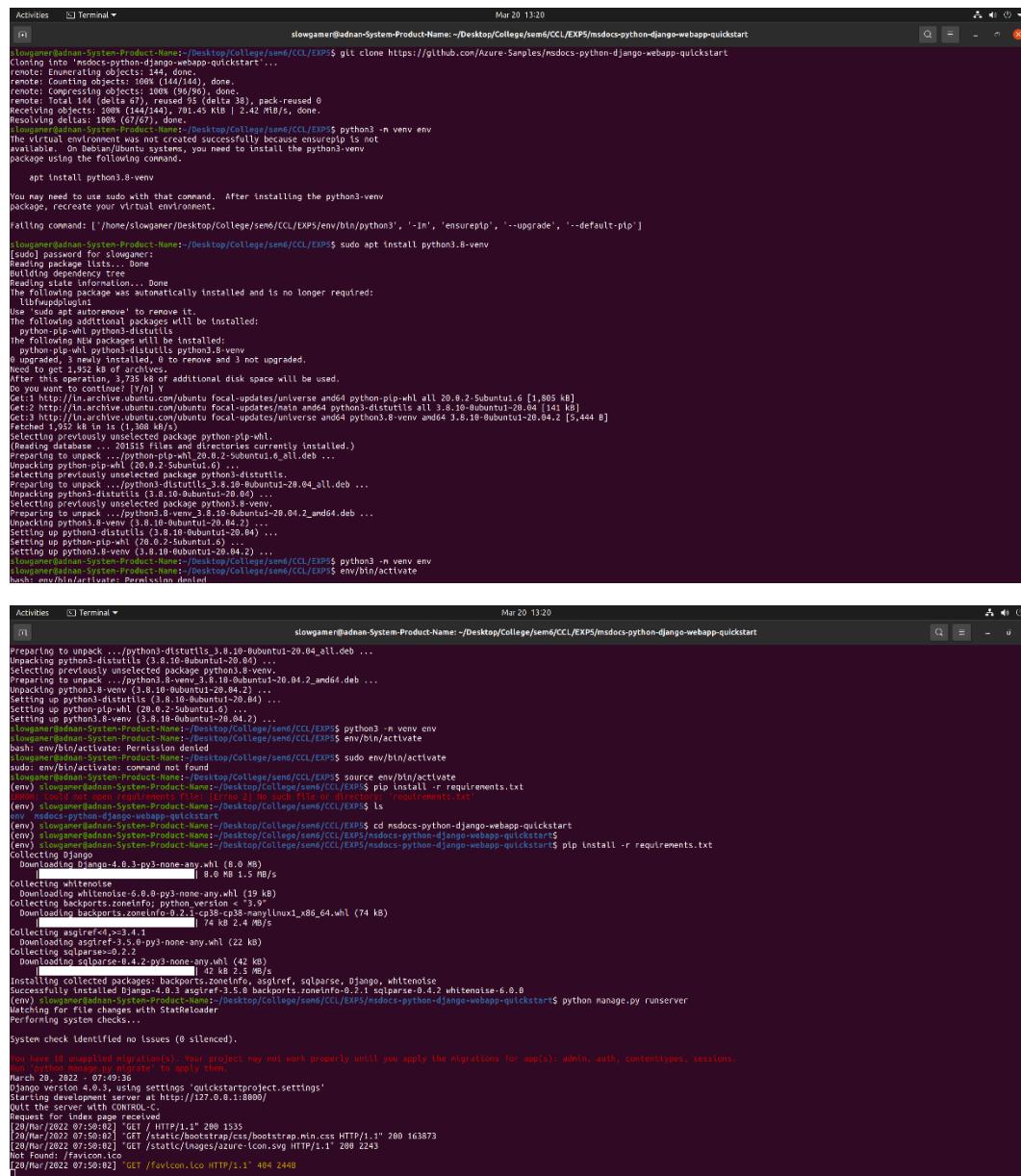
AWS Elastic Beanstalk: a web platform for software deployment and management, powered by the AWS Cloud. Users upload their applications to the service, and it automatically monitors the performance, load capacity, and checks for deployment errors.

Apache Stratos: the Cloud computing platform for arranging PHP and MySQL. The PaaS provides users with ready-to-use tools for database development and testing, performance monitoring, integration, and billing.

Magento Commerce Cloud: Magento Cloud offers tools for e-commerce development, testing, deployment, and maintenance. The Cloud environment allows accessing the store settings anytime and anywhere as well as automates the key processes.

Implementation:

1) Cloning sample project of Azure to deploy it using Azure App service



```

Activities Terminal Mar 20 13:20
slowgamer@adnan-System-Product-Name: ~/Desktop/College/sem6/CCL/EXP$ git clone https://github.com/Azure-Samples/msdocs-python-django-webapp-quickstart
Cloning into 'msdocs-python-django-webapp-quickstart'...
remote: Enumerating objects: 144, done.
remote: Counting objects: 100% (144/144), done.
remote: Compressing objects: 100% (112/112), done.
remote: Total 144 (delta 67), reused 95 (delta 38), pack-reused 0
Receiving objects: 100% (144/144), 701.45 KB | 2.42 MB/s, done.
Resolving deltas: 100% (67/67), done.
slowgamer@adnan-System-Product-Name: ~/Desktop/College/sem6/CCL/EXP$ python3 -m venv env
The virtual environment was not created successfully because ensurepip is not
available. On Debian/Ubuntu systems, you need to install the python3-venv
package using the following command.

  apt install python3.8-venv

You may need to use sudo with that command. After installing the python3-venv
package, recreate your virtual environment.

 Falling command: ['~/home/slowgamer/Desktop/College/sem6/CCL/EXP/venv/bin/python3', '-Im', 'ensurepip', '--upgrade', '--default-pip']
slowgamer@adnan-System-Product-Name: ~/Desktop/College/sem6/CCL/EXP$ sudo apt install python3.8-venv
[...]
Building dependency tree...
Reading package lists...
Building dependency tree...
Reading package information... Done
The following NEW packages will be installed:
  liblippudplplugin
The following existing package was automatically installed and is no longer required:
  liblippudplplugin
Use 'sudo apt autoremove' to remove it.
The following NEW packages will be installed:
  python3-pip-wl python3-distutils
The following NEW packages will be installed:
  python3-pip-wl python3-distutils python3.8-venv
  python3.8-venv depends on liblippudplplugin (>= 0.1.0) to remove and is not upgraded.
Need to get 1,352 kB of archives.
After this operation, 4,735 kB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://in.archive.ubuntu.com/ubuntu focal-updates/universe amd64 python-pip-wl all 20.0.2-Subnubt1.6 [1,805 kB]
Get:2 http://in.archive.ubuntu.com/ubuntu focal-updates/main amd64 python3-distutils all 3.8.10-Subnubt1-20.04 [141 kB]
Get:3 http://in.archive.ubuntu.com/ubuntu focal-updates/universe amd64 python3.8-venv amd64 3.8.10-Subnubt1-20.04.2 [5,444 kB]
Fetched 1,956 kB in 1s (3,003 kB/s)
Selecting previously unselected package python-pip-wl.
(Reading database ... 2,01515 files and directories currently installed.)
Preparing to unpack .../python-pip-wl_20.0.2-Subnubt1.6_all.deb ...
Unpacking python-pip-wl (20.0.2-Subnubt1.6) ...
Selecting previously unselected package python3-distutils.
Preparing to unpack .../python3-distutils_3.8.10-Subnubt1-20.04_all.deb ...
Unpacking python3-distutils (3.8.10-Subnubt1-20.04) ...
Selecting previously unselected package python3.8-venv.
Preparing to unpack .../python3.8-venv_3.8.10-Subnubt1-20.04.2_amd64.deb ...
Unpacking python3.8-venv (3.8.10-Subnubt1-20.04.2) ...
Setting up python3-distutils (3.8.10-Subnubt1-20.04) ...
Setting up python-pip-wl (20.0.2-Subnubt1.6) ...
Setting up python3.8-venv (3.8.10-Subnubt1-20.04.2) ...
slowgamer@adnan-System-Product-Name: ~/Desktop/College/sem6/CCL/EXP$ python3 -m venv env
slowgamer@adnan-System-Product-Name: ~/Desktop/College/sem6/CCL/EXP$ env/bin/activate
[bash]: env/bin/activate: Permission denied

Activities Terminal Mar 20 13:20
slowgamer@adnan-System-Product-Name: ~/Desktop/College/sem6/CCL/EXP$ python3 -m venv env
slowgamer@adnan-System-Product-Name: ~/Desktop/College/sem6/CCL/EXP$ env/bin/activate
bash: env/bin/activate: Permission denied
slowgamer@adnan-System-Product-Name: ~/Desktop/College/sem6/CCL/EXP$ sudo env/bin/activate
sudo: env/bin/activate: command not found
slowgamer@adnan-System-Product-Name: ~/Desktop/College/sem6/CCL/EXP$ source env/bin/activate
(env) slowgamer@adnan-System-Product-Name: ~/Desktop/College/sem6/CCL/EXP$ pip install -r requirements.txt
(env) slowgamer@adnan-System-Product-Name: ~/Desktop/College/sem6/CCL/EXP$ Could not open requirements file: [Errno 2] No such file or directory: 'requirements.txt'
(env) slowgamer@adnan-System-Product-Name: ~/Desktop/College/sem6/CCL/EXP$ ls
env  msdocs-python-django-webapp-quickstart
(env) slowgamer@adnan-System-Product-Name: ~/Desktop/College/sem6/CCL/EXP$ cd msdocs-python-django-webapp-quickstart
(env) slowgamer@adnan-System-Product-Name: ~/Desktop/College/sem6/CCL/EXP$ pip install -r requirements.txt
Collecting Django
  Downloading Django-4.0.3-py3-none-any.whl (8.0 MB)
    0%|██████████| 0.0 MB 1.5 MB/s
Collecting whitenoise
  Downloading whitenoise-6.0.0-py3-none-any.whl (10 kB)
Collecting backports.zoneinfo; python_version < '3.8'
  Downloading backports-zoneinfo-0.2.1-py3-pypy3-manylinux1_x86_64.whl (74 kB)
    0%|██████████| 74 kB 2.4 MB/s
Collecting asyref
  Downloading asyref-0.1.3-py3-none-any.whl (22 kB)
Collecting sqlparse
  Downloading sqlparse-0.2.2-py3-none-any.whl (42 kB)
Collecting django-filter
  Downloading django-filter-3.1.1-py3-none-any.whl (22 kB)
Collecting whiteNoise
  Downloading whiteNoise-0.1.3-py3-none-any.whl (22 kB)
Collecting backports.zoneinfo; python_version < '3.8'
  Downloading backports-zoneinfo-0.2.1-py3-pypy3-manylinux1_x86_64.whl (74 kB)
    0%|██████████| 74 kB 2.4 MB/s
Collecting asyref
  Downloading asyref-0.1.3-py3-none-any.whl (22 kB)
Collecting sqlparse
  Downloading sqlparse-0.2.2-py3-none-any.whl (42 kB)
Collecting whiteNoise
  Downloading whiteNoise-0.1.3-py3-none-any.whl (22 kB)
Installing collected packages: backports.zoneinfo, asyref, sqlparse, Django, whitenoise
Successfully installed Django-4.0.3 asyref-0.1.3.0 backports.zoneinfo-0.2.1 sqlparse-0.2.2 whitenoise-6.0.0
(env) slowgamer@adnan-System-Product-Name: ~/Desktop/College/sem6/CCL/EXP$ python manage.py runserver
Watching for file changes with StatReloader
Performing system checks.

System check identified no issues (0 silenced).

You have 10 unapplied migration(s). Your project may not work properly until you apply the migrations for app(s): admin, auth, contenttypes, sessions.
Run 'python manage.py migrate' to apply them.

[28/Mar/2022 07:50:02] "GET / HTTP/1.1" 200 16387
Django version 4.0.3, using settings 'quickstartproject.settings'
Starting development server at http://127.0.0.1:8000/
Quit the server with CONTROL-C.
Request received at 2022-03-28T07:50:02Z
[28/Mar/2022 07:50:02] "GET /static/bootstrap/css/bootstrap.min.css HTTP/1.1" 200 16387
[28/Mar/2022 07:50:02] "GET /static/bootstrap/css/bootstrap.min.css HTTP/1.1" 200 16387
[28/Mar/2022 07:50:02] "GET /static/images/azure-icon.svg HTTP/1.1" 200 2243
[28/Mar/2022 07:50:02] "GET /favicon.ico HTTP/1.1" 404 2448
[28/Mar/2022 07:50:02] "GET /favicon.ico HTTP/1.1" 404 2448

```

2) Creating App service

The screenshot shows the Microsoft Azure portal's App Services blade. At the top, there are several tabs: Activities, Google Chrome, (2) WhatsApp, Computer_TE_Syllabus_R, Quickstart: Deploy a Python, App Services - Microsoft, Hello Azure - Python Quick. The main content area has a heading 'App Services' and a sub-section 'Default Directory'. Below this, there are filter buttons for 'Subscription == all', 'Resource group == all', 'Location == all', and an 'Add filter' button. A search bar at the top right says 'Search resources, services, and docs (G+?)'. On the left, there are navigation links for Home > App Services. The main message is 'No app services to display' with a large circular icon. Below it, a sub-message reads: 'Create, build, deploy, and manage powerful web, mobile, and API apps for employees or customers using a single back-end. Build standards-based web apps and APIs using .NET, Java, Node.js, PHP, and Python.' There is a prominent blue 'Create app service' button. At the bottom, there is a link 'Learn more about App Service'.

Selecting plan

The screenshot shows the Microsoft Azure portal's 'Create Web App' blade. The top navigation bar includes activities like WhatsApp, Computer_TE_Syllabus_R, Quickstart: Deploy a Python, Spec Picker - Microsoft, Hello Azure - Python Quick. The main content is titled 'Create Web App' with a sub-section '...'. It contains fields for 'Subscription' (Azure for Students), 'Resource Group' (msdocs-python-webapp-quickstart), and a 'Create new' button. Below this is the 'Instance Details' section with fields for 'Name' (msdocs-python-webapp-quickstart-URT), 'Publish' (Code, Docker Container, Static Web App), 'Runtime stack' (Python 3.9), 'Operating System' (Linux, Windows), and 'Region' (Central India). A note says 'Not finding your App Service Plan? Try a different region or select your App Service Environment.' The 'App Service Plan' section shows 'Linux Plan (Central India)' (New ASP-msdocspythonwebappquickstart-bl11) and a 'Create new' button. It also includes 'Sku and size' (Premium V2 P1v2, 210 total ACU, 3.5 GB memory, Change size) and 'Zone redundancy' (Enabled: Your App Service plan and the apps in it will be zone-redundant). At the bottom are 'Review + create' and 'Next : Deployment >' buttons. To the right, a 'Spec Picker' sidebar shows three options: 'Dev/Test' (For less demanding workloads), 'Production' (For most production workloads, highlighted in green), and 'Isolated' (Advanced networking and scale). It also lists 'Recommended pricing tiers' (F1, B1, P1), 'Included features' (Custom domains / SSL, Manual scale), and 'Included hardware' (Azure Compute Units (ACU), Memory, Storage).

Configuration and specs

Subscription: Azure for Students
 Resource Group: (New) msdocs-python-webapp-quickstart
 Name: msdocs-python-webapp-quickstart-URT
 Runtime stack: Python 3.9
 Operating System: Linux
 Region: Central India
 App Service Plan: (New) ASP-msdocspythonwebappquickstart-bb11 (Basic B1)
 Zone redundancy: Enabled

Review and create

Web App by Microsoft (Basic (B1) sku)
 Subscription: 8cb997fb-3dec-4107-a690-e8159e8a5d22
 Resource Group: msdocs-python-webapp-quickstart
 Name: msdocs-python-webapp-quickstart-URT
 Publish: Code
 Runtime stack: Python 3.9
 App Service Plan (New): ASP-msdocspythonwebappquickstart-bb11 (Linux, Central India, Basic, Small, 100 total ACU, 1.75 GB memory)
 Monitoring: Application Insights Not enabled
 Deployment: Continuous deployment Not enabled / Set up after app creation

Deployment complete

The screenshot shows the Microsoft Azure portal interface. The main title bar says "Microsoft.Web-WebApp-Portal-66e3f525-982e | Overview". The left sidebar has "Overview" selected under "Deployment". The main content area displays a green checkmark icon and the message "Your deployment is complete". It provides deployment details: Deployment name: Microsoft.Web-WebApp-Portal-66e3f525-982e, Subscription: Azure for Students, Resource group: msdocs-python-webapp-quickstart, Start time: 3/20/2022, 1:25:24 PM, Correlation ID: 89e99c9a-736d-47f6-ba1f-86e046109bf. Below this, there are sections for "Deployment details" (with a download link) and "Next steps" (with links for "Manage deployments for your app" and "Protect your app with authentication"). To the right, there are promotional cards for "Cost Management", "Microsoft Defender for Cloud", and "Free Microsoft tutorials".

3) Sample App deployment in above app service using Azure tool in VSCode

Linking Azure account and selecting Deploy to Web app

The screenshot shows the Visual Studio Code interface with the "Azure" extension installed. The left sidebar shows a tree view of Azure resources, including "myfirstpythonwebapp" under "APP SERVICE". A context menu is open over this item with options like "Open in Portal", "Browse Website", "Deploy to Web App...", "Configure Deployment Source...", "Start", "Stop", "Restart", "Delete...", "Start Streaming Logs", "Stop Streaming Logs", "Generate Azure CLI Script", "Start Remote Debugging", "SSH Into Web App", "View Properties", and "Refresh". The main content area has a "Getting Started with Docker" guide. The "TERMINAL" tab at the bottom shows a command-line session with several commands listed:

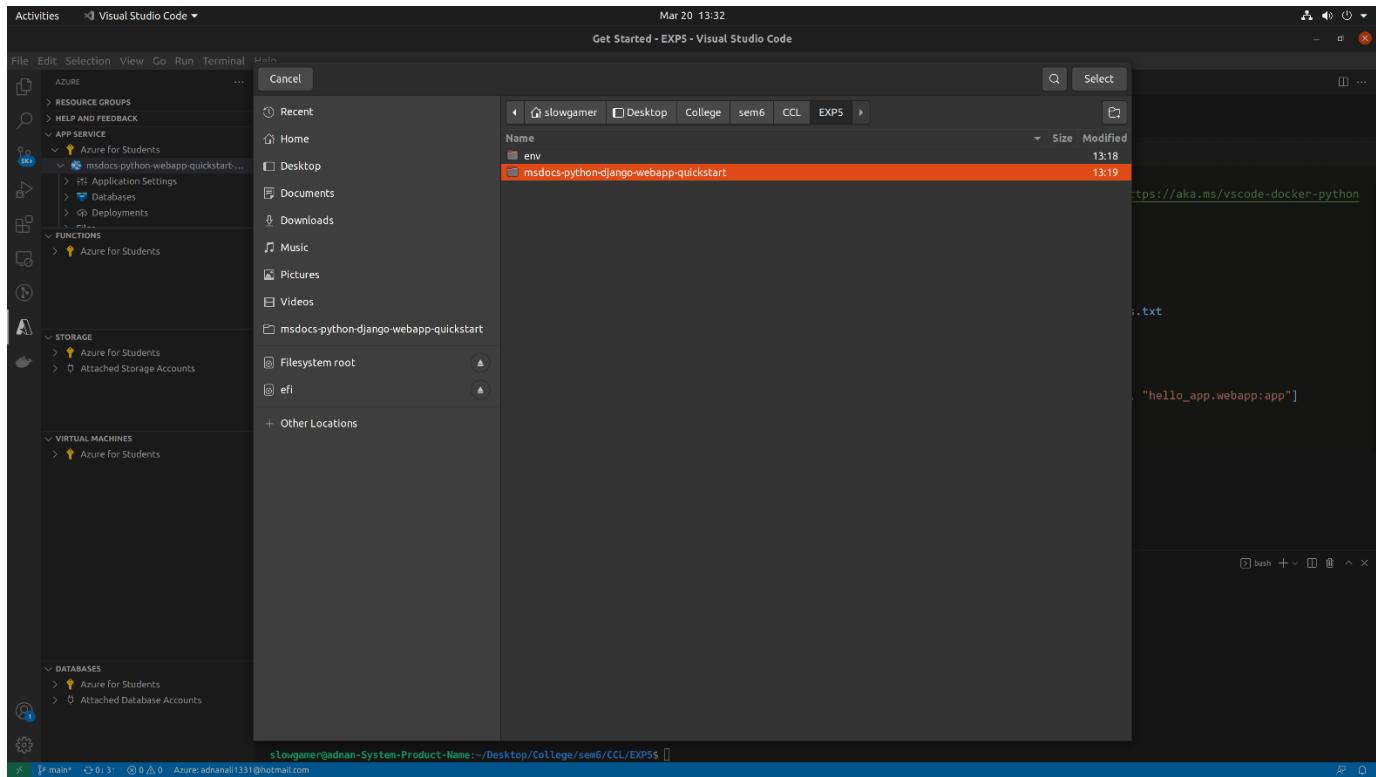
```

command 'root' from deb mnh (0.4.2)
command 'next' from deb mnh (1.7.1-6)
command 'ex' from deb vte (2:8.1.2269-1ubuntu5.7)
command 'ex' from deb vim-tiny (2:8.1.2269-1ubuntu5.7)
command 'ex' from deb vim-athena (2:8.1.2269-1ubuntu5.7)
command 'ex' from deb vim-gtk3 (2:8.1.2269-1ubuntu5.7)
command 'ex' from deb vim-nox (2:8.1.2269-1ubuntu5.7)
command 'ex' from deb vim (2:8.1.2269-1ubuntu5.7)
command 'ex' from deb nvi (1.81.6-15ubuntu1)
command 'ent' from deb ent (1.2debian-2)
command 'eet' from deb libet-bin (1.23.3-8)

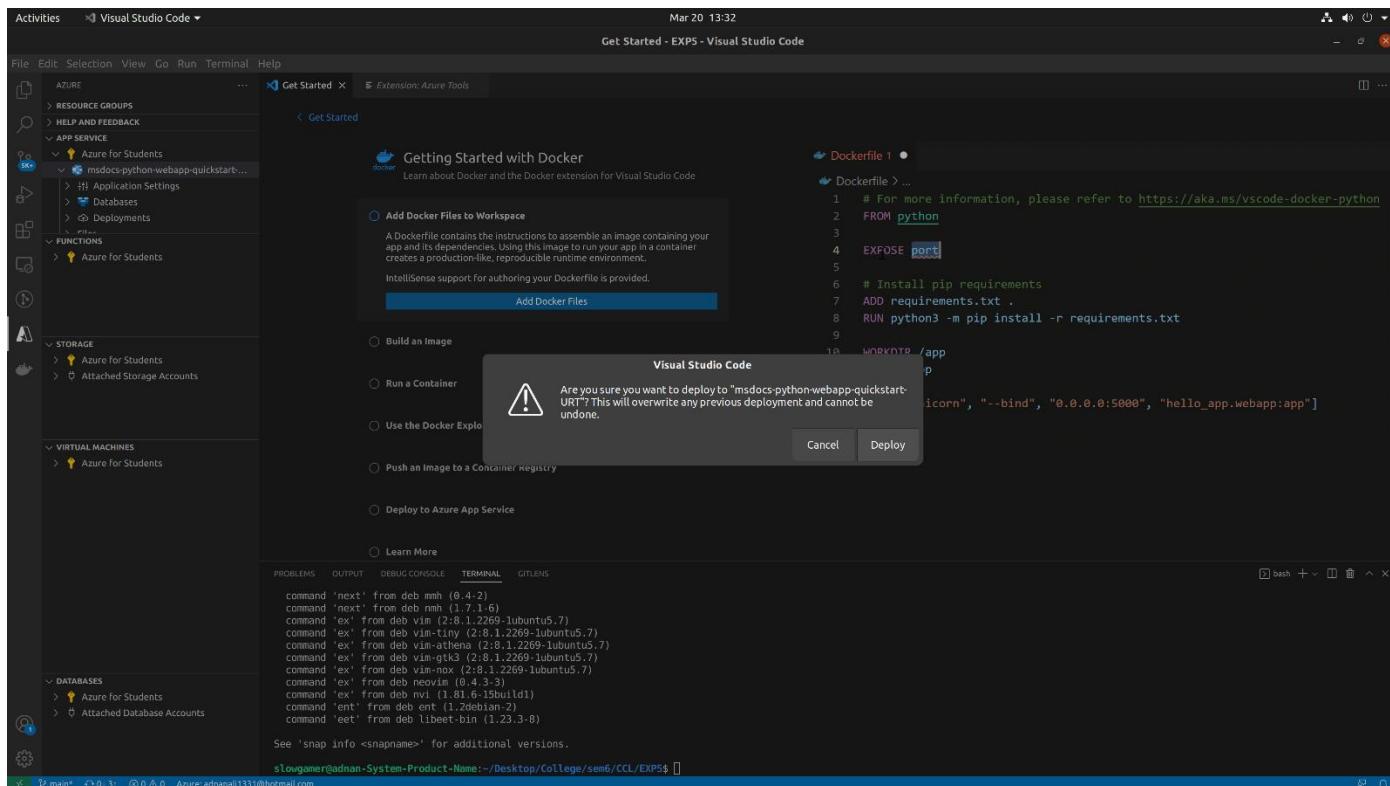
See 'snap info <snapshot>' for additional versions.

```

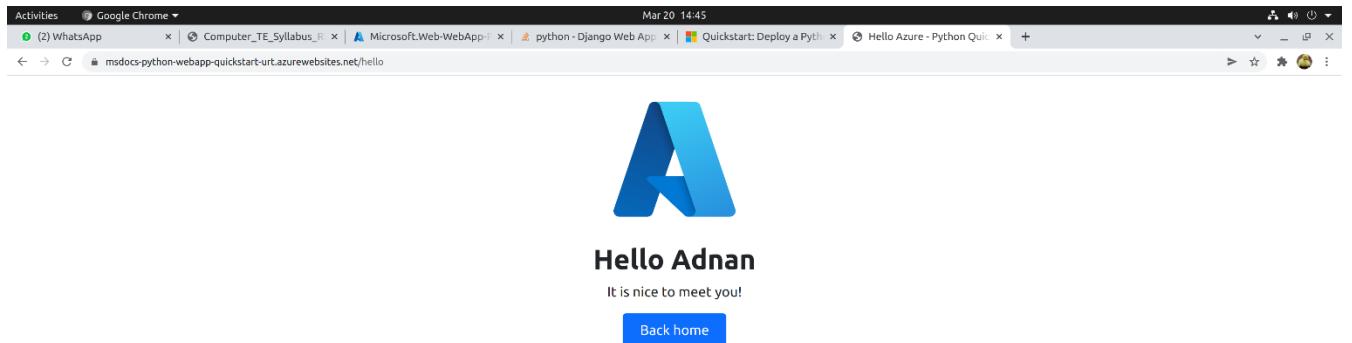
Selecting App to be Deploy



Finalizing Deployment



4) Result:



Conclusion: We have successfully implemented Platform as a Service in Azure.

Experiment No. 6

Aim: To study and Implement Storage as a Service using Own Cloud/ AWS S3, Glaciers/ Azure Storage.

Requirements: Windows/Mac/Linux O.S and AWS/Azure account.

Theory:

What Is Storage as a Service?

Storage as a service (STaaS) is a data storage business model where a provider rents storage resources to a customer through a subscription. STaaS saves you money through operating expenditure (OpEx) agility—you only pay for the storage you need, when you need it.

Why Use Storage as a Service?

Buying new storage capacity can be an expensive capital expenditure (CapEx), especially if you aren't sure how much capacity you'll need in the future. You can try to predict the growth of your business and purchase with the future in mind, but it can tie up financial resources that might have more impact elsewhere in your business.

Fortunately, there's no shortage of major tech companies with large data centers that are willing to sell their excess capacity. For these businesses, storage is just another service that's part of their expansive product offerings, and they're more than happy to absorb the expenses of managing, upgrading, and maintaining large-scale storage area networks (SANs). Amazon Web Services (AWS), Microsoft Azure, Google Cloud, and Oracle Cloud are all examples of major cloud storage providers with STaaS subscription options.

STaaS lets you treat storage as OpEx. You sign a service level agreement (SLA) with your STaaS provider and pay for storage and data transfer rates (e.g., cost per gigabyte). Best of all,

this whole process is automated, allowing you to scale your storage needs up and down as demand requires while maintaining performance and availability 24/7.

Benefits of Storage as a Service

- OpEx subscription model that lets you optimize your storage costs
- Ability to quickly scale and provision storage resources to your apps as you grow
- Always-on reliability of major cloud service providers
- Simplified storage management environment

Implementation:

1) Creating Storage Account

The screenshot shows the Microsoft Azure portal's 'Storage accounts' blade. The URL is <https://portal.azure.com/#blade/HubsExtension/BrowseResource/resourceType/Microsoft.Storage%2FStorageAccounts>. The page title is 'Storage accounts'. It displays a search bar and filter options for 'Subscription == all', 'Resource group == all', and 'Location == all'. Below these, there are sorting options for 'Name ↑', 'Type ↑', 'Kind ↑', 'Resource group ↑', 'Location ↑', and 'Subscription ↑'. A message at the top states 'Showing 0 to 0 of 0 records.' In the center, there is a large gray placeholder icon and the text 'No storage accounts to display'. Below this, a descriptive paragraph explains how to create a storage account for storing data in the cloud. At the bottom, there is a blue 'Create storage account' button and a 'Learn more' link.

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a) Basics

The screenshot shows the 'Create a storage account' wizard in the Microsoft Azure portal. The current step is 'Basics'. The 'Project details' section is visible, showing the subscription 'Azure for Students' and the resource group 'DefaultResourceGroup-CID'. The 'Instance details' section includes fields for the storage account name ('tempo'), region ('(Asia Pacific) Central India'), performance level ('Standard: Recommended for most scenarios (general-purpose v2 account)'), redundancy ('Geo-redundant storage (GRS)'), and a checked checkbox for 'Make read access to data available in the event of regional unavailability'. Navigation buttons at the bottom include 'Review + create', '< Previous', and 'Next : Advanced >'.

b) Advance

The screenshot shows the 'Create a storage account' wizard in the Microsoft Azure portal. The current step is 'Advanced'. A note at the top states: 'Certain options have been disabled by default due to the combination of storage account performance, redundancy, and region.' The 'Security' section contains several checkboxes: 'Require secure transfer for REST API operations' (checked), 'Enable blob public access' (checked), 'Enable storage account key access' (checked), and 'Default to Azure Active Directory authorization in the Azure portal' (unchecked). The 'Minimum TLS version' dropdown is set to 'Version 1.2'. The 'Data Lake Storage Gen2' section is present with a note about hierarchical namespaces. The 'Blob storage' section is also visible. Navigation buttons at the bottom include 'Review + create', '< Previous', and 'Next : Networking >'.

c) Network

The screenshot shows the 'Networking' tab of the Azure Storage Account creation wizard. It includes sections for 'Network connectivity' (with 'Public endpoint (all networks)' selected), 'Network routing' (with 'Microsoft network routing' selected), and a 'Review + create' button.

d) Protection

The screenshot shows the 'Data protection' tab of the Azure Storage Account creation wizard. It includes sections for 'Recovery' (with 'Enable soft delete for blobs' checked and 'Days to retain deleted blobs' set to 7), 'Tracking' (with 'Enable blob change feed' checked), and a 'Review + create' button.

e) Encryption

The screenshot shows the 'Create a storage account' wizard on the 'Encryption' tab. The 'Encryption type' section is selected, showing two options: 'Microsoft-managed keys (MMK)' (selected) and 'Customer-managed keys (CMK)'. Below this, under 'Enable support for customer-managed keys', the 'Blobs and files only' option is selected. A note indicates that this cannot be changed after account creation. Under 'Enable infrastructure encryption', there is an unchecked checkbox. At the bottom, there are 'Review + create', '< Previous', and 'Next : Tags >' buttons.

d) Tags

The screenshot shows the 'Create a storage account' wizard on the 'Tags' tab. It explains that tags are name/value pairs for categorizing resources. It notes that tags will automatically update if resource settings change. Two tags are defined: 'cc1' with value 'temp' and 'Resource' set to 'All resources selected', and another row for a second tag with 'Name' and 'Value' fields empty and 'Resource' set to 'All resources selected'. Navigation buttons at the bottom include 'Review + create', '< Previous', and 'Next : Review + create >'.

e) Reviewing and creating

Validation passed

Basics Advanced Networking Data protection Encryption Tags Review + create

Basics

Subscription	Azure for Students
Resource Group	DefaultResourceGroup-CID
Location	centralindia
Storage account name	tempo
Deployment model	Resource manager
Performance	Standard
Replication	Read-access geo-redundant storage (RA-GRS)

Advanced

Secure transfer	Enabled
Allow storage account key access	Enabled
Allow cross-tenant replication	Enabled
Default to Azure Active Directory authorization in the Azure portal	Disabled
Blob public access	Enabled
Minimum TLS version	Version 1.2
Enable hierarchical namespace	Disabled
Enable network file system v3	Disabled
Access tier	Hot
Enable SFTP	Disabled
Large file shares	Disabled

Next steps

Create < Previous Next > Download a template for automation

d) Successful deployment

Deployment succeeded

Deployment 'tempo_1647776814124' to resource group 'DefaultResourceGroup-CID' was successful.

tempo_1647776814124 | Overview

Deployment

Search (Ctrl+ /) Delete Cancel Redeploy Refresh

We'd love your feedback! →

Your deployment is complete

Deployment name: tempo_1647776814124
Subscription: Azure for Students
Resource group: DefaultResourceGroup-CID

Start time: 3/20/2022, 5:16:58 PM
Correlation ID: d551fcbb-6444-4dc5-8b42-982565c39763

Deployment details (Download)
Next steps
Go to resource

Cost Management
Get notified to stay within your budget and prevent unexpected charges on your bill.
Set up cost alerts >

Microsoft Defender for Cloud
Secure your apps and infrastructure
Go to Microsoft Defender for Cloud >

Free Microsoft tutorials
Start learning today >

Work with an expert
Azure experts are service provider partners who can help manage your assets on Azure and be your first line of support.
Find an Azure expert >

2) Creating Share File storage

The screenshot shows the Azure portal interface for creating a new file share. The left sidebar navigation includes 'Storage accounts', 'File shares', and 'File shares (preview)'. The main content area displays 'File share settings' for a share named 'tempo | File shares'. A modal window titled 'New file share' is open, prompting for a name ('testing') and tier ('Transaction optimized'). Other configuration options like 'Maximum IOPS' and 'Ingress Rate' are visible. At the bottom right of the modal are 'Create' and 'Cancel' buttons.

3) Uploading file

The screenshot shows the Azure portal interface for uploading files to a storage account. The left sidebar shows 'File share' under 'tempo'. The main content area shows a list of files with one entry: 'mickael-ricotti-vlcsnap-2019-01-03-17h05m20s...'. On the right, a 'Upload files' panel is open, showing the uploaded file and providing options to 'Upload' more files or 'Overwrite' existing ones.

4) Creating Linux VM to access this File shares

```
adnan@Azure:~$ group=azure-files-temp
adnan@Azure:~$ name=linux-vm
```

```
adnan@Azure:~$ az vm create \
> --name $name \
> --resource-group $group \
> --image UbuntuLTS \
> --generate-ssh-keys \
> --admin-username adnan
SSH key files '/home/adnan/.ssh/id_rsa' and '/home/adnan/.ssh/id_rsa.pub' have been generated under ~/.ssh to allow SSH access to the VM. If using Microsoft Compute VMs, it is recommended to use parameter "--public-ip-sku Standard" to create new VM with Standard public IP. Please note that the default public IP used in the future.
{
  "fqdns": "",
  "id": "/subscriptions/8cb997f8-3dec-4107-a690-e8159e8a5d22/resourceGroups/azure-files-temp/providers/Microsoft.Compute/virtualMachines/linux-vm",
  "location": "centralindia",
  "macAddress": "60-45-BD-0C-53",
  "powerState": "VM running",
  "privateIpAddress": "10.0.0.4",
  "publicIpAddress": "20.193.242.50",
  "resourceGroup": "azure-files-temp",
  "zones": ""
}
```

5) Accessing storage account through SSH

```
adnan@Azure:~$ az vm show -g $group -n $name -d --query "{name:name,publicIps:publicIps,user:osProfile.adminUsername}" -o jsonc > clouddrive/$name.json
adnan@Azure:~$ cat clouddrive/$name.json
[
  {
    "name": "linux-vm",
    "publicIps": "20.193.242.50",
    "user": "adnan"
  }
]
adnan@Azure:~$ ssh adnan@20.193.242.50
The authenticity of host '20.193.242.50 (20.193.242.50)' can't be established.
ECDSA key fingerprint is SHA256:WK8ib65raW0c3uF9nZeyt578EvA+ma4ByQ+y1Umog.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '20.193.242.50' (ECDSA) to the list of known hosts.
Welcome to Ubuntu 18.04.6 LTS (GNU/Linux 5.4.0-1072-azure x86_64)

 * Documentation: https://help.ubuntu.com
 * Management: https://landscape.canonical.com
 * Support: https://ubuntu.com/advantage

System information as of Sun Mar 20 12:29:05 UTC 2022

System load: 0.0           Processes:      108
Usage of /:  4.8% of 28.90GB   Users logged in:   0
Memory usage: 5%           IP address for eth0: 10.0.0.4
Swap usage:  0%

0 updates can be applied immediately.

The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.

To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

adnan@linux-vm:~$ █
```

6) Connecting VM to File Share storage:

```
adnan@linux-vm:~$ sudo mkdir /mnt/testing
adnan@linux-vm:~$ if [ ! -d "/etc/smbcredentials" ]; then
>   sudo mkdir /etc/smbcredentials
> fi
adnan@linux-vm:~$ if [ ! -f "/etc/smbcredentials/tempo.cred" ]; then
>   sudo bash -c 'echo "username=tempo" >> /etc/smbcredentials/tempo.cred'
>   sudo bash -c 'echo "password=d3TC0pwze0Tqh0Hr1GsfYmgfE0tRkDBUYUE/0sn5q9rYnbgb9seduIq/5Q+AYtcYIEPN18g+DAxMosnZadihg==" >> /etc/smbcredentials/tempo.cred'
> fi
adnan@linux-vm:~$ sudo chmod 600 /etc/smbcredentials/tempo.cred
adnan@linux-vm:~$ sudo bash -c 'echo "//tempo.file.core.windows.net/testing" /mnt/testing cifs nofail,vers=3.0,credentials=/etc/smbcredentials/tempo.cred,dir_m/_/fstab'
adnan@linux-vm:~$ sudo mount -t cifs //tempo.file.core.windows.net/testing /mnt/testing -o vers=3.0,credentials=/etc/smbcredentials/tempo.cred,dir_mode=0777,_
adnan@linux-vm:~$ ls /mnt/
DATALOSS WARNING README.txt  lost+found  testing
```

7) Reading and writing files to File Share storage

```
adnan@linux-vm:~$ ls /mnt/testing/
mickael-riciotti-vlcsnap-2019-01-03-17h05m20s138.jpg
adnan@linux-vm:~$ echo "hello world" > /mnt/testing/temp.txt
adnan@linux-vm:~$ █
```

8) Result

The screenshot shows the Microsoft Azure Storage Account File Share interface. The left sidebar lists options: Overview, Diagnose and solve problems, Access Control (IAM), Settings, Properties, Operations, Snapshots, and Backup. The main area shows a file share named 'testing'. A search bar at the top says 'Search resources, services, and docs (G+)'. Below it, there are buttons for Connect, Upload, Add directory, Refresh, Delete share, Change tier, and Edit quota. A search bar labeled 'Search files by prefix' is present. Two files are listed in the table:

Name	Type	Size	...
mickael-ricotti-vksnap-2019-01-03-17h05m20s138.jpg	File	327.3 KiB	...
temp.txt	File	12 B	...

Conclusion: We have successfully implemented Storage as a Service using Azure.

Experiment no. 7

Aim: To study and Implement Database as a Service on SQL/NOSQL databases like AWS RDS, AZURE SQL/ MongoDB Lab/ Firebase.

Requirements: Azure account and MySQL.

Theory:

What is Azure Database for MySQL?

Azure Database for MySQL is a relational database service in the Microsoft cloud based on the MySQL Community Edition (available under the GPLv2 license) database engine, versions 5.6 (retired), 5.7, and 8.0. Azure Database for MySQL delivers:

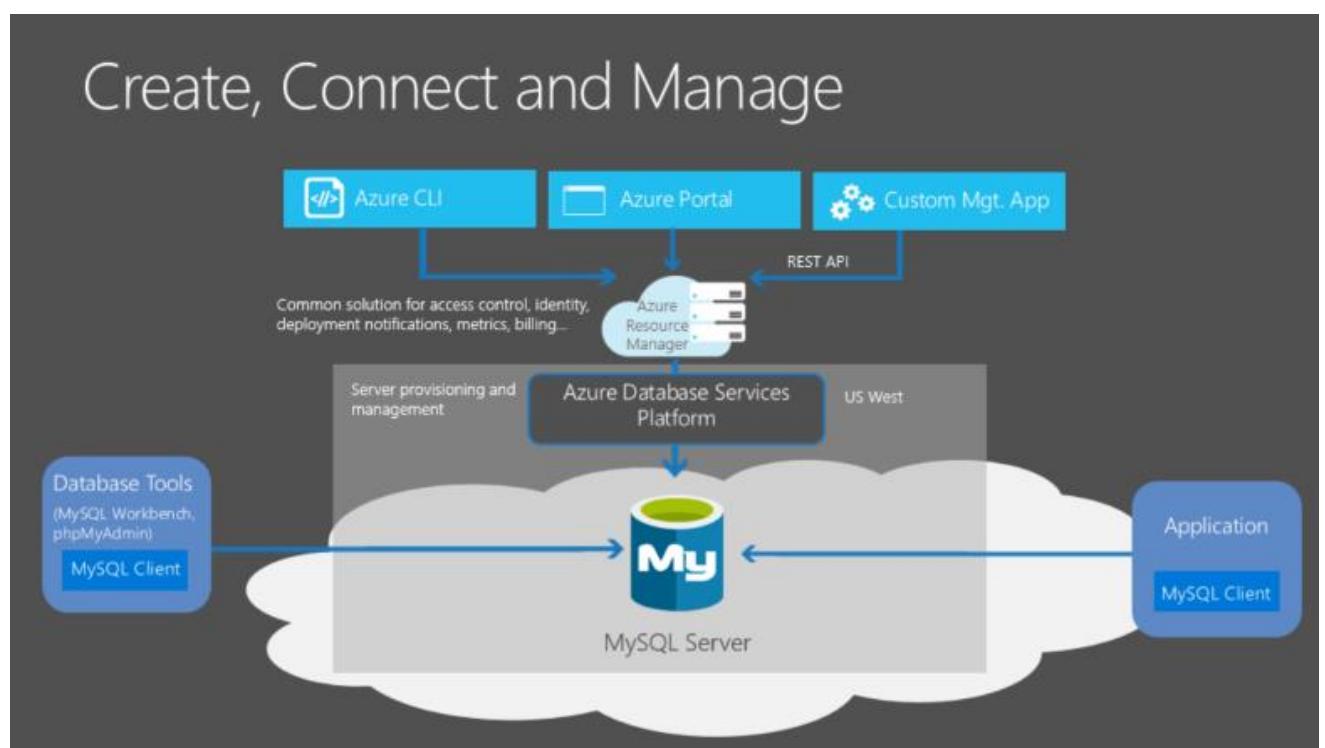
- Zone redundant and same zone high availability.
- Maximum control with ability to select your scheduled maintenance window.
- Data protection using automatic backups and point-in-time-restore for up to 35 days.
- Automated patching and maintenance for underlying hardware, operating system and database engine to keep the service secure and up to date.
- Predictable performance, using inclusive pay-as-you-go pricing.
- Elastic scaling within seconds.
- Cost optimization controls with low cost burstable SKU and ability to stop/start server.
- Enterprise grade security, industry-leading compliance, and privacy to protect sensitive data at-rest and in-motion.
- Monitoring and automation to simplify management and monitoring for large-scale deployments.

- Industry-leading support experience.

These capabilities require almost no administration and all are provided at no additional cost.

They allow you to focus on rapid app development and accelerating your time to market rather than allocating precious time and resources to managing virtual machines and infrastructure.

In addition, you can continue to develop your application with the open-source tools and platform of your choice to deliver with the speed and efficiency your business demands, all without having to learn new skills.



Deployment models

Azure Database for MySQL powered by the MySQL community edition is available in two deployment modes:

- Flexible Server
- Single Server

Azure Database for MySQL - Flexible Server

Azure Database for MySQL Flexible Server is a fully managed production-ready database service designed for more granular control and flexibility over database management functions and configuration settings. The flexible server architecture allows users to opt for high availability within single availability zone and across multiple availability zones. Flexible servers provides better cost optimization controls with the ability to stop/start server and burstable compute tier, ideal for workloads that do not need full compute capacity continuously. Flexible Server also supports reserved instances allowing you to save up to 63% cost, ideal for production workloads with predictable compute capacity requirements. The service supports community version of MySQL 5.7 and 8.0. The service is generally available today in wide variety of Azure regions.

The Flexible Server deployment option offers three compute tiers: Burstable, General Purpose, and Memory Optimized. Each tier offers different compute and memory capacity to support your database workloads. You can build your first app on a burstable tier for a few dollars a month, and then adjust the scale to meet the needs of your solution. Dynamic scalability enables your database to transparently respond to rapidly changing resource requirements. You only pay for the resources you need, and only when you need them.

Flexible servers are best suited for

- Ease of deployments, simplified scaling and low database management overhead for functions like backups, high availability, security and monitoring
- Application developments requiring community version of MySQL with better control and customizations
- Production workloads with same-zone, zone redundant high availability and managed maintenance windows
- Simplified development experience

- Enterprise grade security

Azure Database for MySQL - Single Server

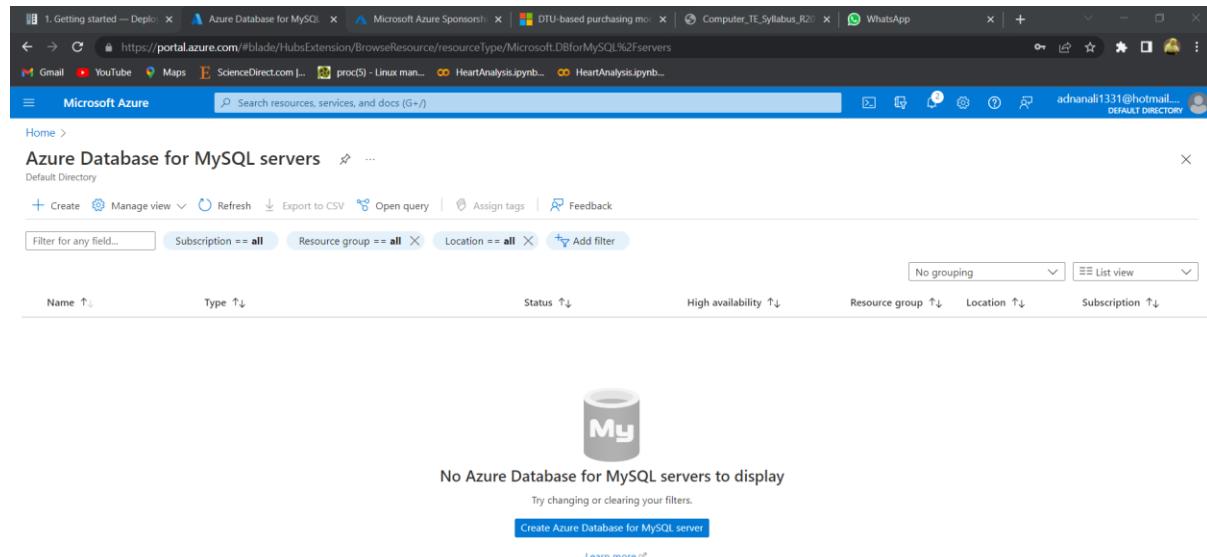
Azure Database for MySQL Single Server is a fully managed database service designed for minimal customization. The single server platform is designed to handle most of the database management functions such as patching, backups, high availability, security with minimal user configuration and control. The architecture is optimized for built-in high availability with 99.99% availability on single availability zone. It supports community version of MySQL 5.6 (retired), 5.7 and 8.0. The service is generally available today in wide variety of Azure regions.

Single servers are best suited **only for existing applications already leveraging single server**.

For all new developments or migrations, Flexible Server would be the recommended deployment option.

Output:

1. Creating MySQL Database



The screenshot shows the Microsoft Azure portal interface. The top navigation bar includes links for 'Getting started — Deploy', 'Azure Database for MySQL', 'Microsoft Azure Sponsor...', 'DTU-based purchasing mode', 'Computer_TE_Syllabus_R20', and 'WhatsApp'. Below the navigation bar, the address bar shows the URL: <https://portal.azure.com/#blade/HubsExtension/BrowseResource/resourceType/Microsoft.DBforMySQL%2Fservers>. The main content area is titled 'Azure Database for MySQL servers' and features a search bar and filter options. The filters are set to 'Subscription == all', 'Resource group == all', and 'Location == all'. The results table is empty, displaying the message: 'No Azure Database for MySQL servers to display. Try changing or clearing your filters.' A large blue button labeled 'Create Azure Database for MySQL server' is centered on the page. The bottom of the screen shows the standard Azure footer with links for 'Feedback', 'Help & support', and 'Logout'.

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The screenshot shows the 'Pricing tier' configuration step in the Azure MySQL server creation wizard. It displays three options: 'Basic' (Up to 2 vCores with variable IO performance), 'General Purpose' (Up to 64 vCores with predictable IO performance), and 'Memory Optimized' (Up to 32 memory optimized vCores with predictable IO performance). A note states that changing compute tier or backup redundancy after creation is not supported. The 'General Purpose' tier is selected. On the right, a 'PRICE SUMMARY' panel shows the cost per vCore (\$1788.13), basic storage (\$7.20), and estimated monthly cost (\$1824.16 INR). A 'Storage Auto-growth' checkbox is checked, and a note indicates storage cannot be scaled down. The 'OK' button is at the bottom.

The screenshot shows the 'Create MySQL server' configuration step. It requires entering server name ('testingcc'), data source ('None / Backup'), location ('(US) East US'), version ('5.7'), and compute/storage ('1 vCores, 5 GB storage'). Under 'Administrator account', admin username ('adnan') and password ('*****') are specified. The 'Review + create' button is at the bottom left, and 'Next: Additional settings >' is at the bottom right.

The screenshot shows the 'Review + create' dialog for the MySQL server. It includes tabs for 'Basics', 'Additional settings', 'Tags', and 'Review + create'. The 'Basics' tab is active, showing product details (Azure Database for MySQL by Microsoft), estimated cost per month (\$1824.16 INR), and terms of use. The 'Terms' section contains legal agreements. The 'Basics' section lists subscription (Azure for Students), resource group (webapp), server name (testingcc), data source (None), and server admin login name (adnan). The 'Create' button is at the bottom left, and 'Download a template for automation' is at the bottom right.

The screenshot shows the Microsoft Azure portal with the URL <https://portal.azure.com/#@adnanali1331hotmail.onmicrosoft.com/resource/subscriptions/8cb597f8-3dec-4107-a690-e8159e8a5d22/resourceGroups/webapp/providers/Microsoft.DBforMySQLservers/testingcc>. The page title is "testingcc" and it's described as "Azure Database for MySQL single server". The main content area is titled "Essentials" and shows the following details:

Resource group	: webapp
Status	: Available
Location	: East US
Subscription	: Azure for Students
Subscription ID	: 8cb597f8-3dec-4107-a690-e8159e8a5d22
Tags (edit)	: Click here to add tags
Server name	: testingcc.mysql.database.azure.com
Server admin login name	: adnan@testingcc
MySQL version	: 5.7
Performance configuration	: Basic, 1 vCore(s), 5 GB
SSL enforce status	: ENABLED

Below this, there is a chart titled "Resource utilization (testingcc)" showing usage over the last hour. The Y-axis ranges from 0% to 100% in 10% increments. The X-axis shows time points: 2 PM, 2:15 PM, and 2:30 PM. The utilization is at 0% for all three points.

The left sidebar contains the following navigation items:

- Overview
- Activity log
- Access control (IAM)
- Tags
- Diagnose and solve problems
- Settings
 - Connection security
 - Connection strings
 - Server parameters
 - Active Directory admin
 - Pricing tier
 - Properties
 - Locks
- Intelligent Performance
 - Query Performance Insight
 - Performance recommendations

Configure a server-level firewall rule

By default, the new server is protected with a firewall. To connect, you must provide access to your IP by completing these steps:

Go to **Connection security** from the left pane for your server resource and add your ip.

The screenshot shows the "Connection security" settings page for the MySQL server "testingcc". The left sidebar shows the following navigation items:

- Overview
- Activity log
- Access control (IAM)
- Tags
- Diagnose and solve problems
- Settings
 - Connection security
 - Connection strings
 - Server parameters
 - Active Directory admin
 - Pricing tier
 - Properties
 - Locks
 - Export template

The main content area is titled "Firewall rules" and contains the following information:

Allow access to Azure services: Yes

Firewall rule name	Start IP	End IP
Firewall rule name	Start IP	End IP

+ Add current client IP address (24.16.139.249) + Add 0.0.0 - 255.255.255.255

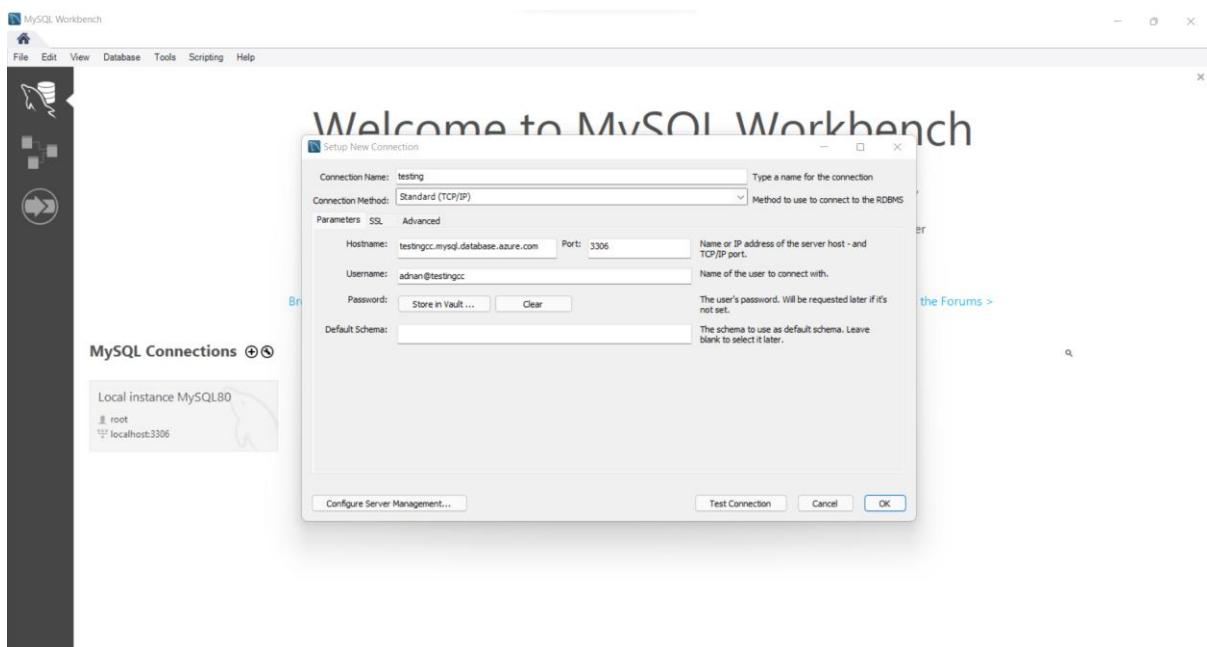
The "SSL settings" section shows:

Enforce SSL connection: ENABLED

Connect to the server by using MySQL Workbench

To connect to Azure MySQL Server by using the GUI tool MySQL Workbench:

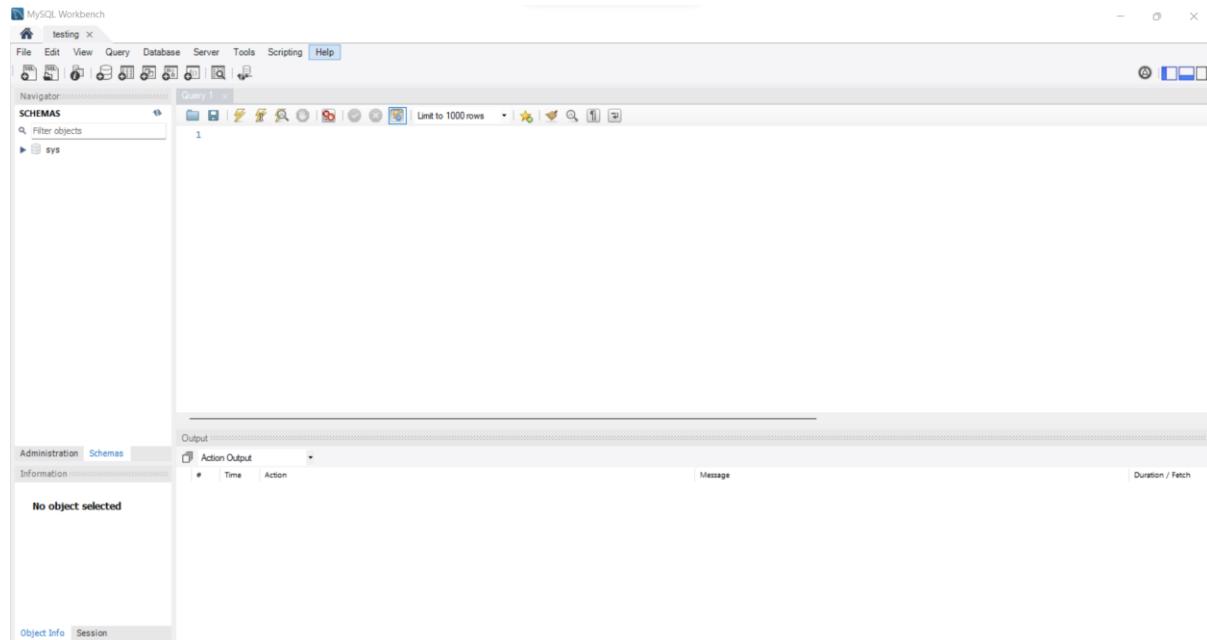
1. Launch the MySQL Workbench application on your computer.
2. In **Setup New Connection** dialog box, enter the following information on the **Parameters** tab:



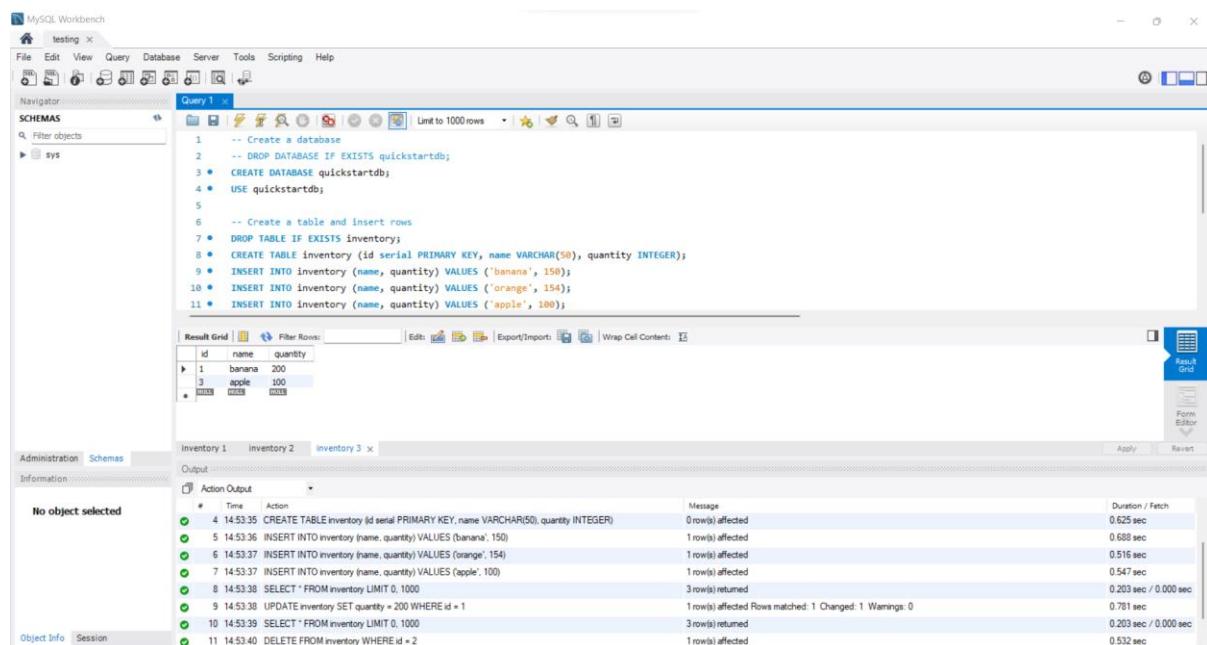
3. Click **Test Connection** to test if all parameters are correctly configured.
4. Click **OK** to save the connection.
5. In the listing of **MySQL Connections**, click the tile corresponding to your server, and then wait for the connection to be established.

Create a table, insert data, read data, update data, delete data (CRUD)

1. Open Azure connected Database in MySQL



2. Perform CRUD



Conclusion: We have successfully implemented database as a service in Azure MySQL and performed CRUD operation.

Experiment no. 8

Aim: To study and Implement Security as a Service on AWS/Azure

Requirements: Azure account

Theory:

We know that security is job one in the cloud and how important it is that you find accurate and timely information about Azure security. One of the best reasons to use Azure for your applications and services is to take advantage of its wide array of security tools and capabilities. These tools and capabilities help make it possible to create secure solutions on the secure Azure platform. Microsoft Azure provides confidentiality, integrity, and availability of customer data, while also enabling transparent accountability.

General Azure security

Microsoft Defender for Cloud A cloud workload protection solution that provides security management and advanced threat protection across hybrid cloud workloads.

Azure Key Vault A secure secrets store for the passwords, connection strings, and other information you need to keep your apps working.

Azure Monitor logs A monitoring service that collects telemetry and other data, and provides a query language and analytics engine to deliver operational insights for your apps and resources. Can be used alone or with other services such as Defender for Cloud.

Azure Dev/Test Labs A service that helps developers and testers quickly create environments in Azure while minimizing waste and controlling cost.

Storage security

Azure Storage Service Encryption A security feature that automatically encrypts your data in Azure storage.

StorSimple Encrypted Hybrid Storage An integrated storage solution that manages storage tasks between on-premises devices and Azure cloud storage.

Azure Client-Side Encryption A client-side encryption solution that encrypts data inside client applications before uploading to Azure Storage; also decrypts the data while downloading.

Azure Storage Shared Access Signatures A shared access signature provides delegated access to resources in your storage account.

Azure Storage Account Keys An access control method for Azure storage that is used for authentication when the storage account is accessed.

Azure File shares with SMB 3.0 Encryption A network security technology that enables automatic network encryption for the Server Message Block (SMB) file sharing protocol.

Azure Storage Analytics A logging and metrics-generating technology for data in your storage account.

Database security

Azure SQL Firewall A network access control feature that protects against network-based attacks to database.

Azure SQL Cell Level Encryption A database security technology that provides encryption at a granular level.

Azure SQL Connection Encryption To provide security, SQL Database controls access with firewall rules limiting connectivity by IP address, authentication mechanisms requiring users

to prove their identity, and authorization mechanisms limiting users to specific actions and data.

Azure SQL Always Encryption Protects sensitive data, such as credit card numbers or national identification numbers (for example, U.S. social security numbers), stored in Azure SQL Database or SQL Server databases.

Azure SQL Transparent Data Encryption A database security feature that encrypts the storage of an entire database.

Azure SQL Database Auditing A database auditing feature that tracks database events and writes them to an audit log in your Azure storage account.

Identity and access management

Azure role-based access control An access control feature designed to allow users to access only the resources they are required to access based on their roles within the organization.

Azure Active Directory A cloud-based authentication repository that supports a multi-tenant, cloud-based directory and multiple identity management services within Azure.

Azure Active Directory B2C An identity management service that enables control over how customers sign-up, sign-in, and manage their profiles when using Azure-based applications.

Azure Active Directory Domain Services A cloud-based and managed version of Active Directory Domain Services.

Azure AD Multi-Factor Authentication A security provision that employs several different forms of authentication and verification before allowing access to secured information.

Backup and disaster recovery

Azure Backup An Azure-based service used to back up and restore data in the Azure cloud.

Azure Site Recovery An online service that replicates workloads running on physical and virtual machines (VMs) from a primary site to a secondary location to enable recovery of services after a failure.

Networking

Network Security Groups A network-based access control feature using a 5-tuple to make allow or deny decisions.

Azure VPN Gateway A network device used as a VPN endpoint to allow cross-premises access to Azure Virtual Networks.

Azure Application Gateway An advanced web application load balancer that can route based on URL and perform SSL-offloading.

Web application firewall (WAF) A feature of Application Gateway that provides centralized protection of your web applications from common exploits and vulnerabilities

Azure Load Balancer A TCP/UDP application network load balancer.

Azure ExpressRoute A dedicated WAN link between on-premises networks and Azure Virtual Networks.

Azure Traffic Manager A global DNS load balancer.

Azure Application Proxy An authenticating front-end used to secure remote access for web applications hosted on-premises.

Azure Firewall A managed, cloud-based network security service that protects your Azure Virtual Network resources.

Azure DDoS protection Combined with application design best practices, provides defense against DDoS attacks.

Virtual Network service endpoints Extends your virtual network private address space and the identity of your VNet to the Azure services, over a direct connection.

Output:

Database Firewall protection

Database:

The screenshot shows the Microsoft Azure portal interface. The URL in the browser is <https://portal.azure.com/#@adnanali1331@hotmail.onmicrosoft.com/resource/subscriptions/8cb997f8-3dec-4107-a690-e8159e8a5d22/resourceGroups/webapp/providers/Microsoft.Sql/server...>. The page title is "testing (testingccl/testing) - Microsoft Azure". The main content area displays the "Overview" tab for a SQL database. Key details shown include:

- Resource group: [\(move\) : webapp](#)
- Status: Online
- Location: East US
- Subscription: [Azure for Students](#)
- Subscription ID: 8cb997f8-3dec-4107-a690-e8159e8a5d22
- Tags: [Click here to add tags](#)
- Server name: [testingccl.database.windows.net](#)
- Elastic pool: [No elastic pool](#)
- Connection strings: [Show database connection strings](#)
- Pricing tier: Basic
- Earliest restore point: 2022-04-20 09:21 UTC

On the left sidebar, under the "Overview" section, there are several tabs: Overview, Activity log, Tags, Diagnose and solve problems, Quick start, and Query editor (preview). Other sections visible include Power Platform (Power BI, Power Apps, Power Automate), Settings (Compute + storage, Connection strings, Properties, Locks), and Data management.

On the right side, there is a "Compute utilization" chart showing usage over the last 1 hour, 24 hours, or 7 days, with an aggregation type set to Max. Below the chart is a circular gauge indicating "Database data storage" at 1.03% used space, which is 21 MB.

Adding Firewall security:

The screenshot shows the 'Firewall settings' page for a SQL server named 'testingccl'. The 'Deny public network access' checkbox is unchecked. The 'Minimum TLS Version' is set to 1.2. Under 'Connection Policy', 'Default' is selected. The 'Allow Azure services and resources to access this server' dropdown is set to 'Yes'. The 'Client IP address' is listed as 45.115.187.209. A table shows a single rule entry: Rule name 'ClientIPAddress_2022-4...', Start IP '45.115.187.209', and End IP '45.115.187.209'. Below this, there's a section for 'Virtual networks' with options to add existing or create new virtual networks. The 'Outbound networking' section is also visible.

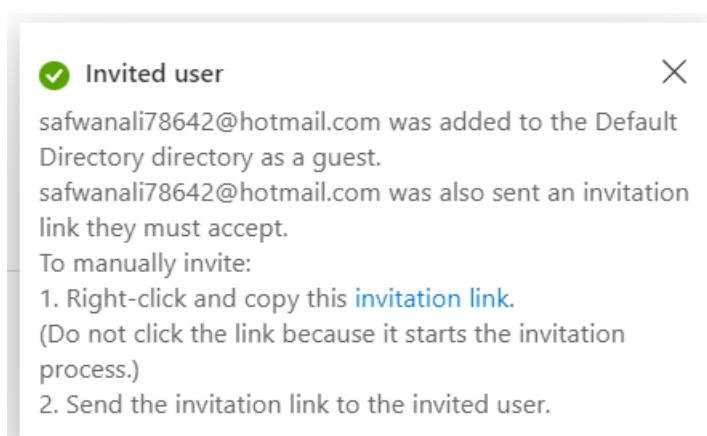
Access Control (IAM)

The screenshot shows the 'Access control (IAM)' page for a resource group named 'webapp'. The left sidebar includes sections for Overview, Activity log, Access control (IAM), Tags, Resource visualizer, Events, Settings (Deployments, Security, Policies, Properties, Locks), Cost Management (Cost analysis, Cost alerts (preview), Budgets), and more. The main area displays four cards: 'My access' (View my access), 'Check access' (Find User, group, or service principal, Search by name or email address), 'Grant access to this resource' (Add role assignment, Learn more), and 'View deny assignments' (View, Learn more).

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The screenshot shows the Microsoft Azure portal interface. The main page displays the 'Add role assignment' step for a 'webapp' resource. The 'Members' tab is currently selected. On the left, configuration options include 'Selected role' (Contributor), 'Assign access to' (User, group, or service principal), and 'Description' (Optional). Below these are sections for 'Members' and 'Description'. The 'Members' section has a link to '+ Select members'. The 'Description' section has a text input field. At the bottom are 'Review + assign', 'Previous', and 'Next' buttons. To the right, a modal window titled 'Select members' is open. It contains a 'Select' button, a search bar with the value 'safwanali78642@hotmail.com', and a note: 'This user will be sent an email that enables them to collaborate with Default Directory.' Below this is a list item: 'safwanali78642@hotmail.com (Guest)' with a small profile icon. At the bottom of the modal are 'Select' and 'Close' buttons.

This screenshot shows the same 'Add role assignment' page as the previous one, but the 'Review + assign' tab is now selected. The configuration remains the same: Selected role (Contributor), Assign access to (User, group, or service principal), and Description (No description). The 'Members' table now lists the selected user: 'safwanali78642@hotmail.com' (Object ID: e8159e8a5d22, Type: User). The 'Description' field still contains 'No description'. At the bottom are 'Review + assign', 'Previous', and 'Next' buttons.



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Microsoft Azure

Home > webapp

webapp | Access control (IAM)

Resource group

Search (Ctrl+)

Add Download role assignments Edit columns Refresh Remove Got feedback?

Check access Role assignments Roles Deny assignments Classic administrators

Number of role assignments for this subscription 1 2000

Search by name or email Type : All Role : All Scope : All scopes Group by : Role

1 items (1 Users)

Name	Type	Role	Scope	Condition
safwanali78642 (Guest) safwanali78642@hotmail.com	User	Contributor	This resource	None

DDOS

Creating DDOS plan:

Microsoft Azure

Home >

DDoS protection plans

Default Directory

+ Create Manage view Refresh Export to CSV Open query Assign tags Feedback

Filter for any field... Subscription == all Resource group == all Location == all Add filter

No grouping List view

Name ↑ Type ↑ Resource group ↑ Location ↑ Subscription ↑

No DDoS protection plans to display

DDoS Protection leverages the scale and elasticity of Microsoft's global network to bring massive DDoS mitigation capacity in every Azure region. Microsoft's DDoS Protection service protects your Azure applications by scrubbing traffic at the Azure network edge before it can impact your service's availability.

Create DDoS protection plan

Learn more about DDoS protection plan

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Create a DDoS protection plan ...

Basics Tags Review + create

Azure DDoS protection can help defend against DDoS (distributed denial of service) attacks directed at your resources. Your resources automatically receive a basic level of protection at no additional charge. Create a DDoS protection plan to enable DDoS standard protection for an advanced level of protection. [Learn more about DDoS protection plans](#)

Project details

Subscription * Resource group * Create new

Instance details

Name * Region *

You can create a single DDoS protection plan and apply it to resources in all of your subscriptions.

Review + create < Previous Next : Tags > Download a template for automation

Create a DDoS protection plan ...

Validation passed

Basics Tags Review + create

Basics

Subscription: Azure for Students
Resource group: appsvc_linux_centralus
Name: testing
Region: Central US

Tags

None

Terms

By clicking create, you agree that you are aware of the cost and pricing structure of a DDoS protection plan and are willing to accept the charges. [Read more about DDoS protection plan pricing](#)

Create < Previous Next > Download a template for automation

Deleted resource group webapp
Deleted resource group webapp

testing - Microsoft Azure https://portal.azure.com/#@adnanali1331@hotmail.onmicrosoft.com/resource/subscriptions/8cb97f8-3dec-4107-a690-e8159e8a5d22/resourceGroups/appsvc_linux_centralus/providers/Microsoft.Network/ddosProtectionPlans/testing

Home > Microsoft.DdosProtectionPlan-202402185532 >

testing DDoS protection plan

Move Delete Refresh Lock

Overview

Activity log

Access control (IAM)

Tags

Diagnose and solve problems

Protected resources

Properties

Locks

Monitoring

Alerts

Metrics

Automation

Tasks (preview)

Export template

Essentials

Resource group (move) : appsvc_linux_centralus
Location : Central US
Subscription (move) : Azure for Students
Subscription ID : 8cb97f8-3dec-4107-a690-e8159e8a5d22
Tags (edit) : Click here to add tags

Configure and manage a protection plan for your organization

Make changes to your plan or link virtual networks from multiple subscriptions to the same plan. [Learn more](#)

Manage protected resources

Enable your DDoS protection plan on a virtual network to automatically mitigate DDoS attacks on your networks. [Learn more](#)

Add protected resource

Telemetry and reporting

View real-time DDoS mitigation metrics via Azure Monitor when the resource is under attack or review post-attack mitigation reports.

View metrics

Configure alerts & export diagnostic logs

DDoS protection planning

Preparation is crucial for minimizing an actual DDoS attack. View best practices and reference architectures to set up your protection plan.

View best practices

Creating Network with DDOS plan:

Create virtual network - Microsoft | What is Azure Active Directory | Azure DDoS Protection Pricing | +

https://portal.azure.com/#create/Microsoft.VirtualNetwork

Gmail YouTube Maps ScienceDirect.com proc(5) - Linux man... HeartAnalysis.ipynb... HeartAnalysis.ipynb...

Microsoft Azure adnanali1331@hotmail... DEFAULT DIRECTORY

Home > Virtual networks >

Create virtual network ...

Basics IP Addresses Security Tags Review + create

Azure Virtual Network (VNet) is the fundamental building block for your private network in Azure. VNet enables many types of Azure resources, such as Azure Virtual Machines (VM), to securely communicate with each other, the internet, and on-premises networks. VNet is similar to a traditional network that you'd operate in your own data center, but brings with it additional benefits of Azure's infrastructure such as scale, availability, and isolation. Learn more about virtual network.

Project details

Subscription * Resource group * Create new

Instance details

Name * Region *

Review + create < Previous Next : IP Addresses > Download a template for automation

Adding DDOS plan as security:

Create virtual network - Microsoft | What is Azure Active Directory | Azure DDoS Protection Pricing | +

https://portal.azure.com/#create/Microsoft.VirtualNetwork

Gmail YouTube Maps ScienceDirect.com proc(5) - Linux man... HeartAnalysis.ipynb... HeartAnalysis.ipynb...

Microsoft Azure adnanali1331@hotmail... DEFAULT DIRECTORY

Home > Virtual networks >

Create virtual network ...

Basics IP Addresses Security Tags Review + create

BastionHost I know my resource ID

DDoS Protection Standard DDoS protection plan *

Firewall

Review + create < Previous Next : Tags > Download a template for automation

Network with active DDOS plan:

The screenshot shows the Microsoft Azure portal interface for a virtual network named 'testing'. The left sidebar lists various settings such as Overview, Activity log, Access control (IAM), Tags, and Diagnose and solve problems. The main content area displays the 'Essentials' section with resource group information (appsvc_linux_centralus), location (Central US), subscription (Azure for Students), and network details (Address space: 10.0.0.0/16, DNS servers: Azure provided DNS service, Flow timeout: Configure, BGP community string: Configure, Virtual network ID: 3b051e8f-fac7-4328-acb9-44b2903e7b43). The 'Capabilities' tab is selected, showing four cards: 'DDoS protection' (Configurable), 'Azure Firewall' (Not configured), 'Peering' (Not configured), and 'Security' (Filter network traffic to and from Azure resources).

Microsoft Defender Security

Creating Microsoft defender resource:

The screenshot shows the Microsoft Azure portal dashboard for Microsoft Defender for Cloud. The left sidebar includes 'Recent resources' (MicroChat, Chatapp, Azure for Students), 'Tools' (Microsoft Learn, Azure Monitor, Microsoft Defender for Cloud, Cost Management), and 'Useful links' (Technical Documentation, Azure Services, Recent Azure Updates, Quickstart Center). The main content area features a 'Free training from Microsoft' section with courses like 'Top 5 security items to consider before pushing...' and 'Security, responsibility and trust in Azure'. It also includes a 'Last Viewed' section and download links for the 'Azure mobile app' (App Store and Google Play).

Adding resources:

The screenshot shows the 'Settings' page for Microsoft Defender for Cloud. It displays a table of resources and their protection status. Key details include:

- Microsoft Defender for Cloud plans will be enabled on 3 resources in this subscription:**
- Servers:** 0 servers, Plan 1 (\$5/Server/Month), Status: Off (On)
- App Service:** 2 instances, \$15/Instance/Month, Status: Off (On)
- Databases:** Protected: 0/0 instances, Selected: 1/4, Status: Off (On)
- Storage:** 1 storage accounts, \$0.02/10K transactions, Status: Off (On)
- Containers:** 0 container registries; 0 kubernetes cores, \$7/VM core/Month, Status: Off (On)
- Key Vault:** 0 key vaults, \$0.02/10K transactions, Status: Off (On)
- Resource Manager:** \$4/1M resource management operations, Status: Off (On)
- DNS:** \$0.7/1M DNS queries, Status: Off (On)

A note at the bottom states: "When you select Save, Microsoft Defender for Cloud's enhanced security features will be enabled on all the resource types you've selected. The first 30 days are free. For more information on Defender for Cloud pricing, visit the [pricing page](#)".

Checking active plan:

The screenshot shows the 'Getting started' page for Microsoft Defender for Cloud. It includes the following sections:

- General:** Overview, Getting started (selected), Recommendations, Security alerts, Inventory, Workbooks, Community, Diagnose and solve problems.
- Cloud Security:** Security posture, Regulatory compliance, Workload protections, Firewall Manager.
- Management:** Environment settings, Security solutions, Workflow automation.
- Microsoft Defender for Cloud:** A large heading with a subtext: "Microsoft Defender for Cloud provides unified security management and advanced threat protection across hybrid cloud workloads." Below this is a "Learn more >" link and a purple circular diagram illustrating cloud workload protection.
- Callouts:**
 - Gain tenant-wide visibility:** Gain visibility and manage the security posture of all your Azure subscriptions by leveraging Azure management groups and assigning a security role on the management group. Includes a "Learn More" button.
 - Configure security policies:** Set policies to define workload configuration, help ensure compliance, and protect sensitive data. Includes a "Configure" button.
 - Add non-Azure servers:** Use the Log Analytics agent to extend Microsoft Defender for Cloud capabilities to servers running outside of Azure, including resources running on-premises and in other clouds. Includes a "Configure" button.

The screenshot shows the Microsoft Defender for Cloud Environment settings page. At the top, it displays 1 Azure subscription, 0 AWS accounts, and 0 GCP projects. A welcome message for the new multi-cloud account management page (preview) is present. Below this, there's a search bar and filters for environments, standards, and coverage. The main table lists a Tenant Root Group (1 of 1 subscriptions) under the Azure category. The row for 'Azure for Students' shows 0 total resources, 0 defender coverage, and 5/5 plans. The status bar at the bottom indicates the date as 20-04-2022 and the time as 19:04.

Enabling Integration:

The screenshot shows the Microsoft Defender for Cloud Settings | Integrations page. The 'Integrations' section is selected in the sidebar. It includes options for Defender plans, Auto provisioning, Email notifications, and CI/CD integration. The CI/CD integration section has two checkboxes: 'Allow Microsoft Defender for Cloud Apps to access my data' and 'Allow Microsoft Defender for Endpoint to access my data'. To the right, a modal window titled 'CI/CD configuration' is open, divided into four steps: Step 1 (Select subscription: Azure for Students), Step 2 (Select a region for the selected default workspace used to store application insights: West US 2), Step 3 (Copy the authentication token and connection string displayed below), and Step 4 (Configure your CI/CD pipeline to do scanning). The status bar at the bottom indicates the date as 20-04-2022 and the time as 19:05.

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Enable Logging:

The screenshot shows the 'Auto provisioning' settings page in Microsoft Defender for Cloud. It lists several extensions that collect security data and events from resources to prevent, detect, and respond to threats. The extensions include:

Extension	Status	Resources missing extension	Description	Configuration
Log Analytics agent for Azure VMs	On	0 of 0 virtual machines	Collects security-related configurations and event logs from the machine and stores the data in your Log Analytics workspace for analysis.	Selected workspace: default workspace Security events: None Edit configuration
Log Analytics agent for Azure Arc Machines (preview)	Off	0 of 0 Azure Arc machines	Collects security-related configurations and event logs from the machine and stores the data in your Log Analytics workspace for analysis.	-
Vulnerability assessment for machines	Off	0 of 0 VMs & servers	Enables vulnerability assessment on your Azure and hybrid machines.	-
Guest Configuration agent (preview)	Off	0 of 0 virtual machines	Checks machines running in Azure and Arc Connected Machines for security misconfigurations. Settings such as configuration of the operating system, application configurations, and environment settings are all validated. To learn more, see Understand Azure Policy's Guest Configuration.	-
Microsoft Defender for Containers components (preview)	Off	0 of 0 Kubernetes clusters	Deploys Defender for Kubernetes components for environment hardening and run-time protections for your Azure, hybrid, and multi-cloud Kubernetes workloads.	-

Setting Email for notification:

The screenshot shows the 'Email notifications' settings page in Microsoft Defender for Cloud. It allows users to select who will receive email notifications for alerts. The configuration includes:

- Email recipients:** Set to "All users with the following roles" and "Owner". An additional email address "adnanshaikh@gmail.com,adnan.shaikh19@comp.sce.edu.in" is listed in the "Additional email addresses (separated by commas)" field.
- Notification types:** Set to "Notify about alerts with the following severity (or higher): High". A note states: "You'll receive a maximum of one email per 6 hours for high-severity alerts, one email per 12 hours for medium-severity alerts, and one email per 24 hours for low-severity alerts."

Work flow automation:

The screenshot shows the Microsoft Defender for Cloud Settings interface. The left sidebar has a 'Workflow automation' section selected. The main area displays a table with columns: Name, Status, Scope, Trigger Type, Description, and Logic App. A message at the top right says 'No workflow automations found'. The status bar at the bottom shows the date as 20-04-2022 and the time as 19:44.

Continuous export:

The screenshot shows the Microsoft Defender for Cloud Settings interface with the 'Continuous export' section selected. It includes configuration for Event hub and Log Analytics workspace. Under 'Exported data types', there are sections for Security recommendations, Secure score, Security alerts, and Regulatory compliance. Under 'Export frequency', options for Streaming updates and Snapshots (Preview) are shown. The status bar at the bottom shows the date as 20-04-2022 and the time as 19:45.

Security Policy:

The screenshot shows the Microsoft Defender for Cloud Settings interface. The left sidebar has a 'Settings' section with 'Security policy' selected. The main area is titled 'Security policy on: Azure for Students' and shows a table of initiatives. One initiative, 'Default initiative', is highlighted. The table includes columns for Assignment, Assigned On, Audit policies, Deny policies, Disabled policies, Exempted policies, and a more options button. Below the table, there's a section for 'Industry & regulatory standards' with four entries: Azure Security Benchmark, PCI DSS 3.2.1, ISO 27001, and SOC TSP. Each entry has a description, status (Out of the box), and a 'Disable' or 'Enable' button. A 'Deprecation' status is shown for ISO 27001. At the bottom, there's a 'Your custom initiatives' section and a timestamp '19:46 20-04-2022'.

Assignment	Assigned On	Audit policies	Deny policies	Disabled policies	Exempted policies	...
ASC Default (subscription: af1d9591-2fdc-46da-96d...)	Subscription	191	0	15	0	[More Options]

Conclusion: We have successfully implemented Security as a service on Azure

Experiment no. 9

Aim: To study and implement Identity and Access Management (IAM) practices on AWS/Azure cloud.

Requirements: Azure account

Theory:

Microsoft Azure IAM, also known as Access Control (IAM), is the product provided in Azure for RBAC and governance of users and roles. Identity management is a crucial part of cloud operations due to security risks that can come from misapplied permissions. Whenever you have a new identity (a user, group, or service principal) or a new resource (such as a virtual machine, database, or storage blob), you should provide proper access with as limited of a scope as possible. Here are some of the questions you should ask yourself to maintain maximum security:

1. Who needs access?

Granting access to an identity includes both human users and programmatic access from applications and scripts. If you are utilizing Azure Active Directory, then you likely want to use those managed identities for role assignments. Consider using an existing group of users or making a new group to apply similar permissions across a set of users, as you can then remove a user from that group in the future to revoke those permissions.

Programmatic access is typically granted through Azure service principals. Since it's not a user logging in, the application or script will use the App Registration credentials to connect and run any commands.

2. What role do they need?

Azure IAM uses roles to give specific permissions to identities. Azure has a number of built-in roles based on a few common functions:

- **Owner** – Full management access, including granting access to others
- **Contributor** – Management access to perform all actions except granting access to others
- **User Access Administrator** – Specific access to grant access to others
- **Reader** – View-only access

These built-in roles can be more specific, such as “Virtual Machine Contributor” or “Log Analytics Reader”. However, even with these specific pre-defined roles, the principle of least privilege shows that you’re almost always giving more access than is truly needed.

For even more granular permissions, you can create Azure custom roles and list specific commands that can be run.

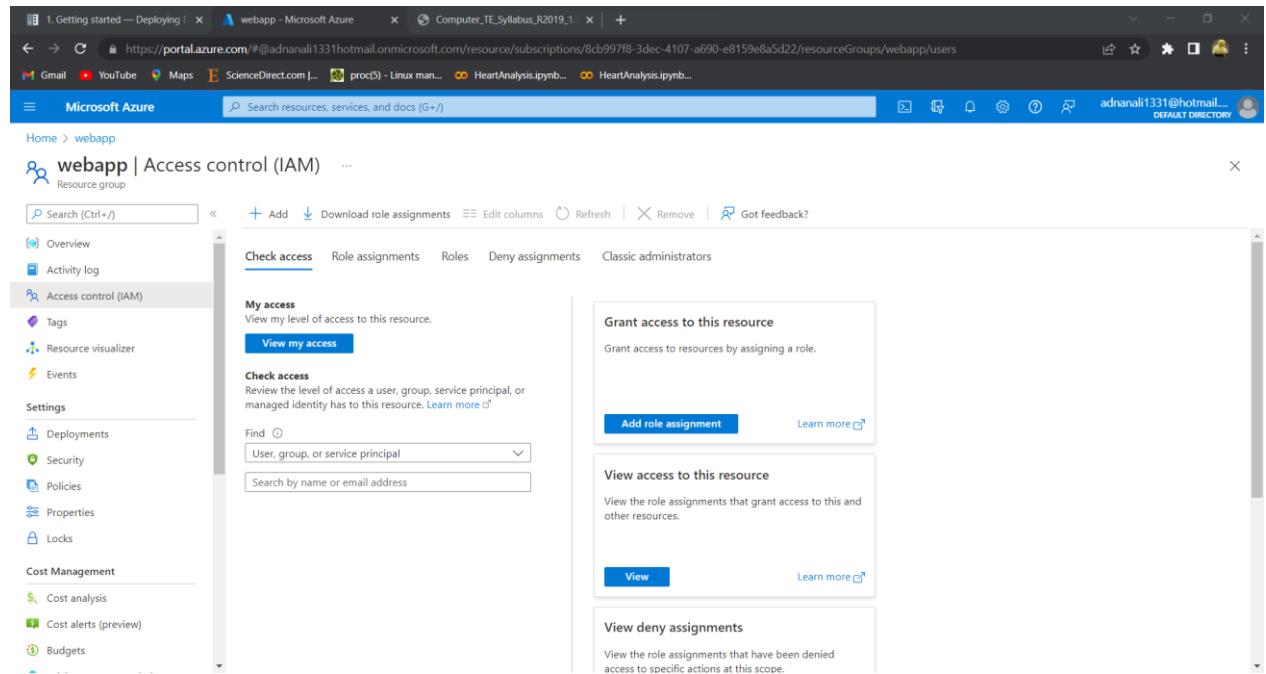
3. Where do they need access?

The final piece of an Azure IAM permission set is deciding the specific resource that the identity should be able to access. This should be at the most granular level possible to maintain maximum security. For example, a Cloud Operations Manager may need access at the management group or subscription level, while a SQL Server utility may just need access to specific database resources. When creating or assigning the role, this is typically referred to as the “scope” in Azure.

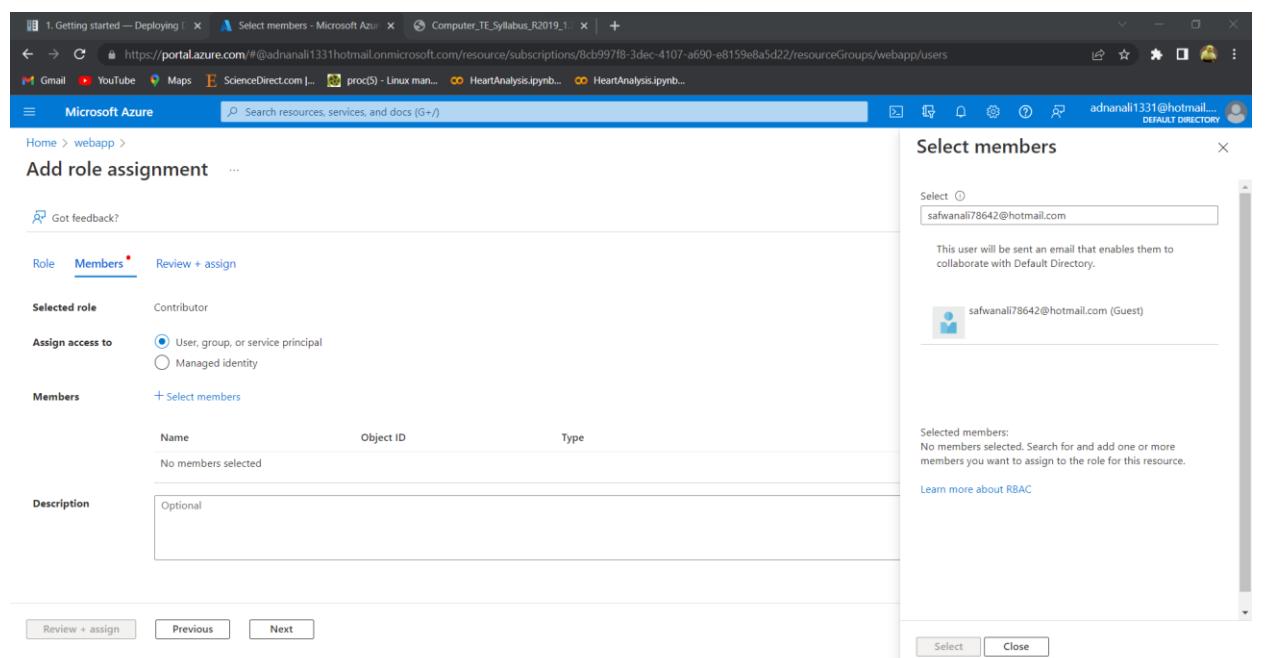
The scope of a role is to always think twice before using the subscription or management group as a scope. The scale of your subscription is going to come into consideration, as organizations with many smaller subscriptions that have very focused purposes may be able to use the subscription-level scope more frequently. On the flip side, some companies have broader

subscriptions, then use resource groups or tags to limit access, which means the scope is often smaller than a whole subscription.

Output:



The screenshot shows the Microsoft Azure Access control (IAM) interface for a resource group named 'webapp'. The left sidebar lists various management options like Overview, Activity log, and Access control (IAM). The main content area is titled 'Check access' and contains several sections: 'My access' (View my level of access to this resource), 'Check access' (Review the level of access a user, group, service principal, or managed identity has to this resource), 'Grant access to this resource' (Grant access to resources by assigning a role), 'View access to this resource' (View the role assignments that grant access to this and other resources), and 'View deny assignments' (View the role assignments that have been denied access to specific actions at this scope).



The screenshot shows the 'Add role assignment' interface. On the left, there are tabs for 'Role', 'Members*', and 'Review + assign'. The 'Members*' tab is selected, showing a 'Selected role' of 'Contributor' and an 'Assign access to' dropdown set to 'User, group, or service principal'. Below these are sections for 'Members' (with a '+ Select members' button) and 'Description' (with an optional text input). At the bottom are buttons for 'Review + assign', 'Previous', 'Next', 'Select' (in the dialog), and 'Close'.

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The screenshot shows the Microsoft Azure portal interface. At the top, there are several browser tabs and a navigation bar with links like 'Home', 'webapp', and 'Search resources, services, and docs (G+)'. The main content area is titled 'Add role assignment' under 'Review + assign'. It displays the following details:

- Role:** Contributor
- Scope:** /subscriptions/8cb997f8-3dec-4107-a690-e8159e8a5d22/resourceGroups/webapp
- Members:** Name: safwanali78642@hotmail.com, Object ID: a690-e8159e8a5d22, Type: User
- Description:** No description

At the bottom of the main page, there are 'Review + assign' and 'Previous' buttons. A modal window titled 'Invited user' is displayed, containing the following text and instructions:

safwanali78642@hotmail.com was added to the Default Directory directory as a guest.
safwanali78642@hotmail.com was also sent an invitation link they must accept.

To manually invite:

1. Right-click and copy this [invitation link](#).
(Do not click the link because it starts the invitation process.)
2. Send the invitation link to the invited user.

The screenshot shows the Microsoft Azure portal interface. At the top, there are several browser tabs and a navigation bar with links like 'Home', 'webapp', and 'Search resources, services, and docs (G+)'. The main content area is titled 'webapp | Access control (IAM)' under 'Resource group'. The left sidebar contains a navigation menu with items such as 'Overview', 'Activity log', 'Access control (IAM)', 'Tags', 'Resource visualizer', 'Events', 'Settings', 'Deployments', 'Security', 'Policies', 'Properties', 'Locks', 'Cost Management', 'Cost analysis', 'Cost alerts (preview)', and 'Budgets'. The 'Access control (IAM)' section is currently selected. The main pane displays the following information:

Number of role assignments for this subscription: 1

Name	Type	Role	Scope	Condition
safwanali78642 (Guest)	User	Contributor	This resource	None

Conclusion: We have successfully implemented Identity and Access Management (IAM) practices on Azure cloud.

Experiment 10

Aim: To study and implement Containerization using Docker.

Requirements: Docker

Theory:

What is Docker?

Docker is an open-source tool designed to create, deploy and run applications with ease by using containers. Docker fits in the deployment phase of the DevOps pipeline. DevOps can be defined as a culture that primarily focuses on improved collaboration, communication and integration between Development and Operations teams.

DevOps improves collaboration and productivity by:

- Automating infrastructure provision
- Automating workflows for building, testing and deploying applications
- Continuously measuring application performances

What is a Container?

A Container is a package which has everything except the Operating System to run the software application.

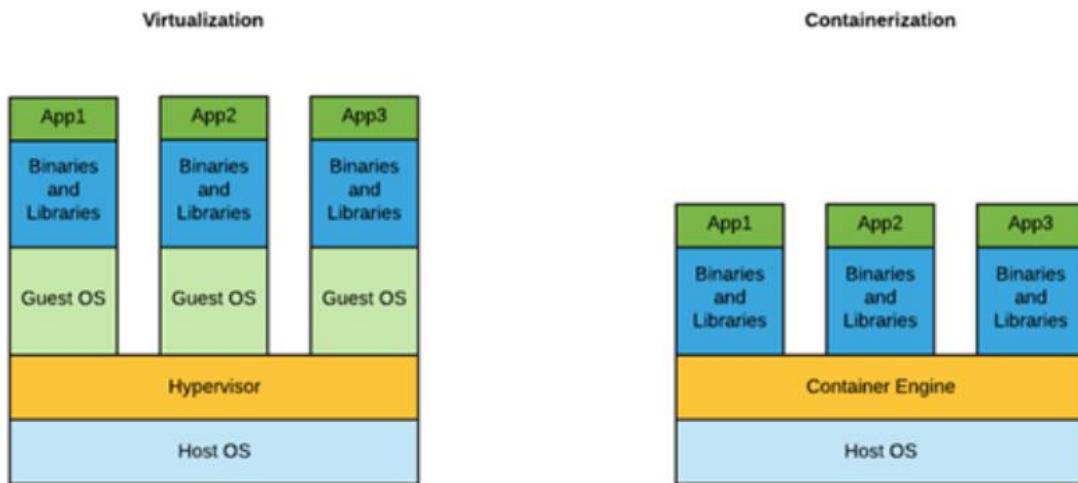
Containers versus Virtual Machines (VM):

Every Virtual Machine has its own Operating System which is the reason why the boot up process takes a longer time. Virtual Machines share the host's hardware with other VMs on the same host.

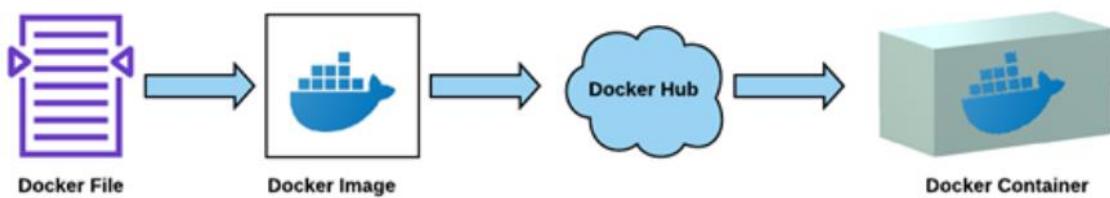
Containers, virtualize the Operating System – every container has its own CPU, memory, block I/O, network stack and uses the host's Operating System.

Containers have a short boot up process. They offer increased efficiency, better utilization and are portable.

Containers versus Virtual Machines (VM):



Docker Architecture:



Docker File:

A Docker file is a text document that contains all the commands a user could call on the command line to assemble an image. Every time, we are going to pick up a base image and build on top of that image.

For example, in the below Docker File, we are taking the base image “tomcat” and adding our web application war file.

From tomcat

ADD LeaveManagementApp.war /usr/local/tomcat/webapps

CMD "catalina.sh" "run"

EXPOSE 8080

Docker Image:

Docker Image is built from the Docker File. Docker Images are made up of multiple layers which are a read only file system A layer is created for each instruction in the Docker File and placed on top of previous layer

`docker build -t LeaveManagementImage:1.0`

Using the Docker build command, a Docker Image can be created.

Docker Hub:

Once the Docker Image is build, it can be stored or shared through Docker Hub. Just like GitHub, we can create an account in Docker Hub, create public or private repositories and maintain the Docker Images. Using the command below, we can set the Docker Hub configuration to our image:

`docker tag LeaveManagementImage:1.0 myrepo/LeaveManagementImage:1.0`

And then finally push the image to Docker Hub:

`docker push myrepo/LeaveManagementImage:1.0`

Now that the image is available on Docker Hub, you'll be able to run it anywhere. If you try to use it on a new machine that doesn't have it yet, the Docker client will automatically try and download it from Docker Hub.

Docker Containers: Docker Containers are sort of encapsulated environments in which you run applications. A Container is defined by the image and only have access to resources that are defined in the image.

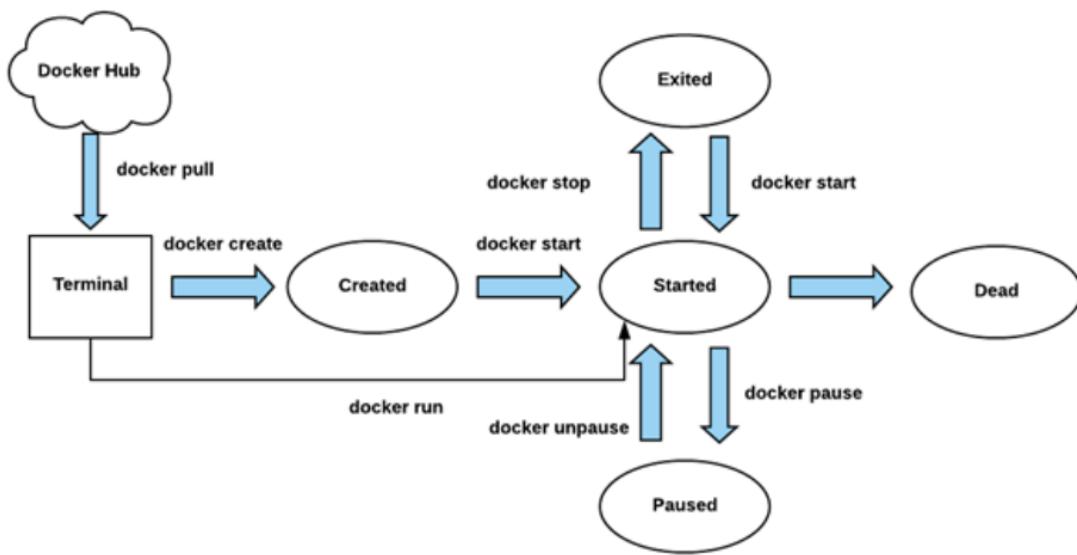
The machine where the container has to run should have a Docker client installed so that Docker commands can be executed. You can use the Docker pull command to get the image from Docker hub to local machine

docker pull LeaveManagementImage

Use Docker run command to fetch the image as well as create a new container from that image

docker run -itd LeaveManagementImage

Once the container is created or has started using the run command, the container can be stopped, paused or started based on the requirement.



Another good use case of Docker is when you want to experiment with different database servers in your development environment. Instead of installing multiple database servers on your computer, simply use Docker containers to run each database server.

Output:

Installing Docker:

```
Activities Terminal ▾ slowgamer@adnan-System-Product-Name:~$ sudo apt-get install \
> ca-certificates \
> curl \
> gnupg \
> lsb-release
Reading package lists... Done
Building dependency tree
Reading state information... Done
lsb-release is already the newest version (11.1.0ubuntu2).
ca-certificates is already the newest version (20210119-20.04.2).
curl is already the newest version (7.68.0-0ubuntu2.7).
gnupg is already the newest version (2.2.19-3ubuntu2.1).
The following packages were automatically installed and are no longer required:
libfwupdplugin1 linux-headers-5.13.0-37-generic
linux-hwe-5.13-headers-5.13.0-37 linux-image-5.13.0-37-generic
linux-modules-5.13.0-37-generic linux-modules-extra-5.13.0-37-generic
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 22 not upgraded.
[slowgamer@adnan-System-Product-Name:~]$ curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo gpg --dearmor -o /usr/share/keyrings/docker-archive-keyring.gpg
File '/usr/share/keyrings/docker-archive-keyring.gpg' exists. Overwrite? (y/N) y
[slowgamer@adnan-System-Product-Name:~]$ echo \
> $(lsb_release -cs) stable | sudo tee /etc/apt/sources.list.d/docker.list > /dev/null
slowgamer@adnan-System-Product-Name:~$ sudo apt-get update
Hit:1 https://download.docker.com/linux/ubuntu focal InRelease
Hit:2 http://in.archive.ubuntu.com/ubuntu focal InRelease
Hit:3 http://in.archive.ubuntu.com/ubuntu focal-updates InRelease
Hit:4 http://in.archive.ubuntu.com/ubuntu focal-backports InRelease
Hit:5 http://ppa.launchpad.net/swi-prolog/stable/ubuntu focal-security InRelease [114 kB]
Hit:7 https://dl.google.com/linux/chrome/deb stable InRelease
Fetched 114 kB in 1s (144 kB/s)
Reading package lists... Done
slowgamer@adnan-System-Product-Name:~$ sudo apt-get install docker-ce docker-ce-cli containerd.io
Reading package lists... Done
Building dependency tree
Reading state information... Done
containerd.io is already the newest version (1.5.11-1).
docker-ce-cli is already the newest version (5:20.10.14-3-0-ubuntu-focal).
docker-ce is already the newest version (5:20.10.14-3-0-ubuntu-focal).
The following packages were automatically installed and are no longer required:
libfwupdplugin1 linux-headers-5.13.0-37-generic
linux-hwe-5.13-headers-5.13.0-37 linux-image-5.13.0-37-generic
linux-modules-5.13.0-37-generic linux-modules-extra-5.13.0-37-generic
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 22 not upgraded.
slowgamer@adnan-System-Product-Name:~$ sudo apt-get update
Hit:1 https://download.docker.com/linux/ubuntu focal InRelease
Hit:2 http://in.archive.ubuntu.com/ubuntu focal InRelease
Hit:3 http://in.archive.ubuntu.com/ubuntu focal-updates InRelease
Hit:4 http://in.archive.ubuntu.com/ubuntu focal-backports InRelease
Hit:5 https://dl.google.com/linux/chrome/deb stable InRelease
Hit:6 http://ppa.launchpad.net/swi-prolog/stable/ubuntu focal InRelease
Get:7 http://security.ubuntu.com/ubuntu focal-security InRelease [114 kB]
Fetched 114 kB in 1s (144 kB/s)
Reading package lists... Done
```

```
Activities Terminal ▾ slowgamer@adnan-System-Product-Name:~$ sudo apt-get install docker-ce docker-ce-cli containerd.io
Reading package lists... Done
Building dependency tree
Reading state information... Done
containerd.io is already the newest version (1.5.11-1).
docker-ce-cli is already the newest version (5:20.10.14-3-0-ubuntu-focal).
docker-ce is already the newest version (5:20.10.14-3-0-ubuntu-focal).
The following packages were automatically installed and are no longer required:
libfwupdplugin1 linux-headers-5.13.0-37-generic
linux-hwe-5.13-headers-5.13.0-37 linux-image-5.13.0-37-generic
linux-modules-5.13.0-37-generic linux-modules-extra-5.13.0-37-generic
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 22 not upgraded.
slowgamer@adnan-System-Product-Name:~$ sudo apt-get update
Hit:1 https://download.docker.com/linux/ubuntu focal InRelease
Hit:2 http://in.archive.ubuntu.com/ubuntu focal InRelease
Hit:3 http://in.archive.ubuntu.com/ubuntu focal-updates InRelease
Hit:4 http://in.archive.ubuntu.com/ubuntu focal-backports InRelease
Hit:5 https://dl.google.com/linux/chrome/deb stable InRelease
Hit:6 http://ppa.launchpad.net/swi-prolog/stable/ubuntu focal InRelease
Get:7 http://security.ubuntu.com/ubuntu focal-security InRelease [114 kB]
Fetched 114 kB in 1s (144 kB/s)
Reading package lists... Done
slowgamer@adnan-System-Product-Name:~$ sudo docker run hello-world
Hello from Docker!
This message shows that your installation appears to be working correctly.

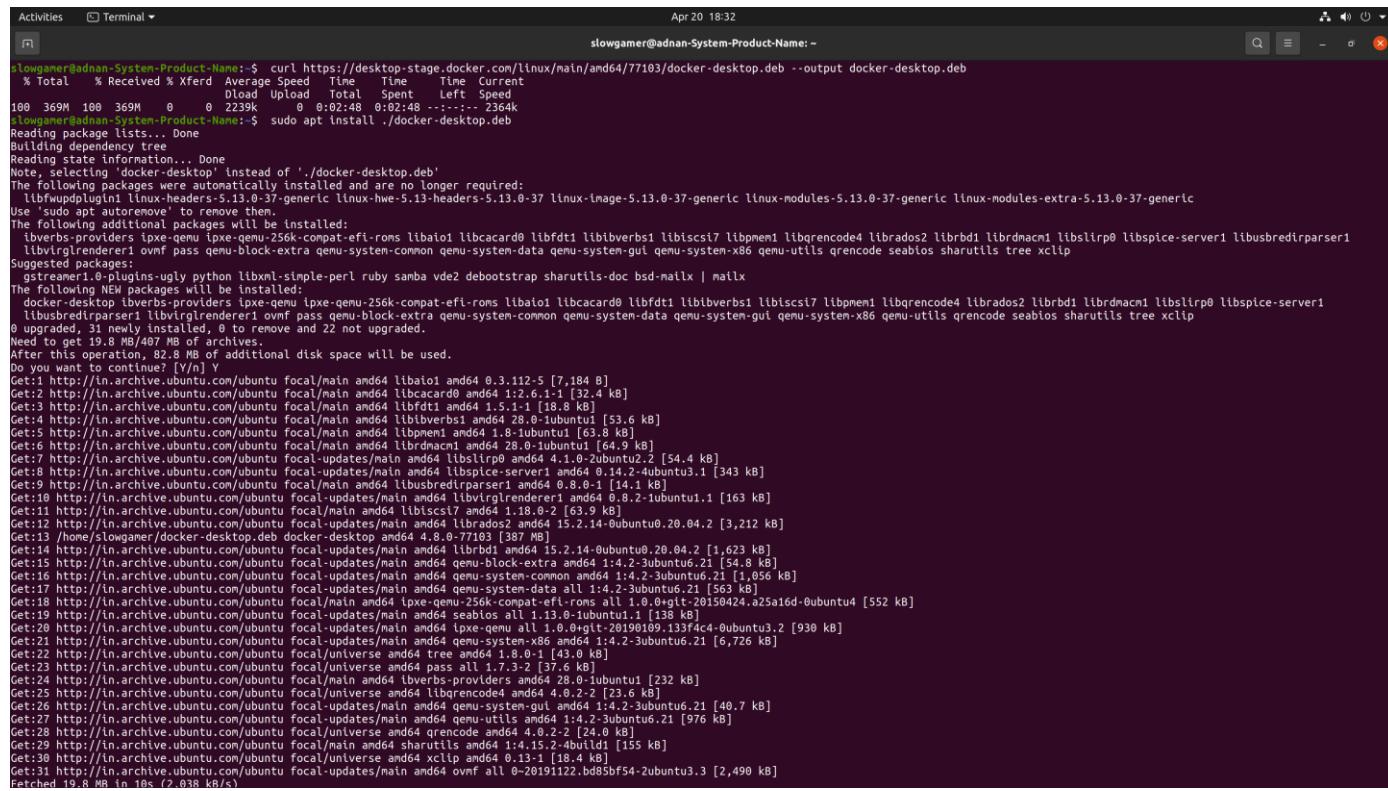
To generate this message, Docker took the following steps:
 1. The Docker client contacted the Docker daemon.
 2. The Docker daemon pulled the "hello-world" image from the Docker Hub.
    (amd64)
 3. The Docker daemon created a new container from that image which runs the
 executable that produces the output you are currently reading.
 4. The Docker daemon streamed that output to the Docker client, which sent it
 to your terminal.

To try something more ambitious, you can run an Ubuntu container with:
$ docker run -it ubuntu bash

Share images, automate workflows, and more with a free Docker ID:
https://hub.docker.com/

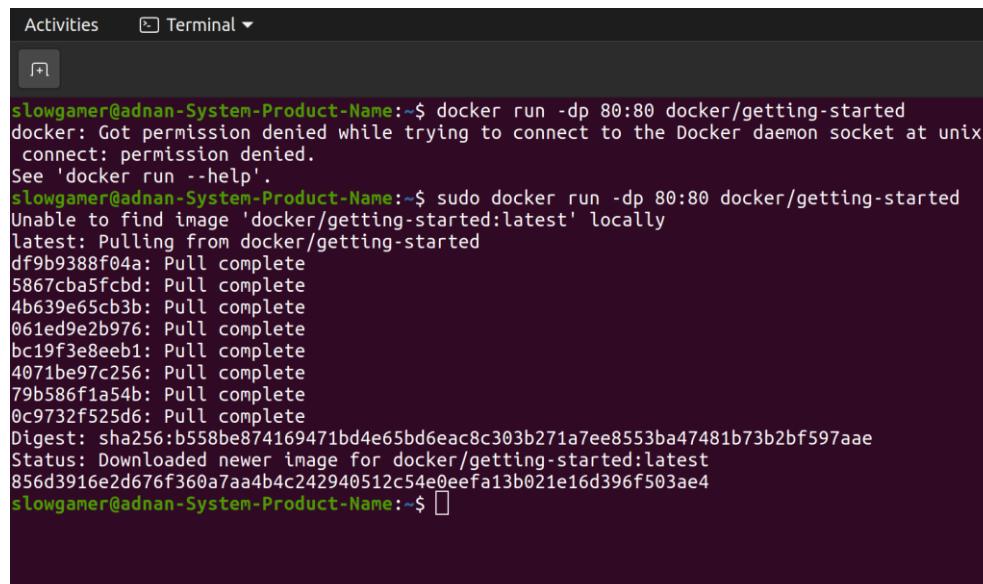
For more examples and ideas, visit:
https://docs.docker.com/get-started/
slowgamer@adnan-System-Product-Name:~$
```

Installing Docker GUI:



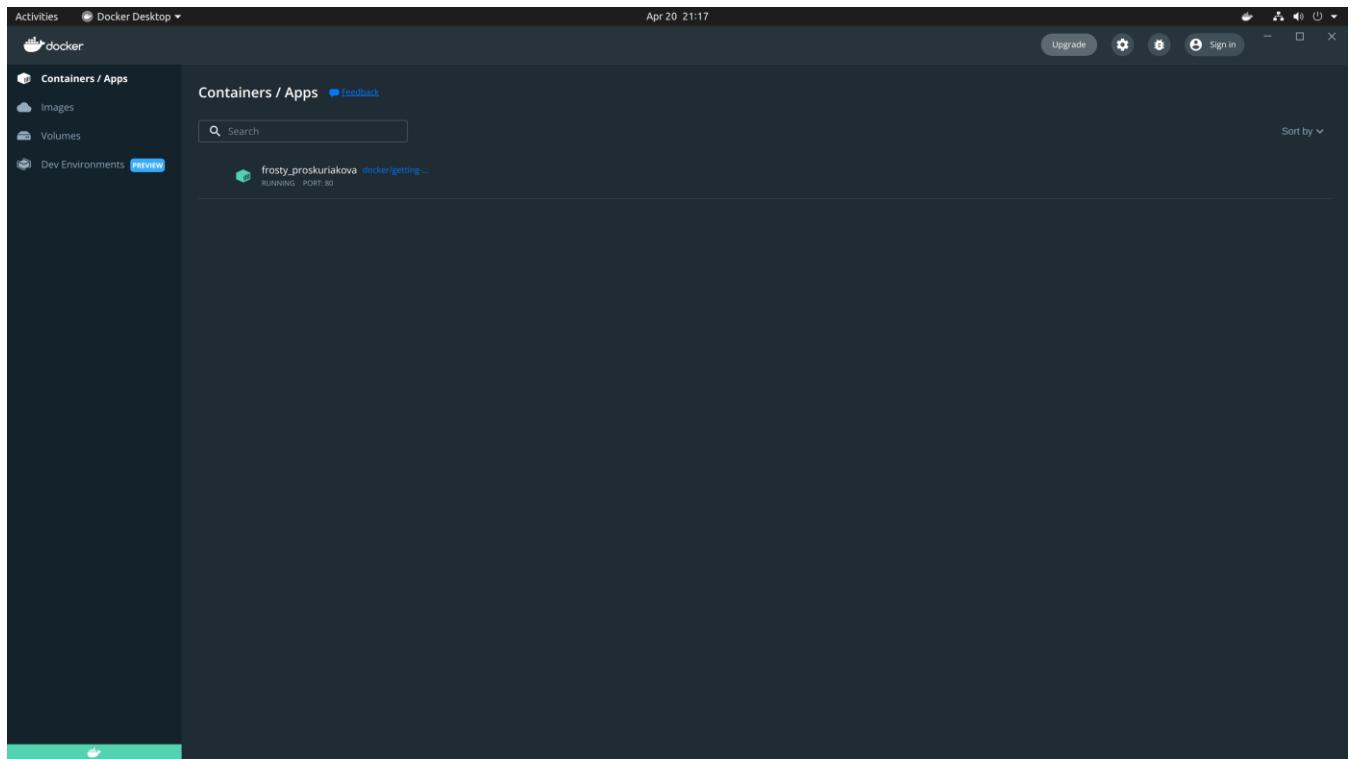
```
Activities Terminal ▾ slowgamer@adnan-System-Product-Name:~$ curl https://desktop-stage.docker.com/linux/main/amd64/77103/docker-desktop.deb --output docker-desktop.deb
slowgamer@adnan-System-Product-Name:~$ sudo apt install ./docker-desktop.deb
Reading package lists... Done
Building dependency tree
Reading state information... Done
Note, selecting 'docker-desktop' instead of './docker-desktop.deb'
The following packages were automatically installed and are no longer required:
  linux-image-5.13.0-37-generic linux-hwe-5.13-headers-5.13.0-37 linux-image-5.13.0-37-generic linux-modules-5.13.0-37-generic linux-modules-extra-5.13.0-37-generic
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  libverbs-providers ipxe-qemu ipxe-qemu-256k-compat-efi-roms libibcocard0 libibfdt1 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1 libusbredirparser1
  libvirlrenderer1 ovmf pass qemu-block-extra qemu-system-common qemu-system-data qemu-system-gui qemu-system-x86 qemu-utils qrencode seabios sharutils tree xclip
Suggested packages:
  gstreamer1.0-plugins-ugly python liblxml simple-perl ruby samba vde2 debootstrap sharutils-doc bsd-mailx | mailx
The following NEW packages will be installed:
  docker-desktop libverbs-providers ipxe-qemu ipxe-qemu-256k-compat-efi-roms libibcocard0 libibfdt1 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
  libusbredirparser1 libvirlrenderer1 ovmf pass qemu-block-extra qemu-system-common qemu-system-data qemu-system-gui qemu-system-x86 qemu-utils qrencode seabios sharutils tree xclip
0 upgraded, 31 newly installed, 0 to remove and 22 not upgraded.
Need to get 19.8 MB/407 MB of archives.
After this operation 82.8 MB of additional disk space will be used.
Do you want to continue? [Y/n]
Get: 1 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibcocard0 libibfdt1 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 2 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibfdt1 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 3 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 4 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 5 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 6 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 7 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 8 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 9 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 10 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 11 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 12 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 13 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 14 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 15 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 16 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 17 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 18 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 19 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 20 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 21 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 22 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 23 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 24 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 25 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 26 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 27 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 28 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 29 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 30 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Get: 31 http://in.archive.ubuntu.com/ubuntu focal/main amd64 libibverbs1 libiscsi7 libpmem1 libqrencode4 librados2 librbd1 librdmacm1 libslirp0 libspice-server1
Fetched 19.8 MB in 10s (2,038 kB/s)
```

Running first container:



```
Activities Terminal ▾ slowgamer@adnan-System-Product-Name:~$ docker run -dp 80:80 docker/getting-started
docker: Got permission denied while trying to connect to the Docker daemon socket at unix:/var/run/docker.sock.
See 'docker run --help'.
slowgamer@adnan-System-Product-Name:~$ sudo docker run -dp 80:80 docker/getting-started
Unable to find image 'docker/getting-started:latest' locally
latest: Pulling from docker/getting-started
df9b9388f04a: Pull complete
5867cba5fcbd: Pull complete
4b639e65cb3b: Pull complete
061ed9e2b976: Pull complete
bc19f3e8eeb1: Pull complete
4071be97c256: Pull complete
79b586f1a54b: Pull complete
0c732f525d6: Pull complete
Digest: sha256:b558be874169471bd4e65bd6eac8c303b271a7ee8553ba47481b73b2bf597aae
Status: Downloaded newer image for docker/getting-started:latest
856d3916e2d676f360a7aa4b4c242940512c54e0eefaa13b021e16d396f503ae4
slowgamer@adnan-System-Product-Name:~$
```

Container in Docker GUI:



Container log:

```
Activities Docker Desktop Apr 20 21:24
docker
Containers / Apps frosty_proskuriakova RUNNING
Images Volumes Dev Environments
Logs Inspect Stats
< docker-entrypoint.sh: /docker-entrypoint.d/ is not empty, will attempt to perform configuration
/docker-entrypoint.sh: Looking for shell scripts in /docker-entrypoint.d/
/docker-entrypoint.sh: Launching /docker-entrypoint.d/10-listen-on-ipv6-by-default.sh
10-listen-on-ipv6-by-default.sh: info: Enabled listen on IPv6 in /etc/nginx/conf.d/default.conf
/docker-entrypoint.sh: Launching /docker-entrypoint.d/30-tune-worker-processes.sh
/docker-entrypoint.sh: Configuration complete; ready for start up
2022/04/20 15:46:55 [notice] 1#1: using the "epoll" event method
2022/04/20 15:46:55 [notice] 1#1: nginx/1.21.6
2022/04/20 15:46:55 [notice] 1#1: built by gcc 10.3.1 20221027 (Alpine 10.3.1_gitt20221027)
2022/04/20 15:46:55 [notice] 1#1: 0$: Linux 5.10.104+ linuxkit
2022/04/20 15:46:55 [notice] 1#1: getrlimit(RLIMIT_NOFILE): 1040576:1048576
2022/04/20 15:46:55 [notice] 1#1: start worker processes
2022/04/20 15:46:55 [notice] 1#1: start worker process 33
2022/04/20 15:46:55 [notice] 1#1: start worker process 34
2022/04/20 15:46:55 [notice] 1#1: start worker process 35
2022/04/20 15:46:55 [notice] 1#1: start worker process 36
2022/04/20 15:46:55 [notice] 1#1: start worker process 37
2022/04/20 15:46:55 [notice] 1#1: start worker process 38
172.17.0.1 - - [29/Apr/2022:15:47:10 +0000] "GET /index.html" 200 8997 "-" "Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/100.0.4896.75 Safari/537.36" "-"
172.17.0.1 - - [29/Apr/2022:15:47:10 +0000] "GET /assets/styleSheets/application.adb849c.css HTTP/1.1" 200 76332 "http://localhost/" "Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/100.0.4896.75 Safari/537.36" "-"
172.17.0.1 - - [29/Apr/2022:15:47:10 +0000] "GET /assets/styleSheets/application-palette.e0b83c9d.css HTTP/1.1" 200 38773 "http://localhost/" "Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/100.0.4896.75 Safari/537.36" "-"
172.17.0.1 - - [29/Apr/2022:15:47:10 +0000] "GET /assets/javascripts/modernizr.8642ceb.js HTTP/1.1" 200 7296 "http://localhost/" "Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/100.0.4896.75 Safari/537.36" "-"
172.17.0.1 - - [29/Apr/2022:15:47:10 +0000] "GET /assets/fonts/modernir.8642ceb.js HTTP/1.1" 200 7296 "http://localhost/" "Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/100.0.4896.75 Safari/537.36" "-"
172.17.0.1 - - [29/Apr/2022:15:47:10 +0000] "GET /css/styles.css HTTP/1.1" 200 892 "http://localhost/" "Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/100.0.4896.75 Safari/537.36" "-"
172.17.0.1 - - [29/Apr/2022:15:47:10 +0000] "GET /assets/fonts/material-icons.css HTTP/1.1" 200 873 "http://localhost/" "Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/100.0.4896.75 Safari/537.36" "-"
172.17.0.1 - - [29/Apr/2022:15:47:10 +0000] "GET /assets/fonts/fontawesome-free-5.15.3-web.woff2 HTTP/1.1" 200 14833 "http://localhost/" "Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/100.0.4896.75 Safari/537.36" "-"
172.17.0.1 - - [29/Apr/2022:15:47:10 +0000] "GET /assets/fonts/fontawesome-free-5.15.3-web.woff HTTP/1.1" 200 38721 "http://localhost/tutorial/" "Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/100.0.4896.75 Safari/537.36" "-"
172.17.0.1 - - [29/Apr/2022:15:47:10 +0000] "GET /assets/javascripts/application.c1a9706.js HTTP/1.1" 200 79589 "http://localhost/tutorial/" "Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/100.0.4896.75 Safari/537.36" "-"
172.17.0.1 - - [29/Apr/2022:15:47:10 +0000] "GET /tutorial/tutorial-index.html HTTP/1.1" 200 199800 "http://localhost/tutorial/" "Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/100.0.4896.75 Safari/537.36" "-"
172.17.0.1 - - [29/Apr/2022:15:47:10 +0000] "GET /images/docker-labs-logo.svg HTTP/1.1" 200 6469 "http://localhost/tutorial/" "Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/100.0.4896.75 Safari/537.36" "-"
172.17.0.1 - - [29/Apr/2022:15:47:10 +0000] "GET /fonts/hinted-Geomanist-Bold.eot HTTP/1.1" 200 79679568 "http://localhost/tutorial/" "Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/100.0.4896.75 Safari/537.36" "-"
```

Container app running on port 80:

The command you just ran

```
docker run -d -p 80:80 docker/getting-started
```

Pro tip

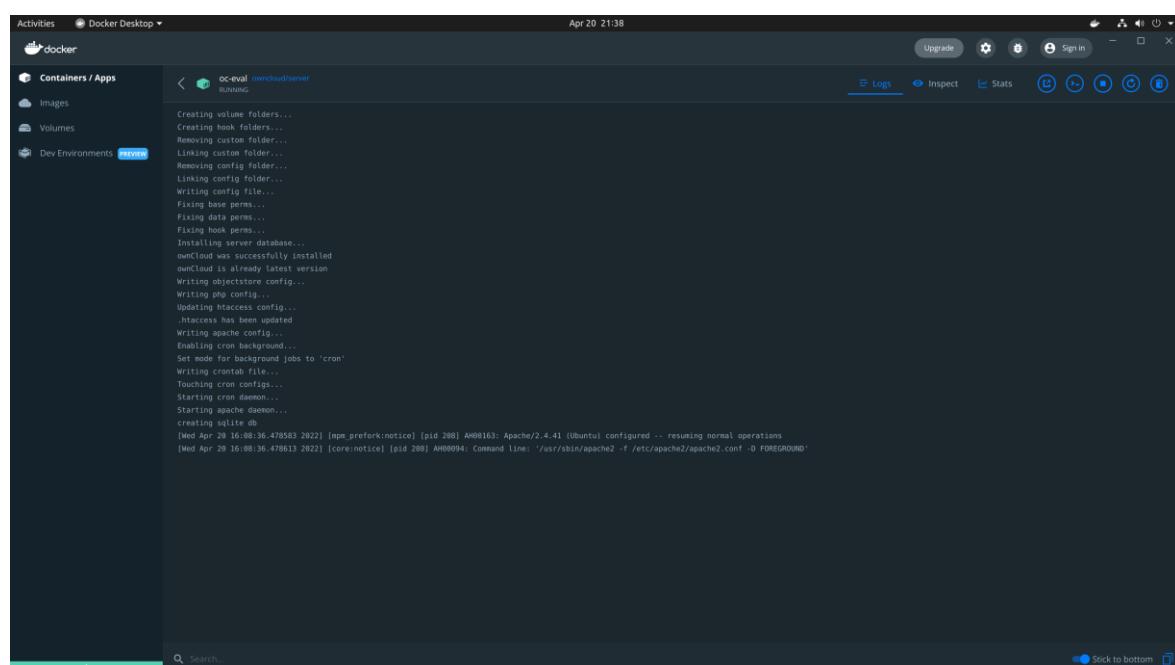
You can combine single character flags to shorten the full command. As an example, the command above could be written as:

```
docker run -dp 80:80 docker/getting-started
```

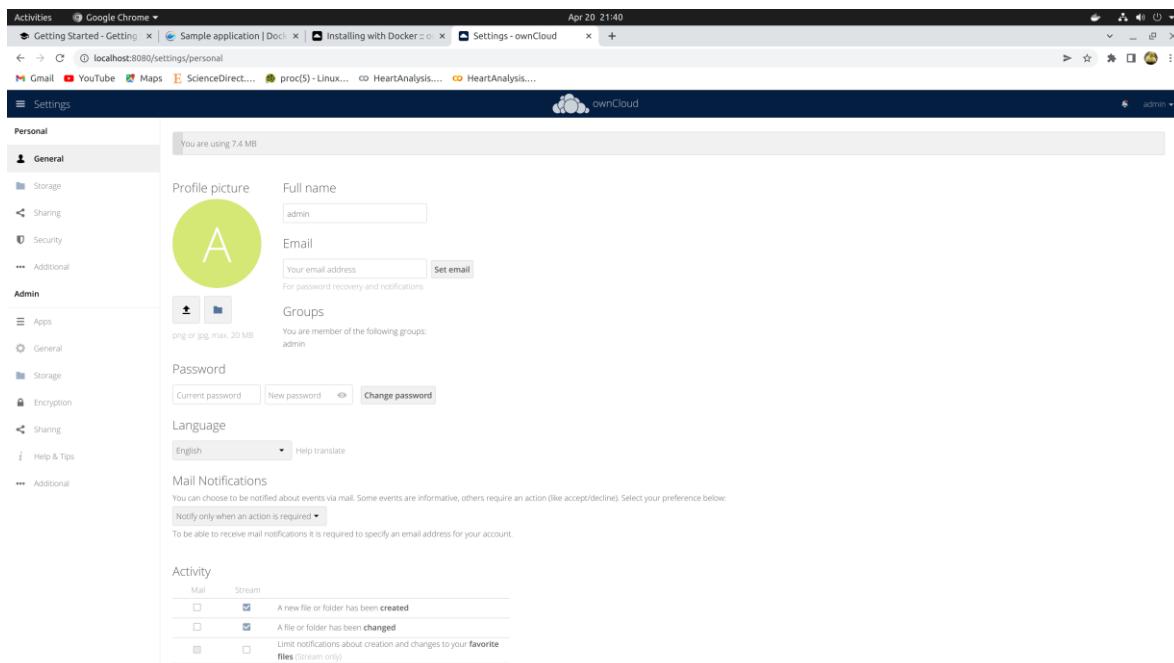
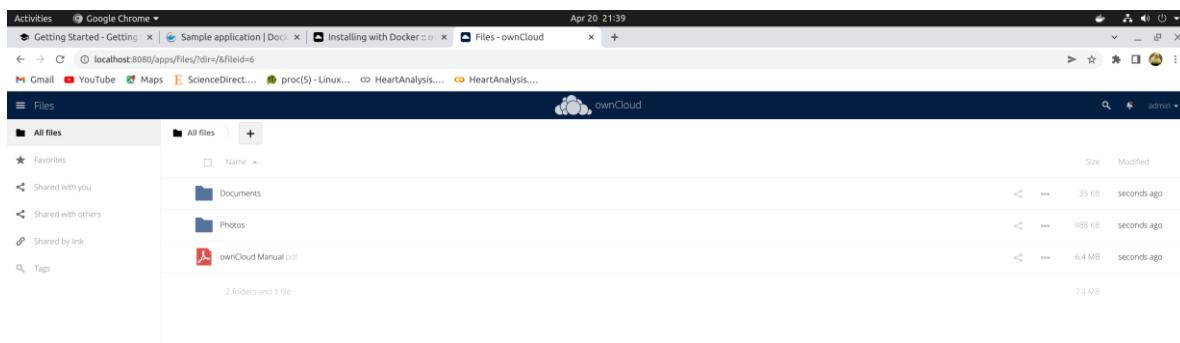
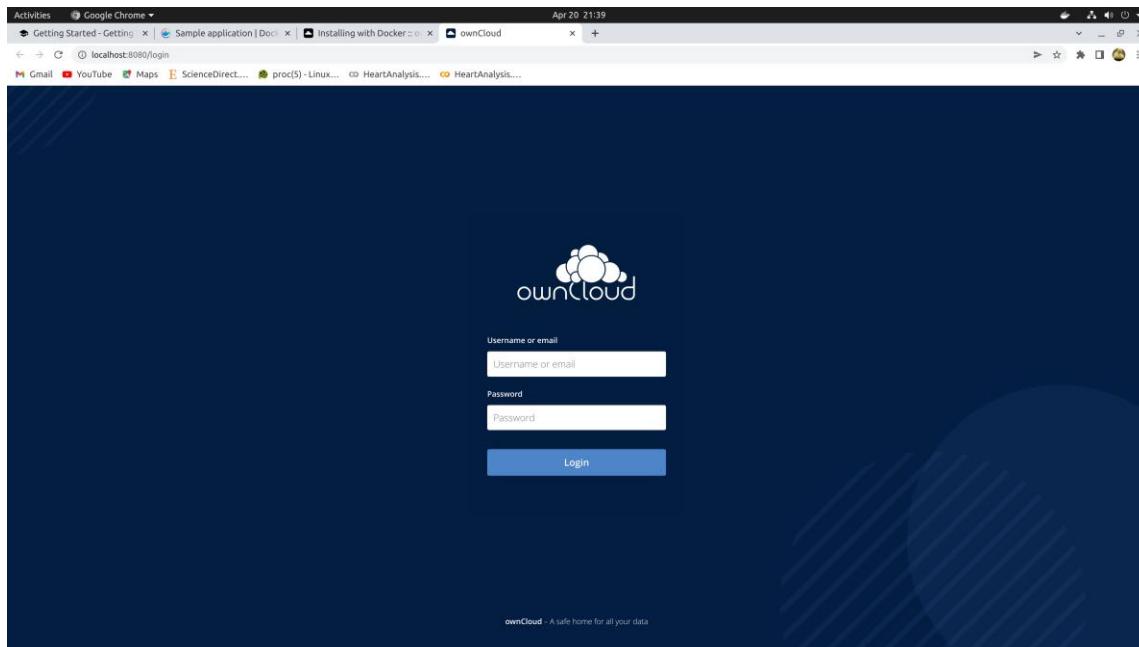
Installing and running container:

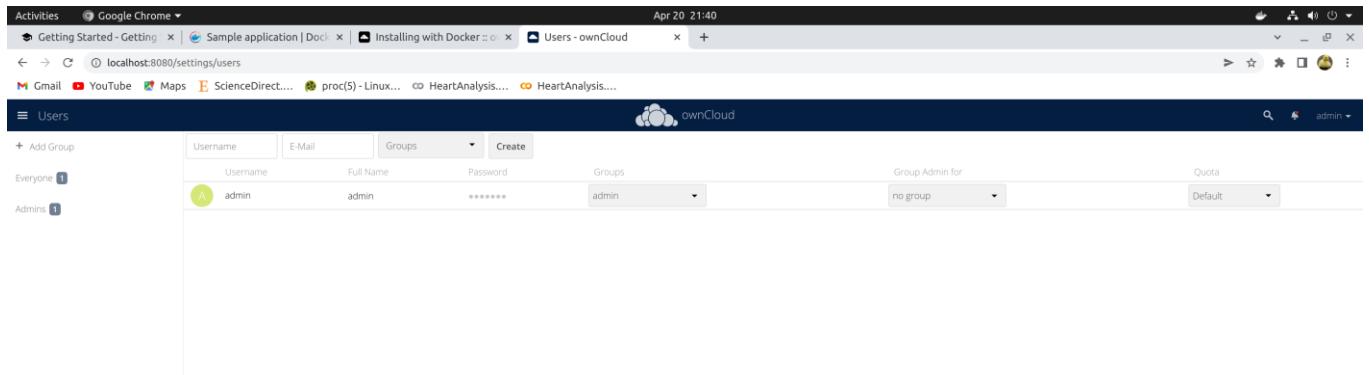
```
slowgamer@adnan-System-Product-Name:~$ docker run --rm --name oc-eval -d -e OWNCLLOUD_DOMAIN=localhost:8080 -p8080:8080 owncloud/server
cdd96fe0f5978dfbeeb57ea9f699082eee146759e70e701c5652882e2b3c6613
slowgamer@adnan-System-Product-Name:~$
```

Container log in GUI:



Container app running on port 8080:





Some Docker commands to list container and to list and remove Images:

```
slowgamer@adnan-System-Product-Name:~$ docker ps -a
CONTAINER ID IMAGE COMMAND CREATED STATUS PORTS NAMES
cdd96fe0f597 owncloud/server "/usr/bin/entrypoint..." 2 minutes ago Up 2 minutes 0.0.0.0:8880->8880/tcp oc-eval
ad42649cc1a1 docker/getting-started "/docker-entrypoint..." 40 minutes ago Exited (255) 4 minutes ago 0.0.0.0:80->80/tcp frosty_proskuriakova
slowgamer@adnan-System-Product-Name:~$ docker images
REPOSITORY TAG IMAGE ID CREATED SIZE
owncloud/server latest b08aa7e7e9048 8 hours ago 1.17GB
docker/getting-started latest cb90f98fd791 5 days ago 28.8MB
slowgamer@adnan-System-Product-Name:~$ docker rmi cb90f98fd791
Command 'dock' not found, did you mean:
  command 'dbck' from deb lyskom-server (2.1.2-16)
  command 'doc' from deb python3-docb (0.8.0-4)
  command 'duck' from deb duck (0.13)
Try: sudo apt install <Deb name>
slowgamer@adnan-System-Product-Name:~$ docker rmi cb90f98fd791
Error response from daemon: conflict: unable to delete cb90f98fd791 (must be forced) - image is being used by stopped container ad42649cc1a1
slowgamer@adnan-System-Product-Name:~$ docker rm -f cb90f98fd791
Untagged: docker/getting-started:latest
Untagged: docker/getting-started@sha256:b558be74169471bda4e65bd6eac8c383b271a7ee8553ba47481b73b2bf597aae
Deleted: sha256:cb90f98fd791dd49f09901cefb224564684d76b093825ea78e0fb7bb8fb3403
slowgamer@adnan-System-Product-Name:~$ docker ps -a
CONTAINER ID IMAGE COMMAND CREATED STATUS PORTS NAMES
cdd96fe0f597 owncloud/server "/usr/bin/entrypoint..." 4 minutes ago Up 4 minutes 0.0.0.0:8880->8880/tcp oc-eval
ad42649cc1a1 cb90f98fd791 "/docker-entrypoint..." 43 minutes ago Exited (255) 6 minutes ago 0.0.0.0:80->80/tcp frosty_proskuriakova
slowgamer@adnan-System-Product-Name:~$ docker image prune -a
WARNING! This will remove all images without at least one container associated to them.
Are you sure you want to continue? [y/N] y
Total reclaimed space: 0B
slowgamer@adnan-System-Product-Name:~$ docker ps -a
CONTAINER ID IMAGE COMMAND CREATED STATUS PORTS NAMES
cdd96fe0f597 owncloud/server "/usr/bin/entrypoint..." 5 minutes ago Up 5 minutes 0.0.0.0:8880->8880/tcp oc-eval
ad42649cc1a1 cb90f98fd791 "/docker-entrypoint..." 43 minutes ago Exited (255) 7 minutes ago 0.0.0.0:80->80/tcp frosty_proskuriakova
slowgamer@adnan-System-Product-Name:~$ docker images
REPOSITORY TAG IMAGE ID CREATED SIZE
owncloud/server latest b08aa7e7e9048 8 hours ago 1.17GB
slowgamer@adnan-System-Product-Name:~$
```

Conclusion: We have successfully implemented Containerization using Docker.

Assignment no. 1

Q.1) Recent trends in cloud computing and related technologies.

1. Edge computing

Edge computing is an alternative approach to computing and storing data in the cloud environment. It is an emerging cloud trend that involves building localized data centers for computation and storage at or near where it's being gathered, rather than on a central location that might be thousands of miles away.

This kind of decentralized computing infrastructure helps in decreasing latency issues and increasing application performance. Since the data and resources are closer to the end user's device, it can be processed locally thus allowing organizations to save money as well. Edge is commonly misunderstood as a threat to cloud computing even though the relationship between the two is complementary.

Edge computing is used for time-sensitive data, whereas cloud computing processes data that is not time-driven. The edge computing market is currently one of the most hyped topics and it's only set to expand next year. It offers clear advantages in terms of an increase in the speed of data processing, minimal to now latency, great connectivity, security, and privacy support, and decreased volumes of transmitted data. It will be an amazing enabler for companies interested in operational efficiency.

2. Serverless functions

Serverless computing has been around for a few years now, a long time by cloud standards. It is now being given more importance by all the bigwigs of the cloud computing world. It promises a legitimate pay-as-you-go model that lets organizations pay only for the services that

are actually used. This way, the infrastructure can scale invisibly depending on the requirements of an application without any significant capital investment.

Serverless computing also helps eliminate the risk of back-end failures and provides safe sandboxes for organizations to implement their code. Serverless within cloud computing will have a big part to play in creating new user experiences in the coming years.

3. Kubernetes enabling blockchain

Blockchain is an revolutionary technology that provides a tamper-evident, shared digital ledger that records data in a public or private network. It maintains accurate records of transactions without relying on a central authority.

Kubernetes is an open-source container orchestration platform that allows organizations to automatically scale, deploy and manage containerized infrastructure. Current public blockchain infrastructure does not scale in terms of big data storage and management, which makes it difficult to incorporate blockchain systems for big data applications. But the use of Kubernetes for blockchain helps to rapidly scale environments and ensure high availability by always having multiple containers running for key services.

Blockchain on Kubernetes enables service interoperability between organizations that are architected differently. The other advantages of blockchain on Kubernetes are simplified deployments and upgradeability. Deploying blockchain networks and its component parts via Kubernetes clusters might be the standard of adoption in a year or two given that they solve two major issues blockchain faces – its inherent complexity and integration into the existing infrastructure.

4. AI in cloud computing

Cloud computing and Artificial Intelligence have a mutual relationship where the latter powers cloud computing and the former plays a key role in the deliverance of AI services. Cloud services also help in democratizing AI by opening it up to a broader consumer base. It gives smaller businesses access to AI-enhanced business services and helps them access advanced machine learning functions.

Combining AI with cloud services enables organizations to get the most out of both applications in a cost-effective way. AI helps the cloud manage data and gain insights whereas the cloud provides a constant data backup and recovery in a virtual environment. The development and evolution of cloud and AI are interwoven and this will only become increasingly true during 2022.

5. The rise of cloud-gaming

Cloud gaming is an emerging technology that allows users to stream a virtually unlimited option of games for a flat monthly fee. It lets one play on any desktop, laptop, or smartphone without the need for an expensive console.

Leveraging cloud technology in the gaming industry fuels the demand and engagement of multiplayers for different games and removes existing platform barriers. Cloud gaming also eliminates the need for users to have storage space, any specialized hardware, and all the piracy problems, all of which translates to lower overall cost and sustainability.

Some major players in the cloud gaming space at the moment are Microsoft, Google, Amazon, Apple, Samsung, Sony, and Nvidia. Although game streaming technology is not yet as powerful as it could be, its transition to the cloud will ensure that the future of cloud gaming

constantly evolves. It will also bring about a future where the cloud is not only the source of the game but also the platform of choice for players.

6. Hybrid cloud and multi-cloud infrastructure

Hybrid services are not about compromise between approaches, instead, they are about combining their strengths. Data that needs quick and frequent access can be kept on public servers and more sensitive data can be kept on private servers with monitored access. A well-integrated and balanced hybrid strategy gives businesses the best of both worlds.

Most organizations have grown past the initial phase of migrating some of their workloads from on-prem to a single cloud vendor, and are looking to indulge in the whole experience. This leads them to deal with multi-cloud environments where multiple services from several different suppliers are used. The multi-cloud model helps companies choose different cloud offerings best suited to their individual application environments, business requirements, and availability needs. Going forward, more organizations will need to develop entirely cloud-native applications with almost no architectural dependence on any specific cloud provider.

Although there has already been significant adoption of hybrid-cloud and multi-cloud strategies as the standard in large organizations, 2022 will witness more business leaders and enterprises realize the advantages of these models and embrace them to enjoy elasticity and agility in the cloud.

Assignment No. 2

Q.2) Comparative study of different computing technologies [Parallel, Distributed, Cluster, Grid, Quantum]

1. High-Performance Computing

In high-performance computing systems, a pool of processors (processor machines or central processing units [CPUs]) connected (networked) with other resources like memory, storage, and input and output devices, and the deployed software is enabled to run in the entire system of connected components.

The processor machines can be of homogeneous or heterogeneous type. The legacy meaning of high-performance computing (HPC) is the supercomputers; however, it is not true in present-day computing scenarios. Therefore, HPC can also be attributed to mean the other computing paradigms that are discussed in the forthcoming sections, as it is a common name for all these computing systems.

Thus, examples of HPC include a small cluster of desktop computers or personal computers (PCs) to the fastest supercomputers. HPC systems are normally found in those applications where it is required to use or solve scientific problems. Most of the time, the challenge in working with these kinds of problems is to perform suitable simulation study, and this can be accomplished by HPC without any difficulty.

Scientific examples such as protein folding in molecular biology and studies on developing models and applications based on nuclear fusion are worth noting as potential applications for HPC.

2. Parallel Computing

Parallel computing is also one of the facets of HPC. Here, a set of processors work cooperatively to solve a computational problem. These processor machines or CPUs are mostly of homogeneous type. Therefore, this definition is the same as that of HPC and is broad enough to include supercomputers that have hundreds or thousands of processors interconnected with other resources.

One can distinguish between conventional (also known as serial or sequential or Von Neumann) computers and parallel computers in the way the applications are executed.

In serial or sequential computers, the following apply:

- It runs on a single computer/processor machine having a single CPU.
- A problem is broken down into a discrete series of instructions. .
- Instructions are executed one after another.

In parallel computing, since there is simultaneous use of multiple processor machines, the following apply:

- It is run using multiple processors (multiple CPUs).
- A problem is broken down into discrete parts that can be solved concurrently.
- Each part is further broken down into a series of instructions.
- Instructions from each part are executed simultaneously on different processors.
- An overall control/coordination mechanism is employed

3. Distributed Computing

Distributed computing is also a computing system that consists of multiple computers or processor machines connected through a network, which can be homogeneous or heterogeneous, but run as a single system. The connectivity can be such that the CPUs in a

distributed system can be physically close together and connected by a local network, or they can be geographically distant and connected by a wide area network.

The heterogeneity in a distributed system supports any number of possible configurations in the processor machines, such as mainframes, PCs, workstations, and minicomputers. The goal of distributed computing is to make such a network work as a single computer. Distributed computing systems are advantageous over centralized systems, because there is a support for the following characteristic features:

1. Scalability: It is the ability of the system to be easily expanded by adding more machines as needed, and vice versa, without affecting the existing setup.
2. Redundancy or replication: Here, several machines can provide the same services, so that even if one is unavailable (or failed), work does not stop because other similar computing supports will be available.

4. Cluster Computing

A cluster computing system consists of a set of the same or similar type of processor machines connected using a dedicated network infrastructure. All processor machines share resources such as a common home directory and have a software such as a message passing interface (MPI) implementation installed to allow programs to be run across all nodes simultaneously. This is also a kind of HPC category. The individual computers in a cluster can be referred to as nodes.

The reason to realize a cluster as HPC is due to the fact that the individual nodes can work together to solve a problem larger than any computer can easily solve. And, the nodes need to communicate with one another in order to work cooperatively and meaningfully together to solve the problem in hand.

If we have processor machines of heterogeneous types in a cluster, this kind of clusters become a subtype and still mostly are in the experimental or research stage.

5. Grid Computing

The computing resources in most of the organizations are underutilized but are necessary for certain operations. The idea of grid computing is to make use of such non utilized computing power by the needy organizations, and thereby the return on investment (ROI) on computing investments can be increased.

Thus, grid computing is a network of computing or processor machines managed with a kind of software such as middleware, in order to access and use the resources remotely. The managing activity of grid resources through the middleware is called grid services. Grid services provide access control, security, access to data including digital libraries and databases, and access to large-scale interactive and long-term storage facilities.

Grid computing is more popular due to the following reasons:

- Its ability to make use of unused computing power, and thus, it is a cost effective solution (reducing investments, only recurring costs)
- As a way to solve problems in line with any HPC-based application
- Enables heterogeneous resources of computers to work cooperatively and collaboratively to solve a scientific problem.

6 Cloud Computing

The computing trend moved toward cloud from the concept of grid computing, particularly when large computing resources are required to solve a single problem, using the ideas of computing power as a utility and other allied concepts.

However, the potential difference between grid and cloud is that grid computing supports leveraging several computers in parallel to solve a particular application, while cloud computing supports leveraging multiple resources, including computing resources, to deliver a unified service to the end user. In cloud computing, the IT and business resources, such as servers, storage, network, applications, and processes, can be dynamically provisioned to the user needs and workload.