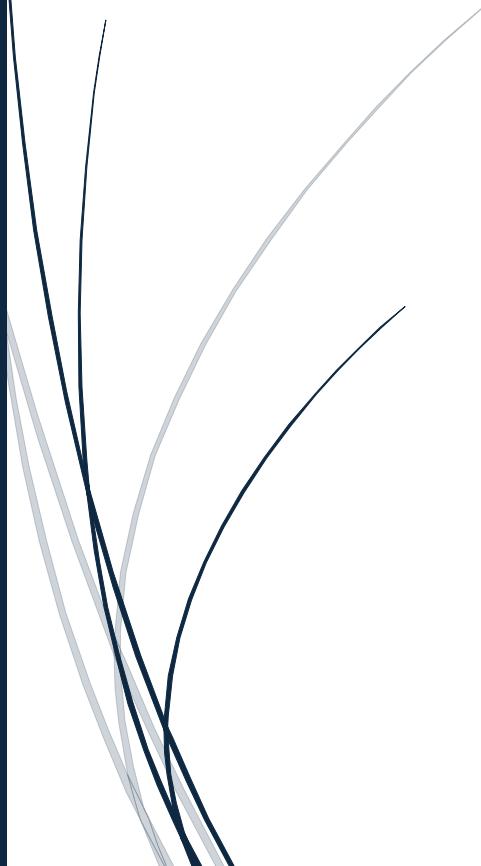


5/8/2025

Cloud and On-Premises Harmony

The Proxmox, Kubernetes,
Ansible, and OCI Journey



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Introduction

The hybrid cloud project integrates on-premises infrastructure with public cloud resources to create a scalable, efficient environment for managing and deploying applications. It combines virtualization, configuration management, and containerized technologies to ensure seamless interaction between private and public cloud components.

Objectives

The main objectives of this project are:

1. Configure a Hybrid Cloud Environment:
 - o Set up both on-premises private cloud systems using Proxmox and Oracle Cloud Infrastructure (OCI) public cloud resources.
2. Automate Configuration Management:
 - o Use Ansible to provision and manage systems uniformly across the hybrid cloud environment.
3. Deploy and Document Key Services:
 - o Deploy containerized web applications and document the configurations, performance data, and architecture design.

Scope

This project includes five systems:

1. Ansible Control Node: Hosted on the Proxmox server to manage configurations.
2. Windows Server Core VM: Provides web services via IIS in the private cloud.
3. Linux Web Server Container: Hosts local web services using Apache.
4. Linux Kubernetes VM: Serves as a staging/testing area for deploying apps with Kubernetes (k3s).
5. OCI Linux VM: Provides public web services hosted in Oracle Cloud Infrastructure.

This comprehensive environment ensures smooth development workflows, robust backup strategies, and scalable production deployments.

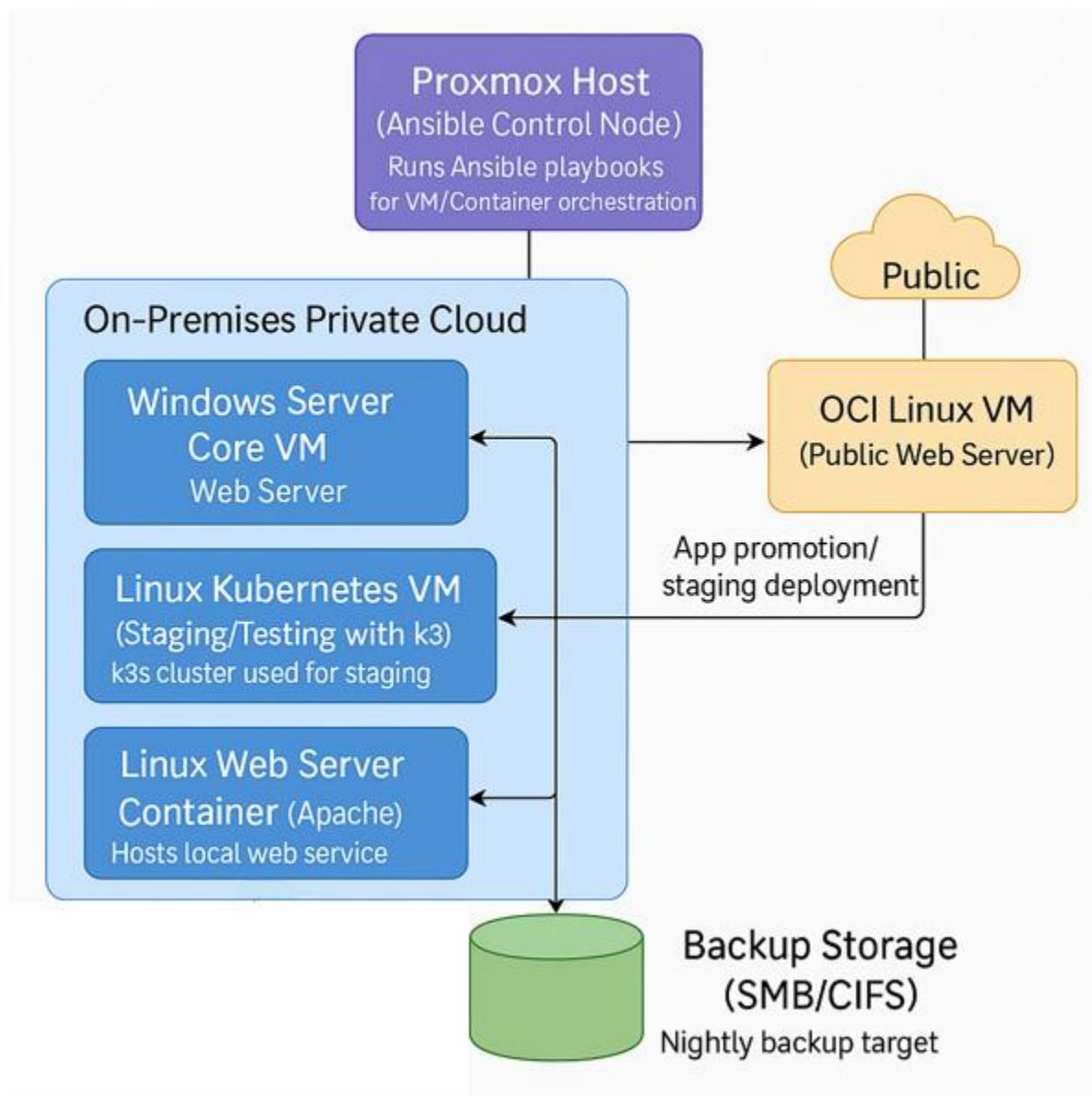
Project Overview

By leveraging technologies like Proxmox, Ansible, Kubernetes, and OCI, the project demonstrates how a hybrid cloud can be deployed to balance control and scalability while providing a practical solution for both private and public hosting needs. The final deliverable includes detailed documentation of the architecture, configuration, and performance metrics, presented in an easy-to-follow report format.

Hybrid Cloud Architecture Design

Introduction

This diagram represents the hybrid cloud architecture designed for the project, showcasing the interaction between on-premises systems and the Oracle Cloud Infrastructure (OCI). The architecture is structured to optimize functionality across both private and public environments, ensuring seamless integration for provisioning, configuration management, and automated deployment processes.



Hybrid Cloud Architecture Diagram

Architecture Components

The diagram illustrates the following components:

1. Proxmox Host (Ansible Control Node):

- Acts as the central node for virtualization and configuration management using Ansible.
- Hosts the private cloud systems, including VMs and containers.

2. Private Cloud Systems:

- Windows Server Core VM:
 - Configured with IIS to provide internal web services.
- Linux Web Server Container:
 - Runs Apache for hosting local web content within the private cloud.
- Linux Kubernetes VM:
 - Acts as a staging/testing environment for deploying a sample web app using Kubernetes (k3s).

3. Public Cloud Component:

- OCI Linux VM:
 - Deployed in Oracle Cloud Infrastructure to host public-facing web services, allowing scalability and accessibility.

4. Backup Storage:

- SMB/CIFS storage integrated with Proxmox to provide backups for all private cloud systems.
- Ensures data security and availability in case of system failures.

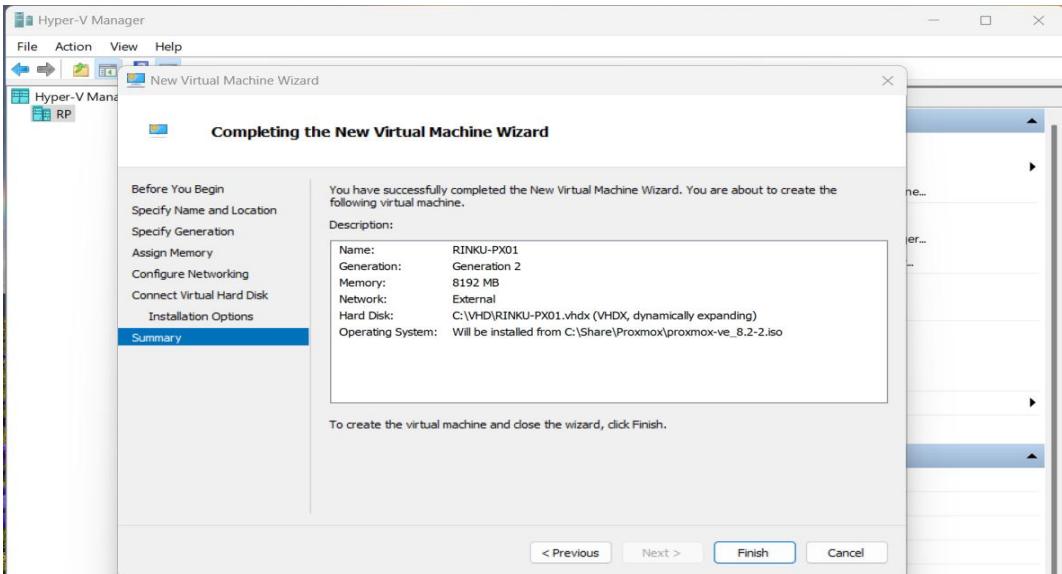
Systems Overview

System Name	Role/Description	IP Address	User	Memory	Core
RINKU-PVE01	Proxmox Host	192.168.2.230	Root	8 GB	8
RINKU-WEB01	Ubuntu 22.04 + Apache	192.168.2.233	Ansible	1 GB	2
RINKU-K8S01	Ubuntu 24.04 + K3s	192.168.2.236	Ansible	3 GB	2
RINKU-WIN01	Windows Server 2019 + IIS, Python, Chocolatey	192.168.2.232	Ansible	4 GB	2
RINKU-OCI01	Oracle Cloud Linux VM/ Canonical Ubuntu 20.04 Minimal	Public IP 129.153.49.245 Private IP 10.0.0.58	Ubuntu	1 GB	1
Backup_Storage	SMB/CIFS Backup Storage		Backup_user	Not Applicable	Not Applicable

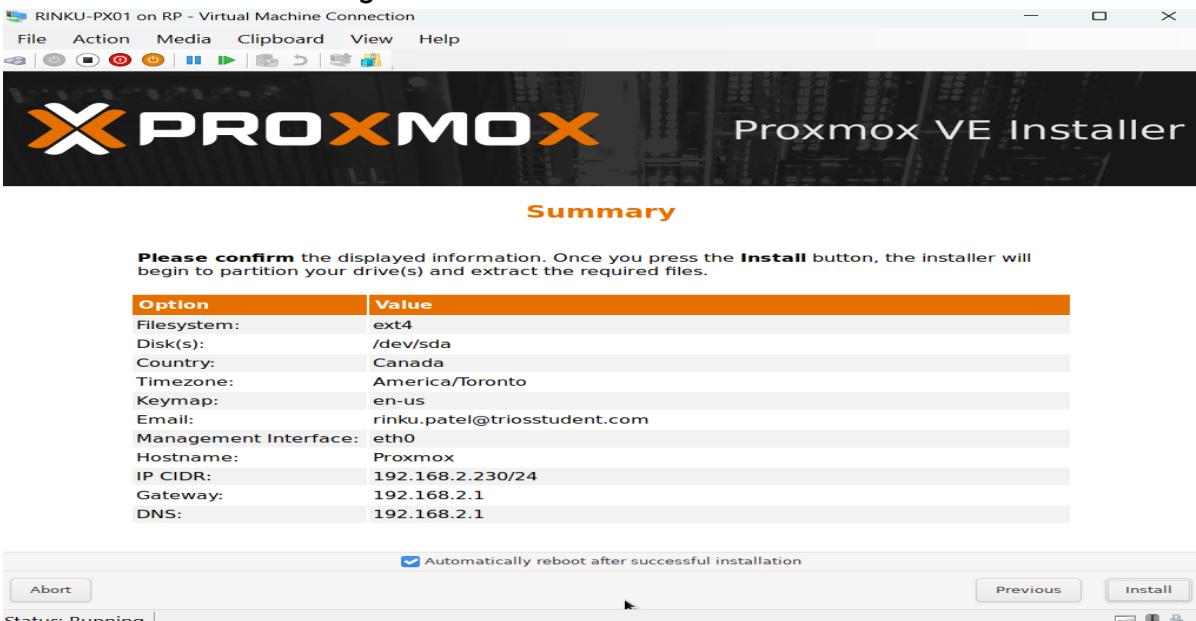
Proxmox Host (Ansible Control Node):

RINKU-PVE01	Proxmox Host/ Proxmox.rinkupatel.net	192.168.2.230	Root	8 GB Memory	8 Core
-------------	---	---------------	------	-------------	--------

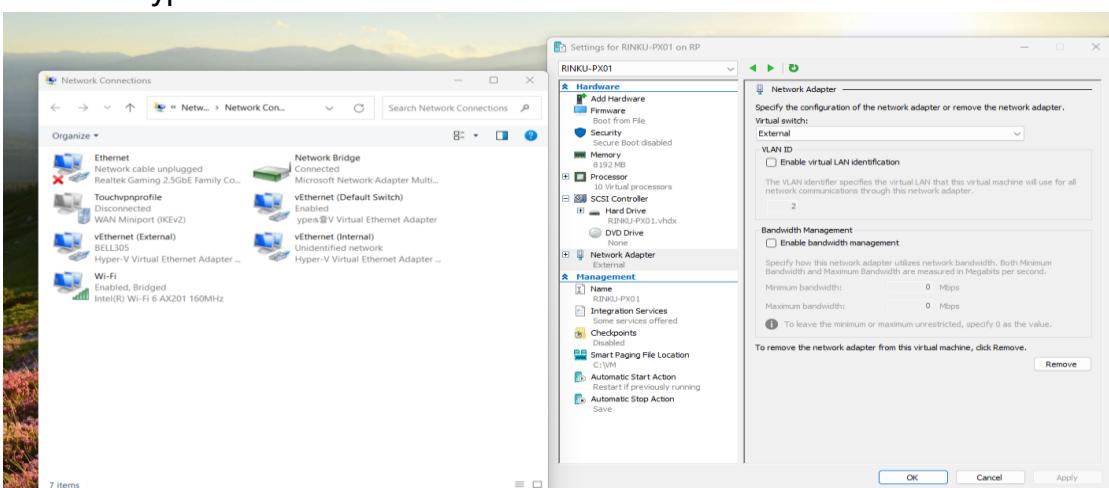
Proxmox Hyper V Installation Configuration



Proxmox Installation Configuration



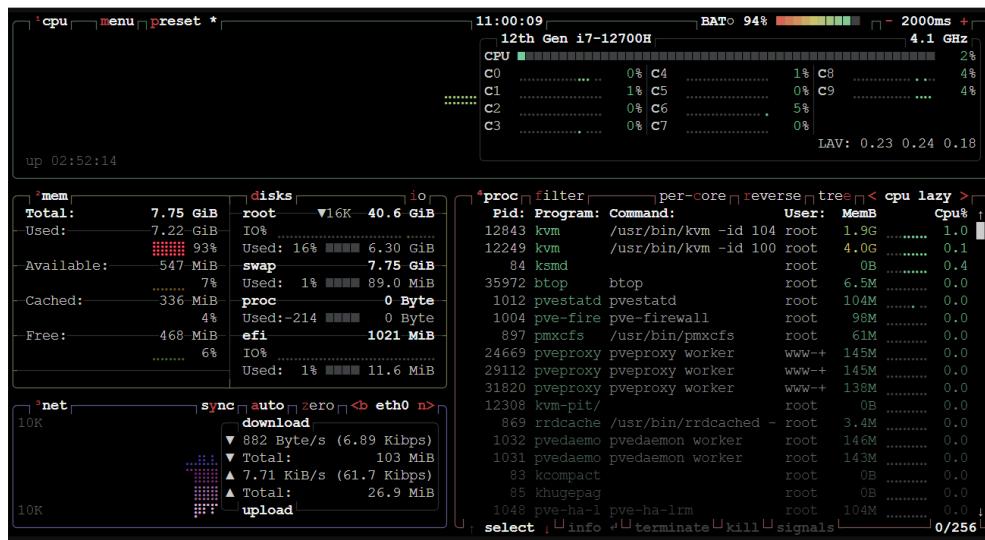
Proxmox Hyper V Network External Switch



Proxmox Updates – All updates are performed before installing Ansible

Proxmox Baseline

Proxmox Btop



Proxmox VirtIO Drivers Uploaded

The screenshot shows the Proxmox Virtual Environment 8.2.2 interface. In the center, a 'Task viewer' window is open, titled 'Copy data'. It shows a single task named 'Copy data' with status 'OK'. The task details indicate it copied an ISO file from '/var/tmp/pveupload-4cc94d5cc2d378515364b7b9717ae' to '/var/lib/vz/template/iso/virtio-win-0.1.266.iso'. The file size is 724.43 MB. Below the task viewer, the 'Tasks' section shows two recent tasks: one for 'Copy data' and another for 'Bulk start VMs and Containers', both completed successfully.

Proxmox Install Ansible Success

```
Processing triggers for man-db (2.11.2-2) ...
root@Proxmox:~# ansible --version
ansible [core 2.14.18]
  config file = None
  configured module search path = ['/root/.ansible/plugins/modules', '/usr/share/ansible/plugins/modules']
  ansible python module location = /usr/lib/python3/dist-packages/ansible
  ansible collection location = /root/.ansible/collections:/usr/share/ansible/collections
  executable location = /usr/bin/ansible
  python version = 3.11.2 (main, Nov 30 2024, 21:22:50) [GCC 12.2.0] (/usr/bin/python3)
  jinja version = 3.1.2
  libyaml = True
root@Proxmox:~# 
```

Proxmox SSH Keygen Success

```
Linux Proxmox 6.8.4-2-pve #1 SMP PREEMPT_DYNAMIC PMX 6.8.4-2 (2024-04-10T17:36Z) x86_64

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

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Wed Apr 16 13:58:36 EDT 2025 on ttym1
root@Proxmox:~# ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/root/.ssh/id_rsa):
/root/.ssh/id_rsa already exists.
Overwrite (y/n)? y
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /root/.ssh/id_rsa
Your public key has been saved in /root/.ssh/id_rsa.pub
The key fingerprint is:
SHA256:w3nTaxRb2M99D0j86mdqQzwEcKj5xQyv5jGjghVqFds root@Proxmox
The key's randomart image is:
+---[RSA 3072]---+
|          .o. |
|       . o... o |
|     + o = . = o |
|   + E. .=o.* o.|
|   o . .Sooo= o =|
|   o .   Bo oto .o|
|   . o   + + .+. .|
|   . . . oo o |
|   . . .o= |
+---[SHA256]---+
root@Proxmox:~# 
```

Proxmox Ubuntu CT SSH Login Success

```
Linux Proxmox 6.8.4-2-pve #1 SMP PREEMPT_DYNAMIC PMX 6.8.4-2 (2024-04-10T17:36Z) x86_64
The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/*copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Wed Apr 16 16:00:53 EDT 2025 on pts/0
root@Proxmox:~# ssh-copy-id ansible@192.168.2.233
/usr/bin/ssh-copy-id: INFO: Source of key(s) to be installed: "/root/.ssh/id_rsa.pub"
The authenticity of host '192.168.2.233 (192.168.2.233)' can't be established.
ED25519 key fingerprint is SHA256:Ytbs8zxa60jpAXTEMcIWxOz1szDQ+Axda27an7GN2ZM.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
/usr/bin/ssh-copy-id: INFO: attempting to log in with the new key(s), to filter out any that are already installed
/usr/bin/ssh-copy-id: INFO: 1 key(s) remain to be installed -- if you are prompted now it is to install the new keys
ansible@192.168.2.233's password:

Number of key(s) added: 1

Now try logging into the machine, with: "ssh 'ansible@192.168.2.233'"
and check to make sure that only the key(s) you wanted were added.

root@Proxmox:~# ssh ansible@192.168.2.233
Welcome to Ubuntu 22.04 LTS (GNU/Linux 6.8.4-2-pve x86_64)

 * Documentation: https://help.ubuntu.com
 * Management: https://landscape.canonical.com
 * Support: https://ubuntu.com/advantage
New release '24.04.2 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

Last login: Wed Apr 16 19:58:30 2025 from 192.168.2.65
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

ansible@RINKU-WEB01:~$ []
```

Proxmox Ubuntu Server SSH Login Success

```
individual files in /usr/share/doc/*/*copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Wed Apr 16 16:08:52 EDT 2025 on pts/0
root@Proxmox:~# ssh-copy-id ansible@192.168.2.236
/usr/bin/ssh-copy-id: INFO: Source of key(s) to be installed: "/root/.ssh/id_rsa.pub"
The authenticity of host '192.168.2.236 (192.168.2.236)' can't be established.
ED25519 key fingerprint is SHA256:DsxmK23DsLmNV08S8HmfLzyjmOhbaj3zVHq7KgY4LlY.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
/usr/bin/ssh-copy-id: INFO: attempting to log in with the new key(s), to filter out any that are already installed
/usr/bin/ssh-copy-id: INFO: 1 key(s) remain to be installed -- if you are prompted now it is to install the new keys
ansible@192.168.2.236's password:

Number of key(s) added: 1

Now try logging into the machine, with: "ssh 'ansible@192.168.2.236'"
and check to make sure that only the key(s) you wanted were added.

root@Proxmox:~# ssh ansible@192.168.2.236
Welcome to Ubuntu 24.04.2 LTS (GNU/Linux 6.8.0-57-generic x86_64)

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

System information as of Thu Apr 17 02:20:01 AM UTC 2025

 System load:  0.0          Processes:           109
 Usage of /:   36.6% of 14.66GB  Users logged in:      1
 Memory usage: 6%
 Swap usage:   0%
                                         IPv4 address for ens18: 192.168.2.236

Expanded Security Maintenance for Applications is not enabled.

0 updates can be applied immediately.

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

Last login: Wed Apr 16 18:37:57 2025 from 192.168.2.65
ansible@RINKU-K8S01:~$ []
```

Proxmox Ubuntu Cloud SSH Login Success

```
root@Proxmox:~# ssh ubuntu@129.153.49.245
Welcome to Ubuntu 20.04.6 LTS (GNU/Linux 5.15.0-1077-oracle x86_64)

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

 * Strictly confined Kubernetes makes edge and IoT secure. Learn how MicroK8s
 just raised the bar for easy, resilient and secure K8s cluster deployment.

 https://ubuntu.com/engage/secure-kubernetes-at-the-edge

This system has been minimized by removing packages and content that are
not required on a system that users do not log into.

To restore this content, you can run the 'unminimize' command.

Expanded Security Maintenance for Applications is not enabled.

0 updates can be applied immediately.

4 additional security updates can be applied with ESM Apps.
Learn more about enabling ESM Apps service at https://ubuntu.com/esm

New release '22.04.5 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

*** System restart required ***
Last login: Thu May  8 12:40:12 2025 from 174.95.195.13
ubuntu@rinku-oci01:~$
```

Proxmox Ping All Success

```
permitted by applicable law.
Last login: Thu May  8 09:09:57 EDT 2025 on pts/0
root@Proxmox:~# ansible ubuntu -m ping
192.168.2.233 | SUCCESS => {
    "ansible_facts": {
        "discovered_interpreter_python": "/usr/bin/python3"
    },
    "changed": false,
    "ping": "pong"
}
192.168.2.236 | SUCCESS => {
    "ansible_facts": {
        "discovered_interpreter_python": "/usr/bin/python3"
    },
    "changed": false,
    "ping": "pong"
}
129.153.49.245 | SUCCESS => {
    "ansible_facts": {
        "discovered_interpreter_python": "/usr/bin/python3"
    },
    "changed": false,
    "ping": "pong"
}
root@Proxmox:~# ansible windows -m win_ping
192.168.2.232 | SUCCESS => {
    "changed": false,
    "ping": "pong"
}
root@Proxmox:~#
```

Proxmox Configurations Files and Playbooks – Ansible.cfg, hosts.inventory, Deployapache.yml, Managewindows.yml

```
root@Proxmox:~# cat ansible.cfg
[defaults]
inventory = hosts.inventory
remote_user = ansible
root@Proxmox:~# cat hosts.inventory
[ubuntuweb]
192.168.2.233

[ubuntuk8s]
192.168.2.236

[ubuntuoci]
129.153.49.245 ansible_user=ubuntu

[ubuntu:children]
ubuntuweb
ubuntuk8s
ubuntuoci

[windows]
192.168.2.232

[windows:vars]
ansible_password=Secret555
ansible_connection=winrm
ansible_winrm_port=5985
ansible_winrm_transport=ntlm
ansible_winrm_scheme=http
ansible_winrm_kerberos_delegation=false

[ubuntu:vars]
ansible_sudo_pass=Secret555
root@Proxmox:~#
```

```
root@Proxmox:~# ls
ansible.cfg deployapache.yml hosts.inventory managewindows.yml
root@Proxmox:~# cat deployapache.yml
---
- name: Deploy Apache Web Server on Ubuntu hosts
  hosts: ubuntu
  become: yes
  become_method: sudo

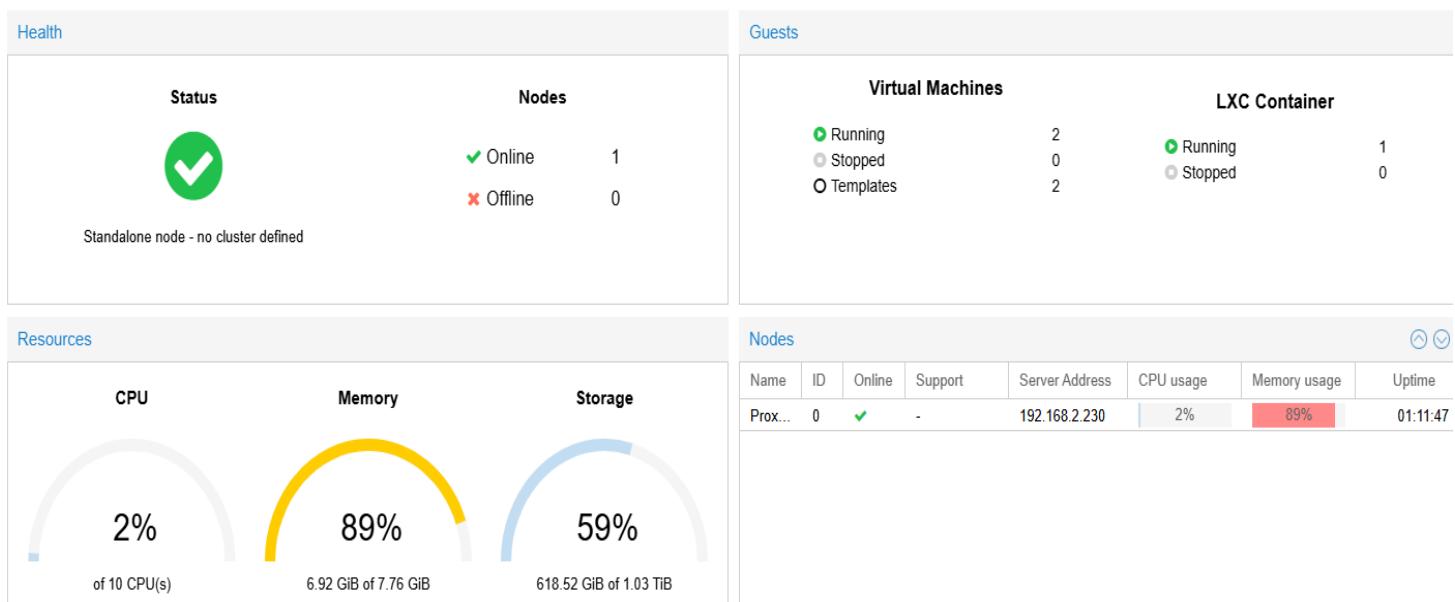
  tasks:
    - name: Install Apache
      apt:
        name: apache2
        state: present

    - name: Ensure Apache is running and started at boot time
      service:
        name: apache2
        state: started
        enabled: yes

root@Proxmox:~# cat managewindows.yml
---
- name: Install web server
  hosts: windows

  tasks:
    - name: Install the IIS web server
      win_feature:
        state: present
        name: Web-Server
```

Proxmox Summary



Linux Web Server Container

RINKU-WEBO1	Ubuntu 22.04 + Apache	192.168.2.233	Ansible	1 GB Memory	2 core
-------------	-----------------------	---------------	---------	-------------	--------

Ubuntu-22.04-Standard Template Download

The screenshot shows the Proxmox Virtual Environment interface. On the left, the 'Server View' sidebar lists Datacenter, Proxmox (with hosts RINKU-WIN01 and RINKU-WinSer-Template), localnetwork (Proxmox), local (Proxmox), and local-lvm (Proxmox). The main area is titled 'Storage "local" on node "Proxmox"'. It has tabs for Summary, Backups, ISO Images, and CT Templates. The CT Templates tab is selected, showing a 'Name' input field and a 'Task viewer' window. The task viewer displays the details of a download task for 'ubuntu/22.04/standard_22.04-1_amd64.tar.zst'. The task status is 'stopped: OK'.

Ubuntu CT Installation Configuration

The screenshot shows the 'Create: LXC Container' dialog box. The 'General' tab is selected, displaying configuration parameters:

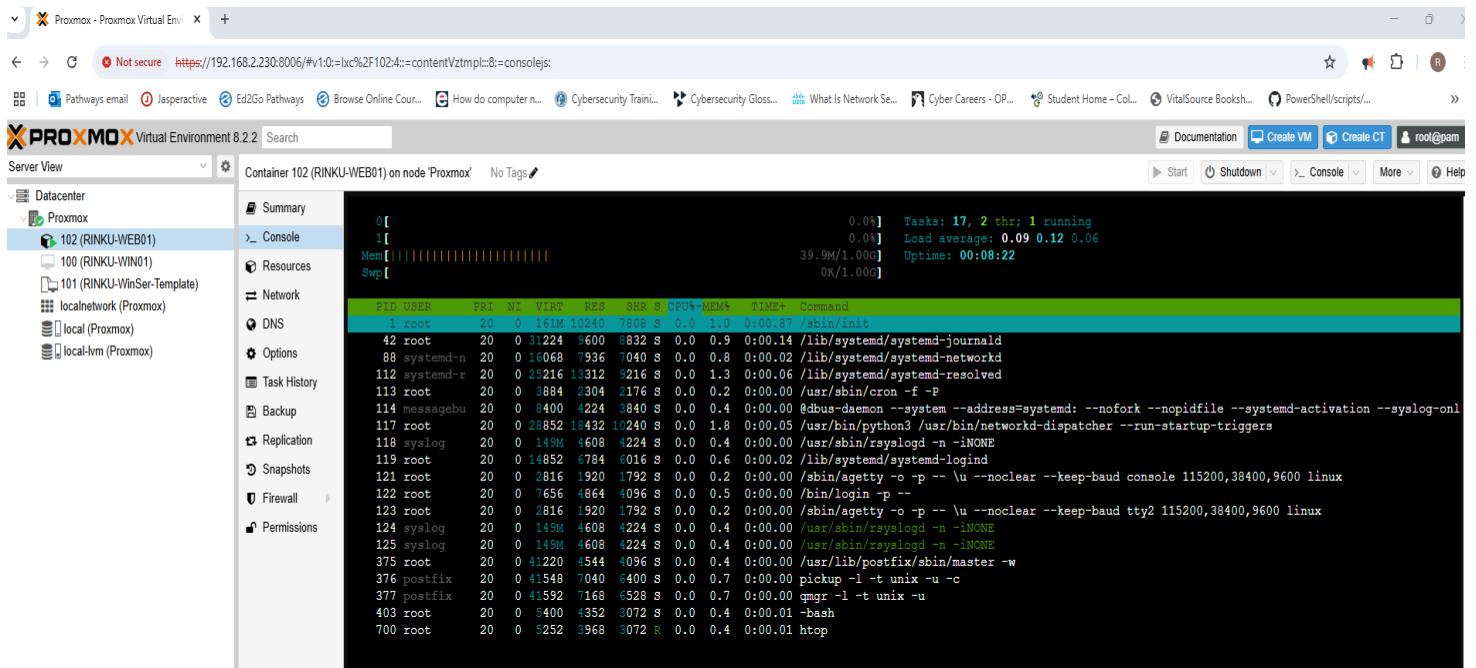
Key ↑	Value
cores	2
features	nesting=1
hostname	RINKU-WEBO1
memory	1024
net0	name=eth0,bridge=vmbr0,firewall=1,ip6=dhcp,ip=dhcp
nodename	Proxmox
ostemplate	local.vztmpl/ubuntu-22.04-standard_22.04-1_amd64.tar.zst
pool	
rootfs	local-lvm:8
ssh-public-keys	
swap	1024
unprivileged	1
vmid	102

Below the table, there is a checkbox for 'Start after created' and buttons for 'Advanced', 'Back', and 'Finish'.

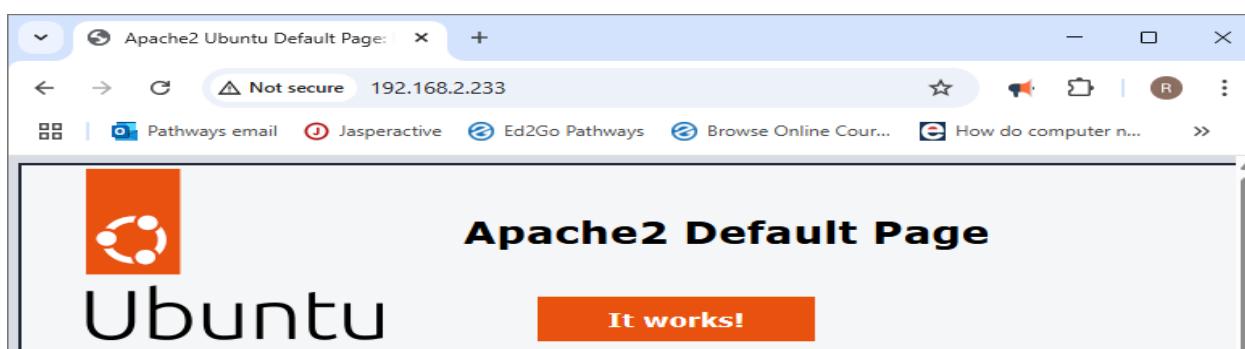
Ubuntu CT Updates

```
root@RINKU-WEB01:~# ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::/128 scope host
        valid_lft forever preferred_lft forever
        valid_lft forever preferred_lft forever
2: eth0@if16: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether bc:24:11:07:15:27 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 192.168.2.233/24 metric 1024 brd 192.168.2.255 scope global dynamic eth0
        valid_lft 259085sec preferred_lft 259085sec
    inet6 fe80::be24:11ff:fe07:1527/64 scope link
        valid_lft forever preferred_lft forever
root@RINKU-WEB01:~# apt update
Get:1 http://archive.ubuntu.com/ubuntu jammy InRelease [270 kB]
Get:2 http://archive.ubuntu.com/ubuntu jammy-updates InRelease [128 kB]
Get:3 http://archive.ubuntu.com/ubuntu jammy-security InRelease [129 kB]
Get:4 http://archive.ubuntu.com/ubuntu jammy/main Translation-en [510 kB]
Get:5 http://archive.ubuntu.com/ubuntu jammy/main amd64 c-n-f Metadata [30.3 kB]
Get:6 http://archive.ubuntu.com/ubuntu jammy/restricted Translation-en [18.6 kB]
Get:7 http://archive.ubuntu.com/ubuntu jammy/restricted amd64 c-n-f Metadata [488 B]
Get:8 http://archive.ubuntu.com/ubuntu jammy/universe Translation-en [5652 kB]
Get:9 http://archive.ubuntu.com/ubuntu jammy/universe amd64 c-n-f Metadata [286 kB]
Get:10 http://archive.ubuntu.com/ubuntu jammy/multiverse Translation-en [112 kB]
Get:11 http://archive.ubuntu.com/ubuntu jammy/multiverse amd64 c-n-f Metadata [8372 B]
Reading package lists... Done
E: Release file for http://archive.ubuntu.com/ubuntu/dists/jammy-updates/InRelease is not valid yet (invalid for another 5h 16min 2s). Updates for this repository will not be applied.
E: Release file for http://archive.ubuntu.com/ubuntu/dists/jammy-security/InRelease is not valid yet (invalid for another 5h 14min 15s). Updates for this repository will not be applied.
root@RINKU-WEB01:~# apt upgrade
Reading package lists... Done
Building dependency tree... Done
Calculating upgrade... Done
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
root@RINKU-WEB01:~#
```

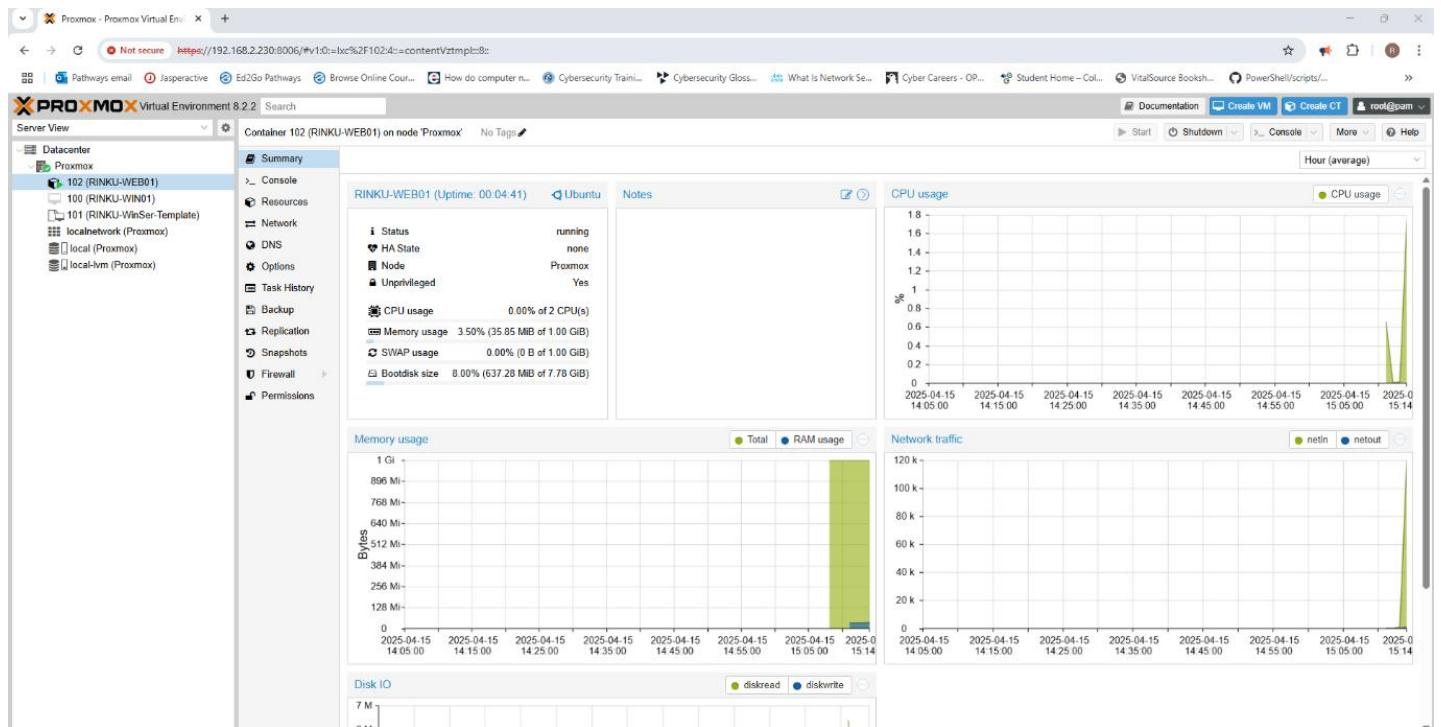
Ubuntu CT Htop



Ubuntu CT Apache2



Ubuntu CT Baseline



Ubuntu CT IP Configuration and Add Ansible User

Container 102 (RINKU-WEB01) on node 'Proxmox' No Tags

Terminal

```
Ubuntu 22.04 LTS RINKU-WEB01 tty1
RINKU-WEB01 login: root
Password:
Welcome to Ubuntu 22.04 LTS (GNU/Linux 6.8.4-2-pve x86_64)

 * Documentation: https://help.ubuntu.com
 * Management: https://landscape.canonical.com
 * Support: https://ubuntu.com/advantage
Last login: Tue Apr 15 19:10:25 UTC 2025 on ttym1
root@RINKU-WEB01:~# ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
        inet 127.0.0.1/8 scope host lo
            valid_lft forever preferred_lft forever
        inet6 ::1/128 scope host
            valid_lft forever preferred_lft forever
2: eth0@if12: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether bc:24:11:07:15:27 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 192.168.2.233/24 metric 1024 brd 192.168.2.255 scope global dynamic eth0
        valid_lft 259028sec preferred_lft 259028sec
        inet6 fe80::be24:11ff:fe07:1527/64 scope link
            valid_lft forever preferred_lft forever
root@RINKU-WEB01:~# useradd -m -s /bin/bash ansible
root@RINKU-WEB01:~# passwd ansible
New password:
Retype new password:
passwd: password updated successfully
root@RINKU-WEB01:~# usermod -aG sudo ansible
root@RINKU-WEB01:~# grep sudo /etc/group
sudo:x:27:ansible
root@RINKU-WEB01:~# grep "%sudo" /etc/sudoers
%sudo  ALL=(ALL:ALL)  ALL
root@RINKU-WEB01:~#
```

Ubuntu CT Putty SSH Woot Login

```
RINKU-WEB01) on node 'Proxmox'  No Tags
[Start] [Shutdown]
[  ] 192.168.2.233 - PuTTY
[  ] login as: woot
[  ] woot@192.168.2.233's password:
Welcome to Ubuntu 22.04 LTS (GNU/Linux 6.8.4-2-pve x86_64)

 * Documentation: https://help.ubuntu.com
 * Management: https://landscape.canonical.com
 * Support: https://ubuntu.com/advantage
New release '24.04.2 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

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.

$ [  ]
```

```
root@RINKU-WEB01:~# useradd -m woot
root@RINKU-WEB01:~# passwd woot
New password:
Retype new password:
passwd: password updated successfully
root@RINKU-WEB01:~# grep -i root /etc/ssh/sshd_config
#PermitRootLogin prohibit-password
# the setting of "PermitRootLogin without-password".
#ChrootDirectory none
root@RINKU-WEB01:~# sudo apt update
Hit:1 http://archive.ubuntu.com/ubuntu jammy InRelease
Get:2 http://archive.ubuntu.com/ubuntu jammy-updates InRelease [128 kB]
Get:3 http://archive.ubuntu.com/ubuntu jammy-security InRelease [129 kB]
Reading package lists... Done
E: Release file for http://archive.ubuntu.com/ubuntu/dists/jammy-updates
    will not be applied.
E: Release file for http://archive.ubuntu.com/ubuntu/dists/jammy-security
    will not be applied.
root@RINKU-WEB01:~# sudo apt upgrade
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
Calculating upgrade... Done
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
root@RINKU-WEB01:~# ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: eth0@if16: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether bc:24:11:07:15:27 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 192.168.2.233/24 metric 1024 brd 192.168.2.255 scope global dynamic eth0
        valid_lft 257863sec preferred_lft 257863sec
    inet6 fe80::be24:11ff:fe07:1527/64 scope link
        valid_lft forever preferred_lft forever
root@RINKU-WEB01:~# [  ]
```

Ubuntu CT Deployapache.yml and Apache2 Works

```
deployapache.yml          100%[=====] 594 --.KB/s  in 0s
2025-04-25 20:24:57 (22.0 MB/s) - 'deployapache.yml' saved [594/594]
root@Proxmox:~# vi deployapache.yml
root@Proxmox:~# cat deployapache.yml
---
- name: Deploy Apache Web Server on Ubuntu hosts
  hosts: ubuntu
  become: yes
  become_method: sudo

  tasks:
    - name: Install Apache
      apt:
        name: apache2
        state: present

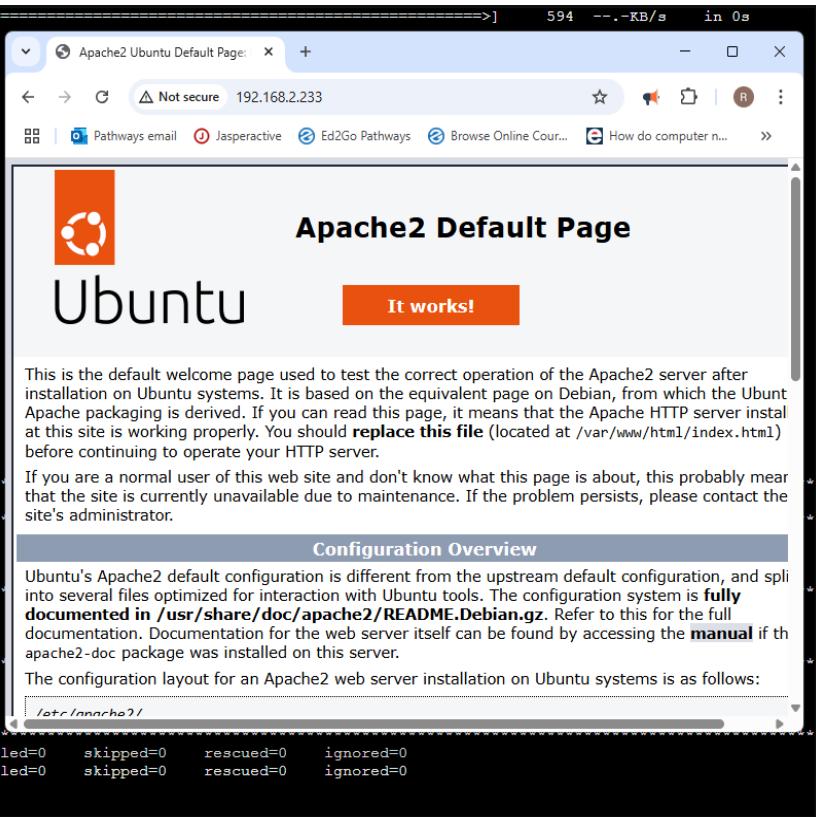
    - name: Ensure Apache is running and started at boot time
      service:
        name: apache2
        state: started
        enabled: yes

root@Proxmox:~# ansible-playbook deployapache.yml
PLAY [Deploy Apache Web Server on Ubuntu hosts] *****
TASK [Gathering Facts] *****
ok: [192.168.2.233]
ok: [192.168.2.236]

TASK [Install Apache] *****
ok: [192.168.2.233]
changed: [192.168.2.236]

TASK [Ensure Apache is running and started at boot time] *****
ok: [192.168.2.233]
ok: [192.168.2.236]

PLAY RECAP *****
192.168.2.233 : ok=3    changed=0    unreachable=0    failed=0    skipped=0    rescued=0    ignored=0
192.168.2.236 : ok=3    changed=1    unreachable=0    failed=0    skipped=0    rescued=0    ignored=0
root@Proxmox:~# [  ]
```



This is the default welcome page used to test the correct operation of the Apache2 server after installation on Ubuntu systems. It is based on the equivalent page on Debian, from which the Ubuntu Apache packaging is derived. If you can read this page, it means that the Apache HTTP server installed at this site is working properly. You should **replace this file** (located at `/var/www/html/index.html`) before continuing to operate your HTTP server.

If you are a normal user of this web site and don't know what this page is about, this probably means that the site is currently unavailable due to maintenance. If the problem persists, please contact the site's administrator.

Configuration Overview

Ubuntu's Apache2 default configuration is different from the upstream default configuration, and splits into several files optimized for interaction with Ubuntu tools. The configuration system is **fully documented in `/usr/share/doc/apache2/README.Debian.gz`**. Refer to this for the full documentation. Documentation for the web server itself can be found by accessing the **manual** if the `apache2-doc` package was installed on this server.

The configuration layout for an Apache2 web server installation on Ubuntu systems is as follows:

```
[  ] /etc/apache2/
```

Windows Server Core VM

RINKU-WIN01	Windows Server 2019 + IIS, Python, Chocolatey	192.168.2.232	Ansible	4 GB Memory	2 Core
-------------	---	---------------	---------	-------------	--------

Windows Server 2019 Install Configuration

The screenshot shows the Proxmox VE interface with the 'Create: Virtual Machine' dialog open. The 'General' tab is selected. The configuration parameters listed are:

- agent: 1
- balloon: 0
- boot: order=scsi0,ide0,ide2,net0
- cores: 2
- cpu: x86-64-v2-AES
- ide0: local:iso/virtio-win-0.1.266.iso,media=cdrom
- ide2: cdrom,media=cdrom
- memory: 4096
- name: RINKU-WinSer
- net0: virtio,bridge=vmbr0,firewall=1
- nodename: Proxmox
- numa: 0
- ostype: win10
- scsi0: local-lvm:32,iothread=on

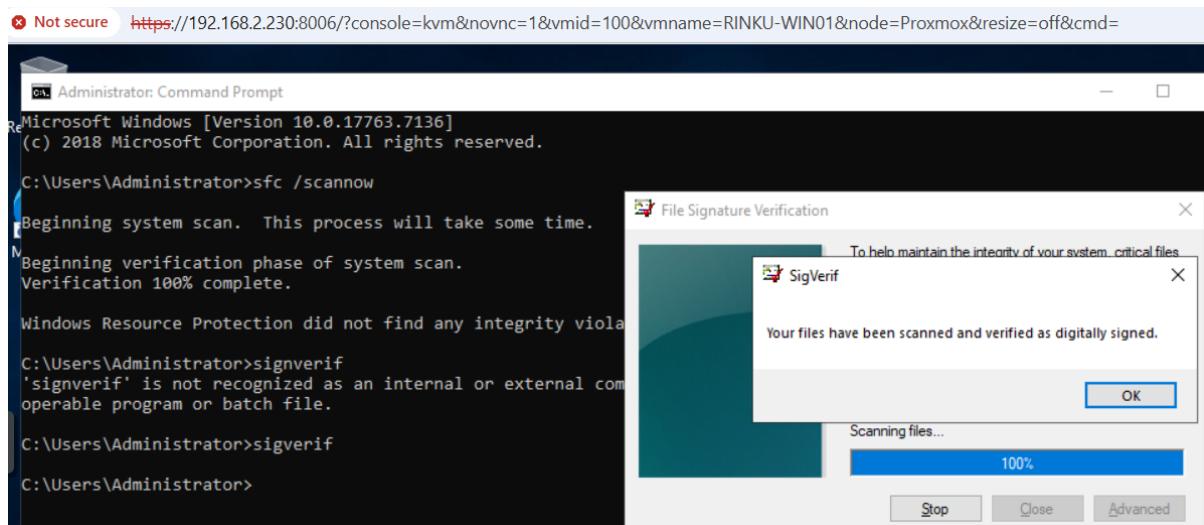
At the bottom of the dialog, there is a checkbox for 'Start after created' and buttons for 'Advanced', 'Back', and 'Finish'.

Windows Server Post Installation All Configurations

PROPERTIES		TASKS	
For RINKU-WIN01			
Computer name	RINKU-WIN01	Last installed updates	Today at 8:43 PM
Workgroup	WORKGROUP	Windows Update	Download updates only, using Windows Update
Windows Defender Firewall	Private: Off	Last checked for updates	Today at 8:41 PM
Remote management	Enabled	Windows Defender Antivirus	Real-Time Protection: On
Remote Desktop	Enabled	Feedback & Diagnostics	Settings
NIC Teaming	Disabled	IE Enhanced Security Configuration	Off
Ethernet	IPv4 address assigned by DHCP, IPv6 enabled	Time zone	(UTC-05:00) Eastern Time (US & Canada)
Operating system version	Microsoft Windows Server 2019 Standard Evaluation	Product ID	00431-10000-00000-AA295 (activated)
Hardware information	BOCHS_BXPC	Processors	QEMU Virtual CPU version 2.5+
		Installed memory (RAM)	4 GB
		Total disk space	31.46 GB

Windows Server SFC Scan and Sigverif

Not secure https://192.168.2.230:8006/?console=kvm&novnc=1&vmid=100&vmname=RINKU-WIN01&node=Proxmox&resize=off&cmd=



```
Administrator: Command Prompt
Microsoft Windows [Version 10.0.17763.7136]
(c) 2018 Microsoft Corporation. All rights reserved.

C:\Users\Administrator>sfc /scannow
Beginning system scan. This process will take some time.
Beginning verification phase of system scan.
Verification 100% complete.

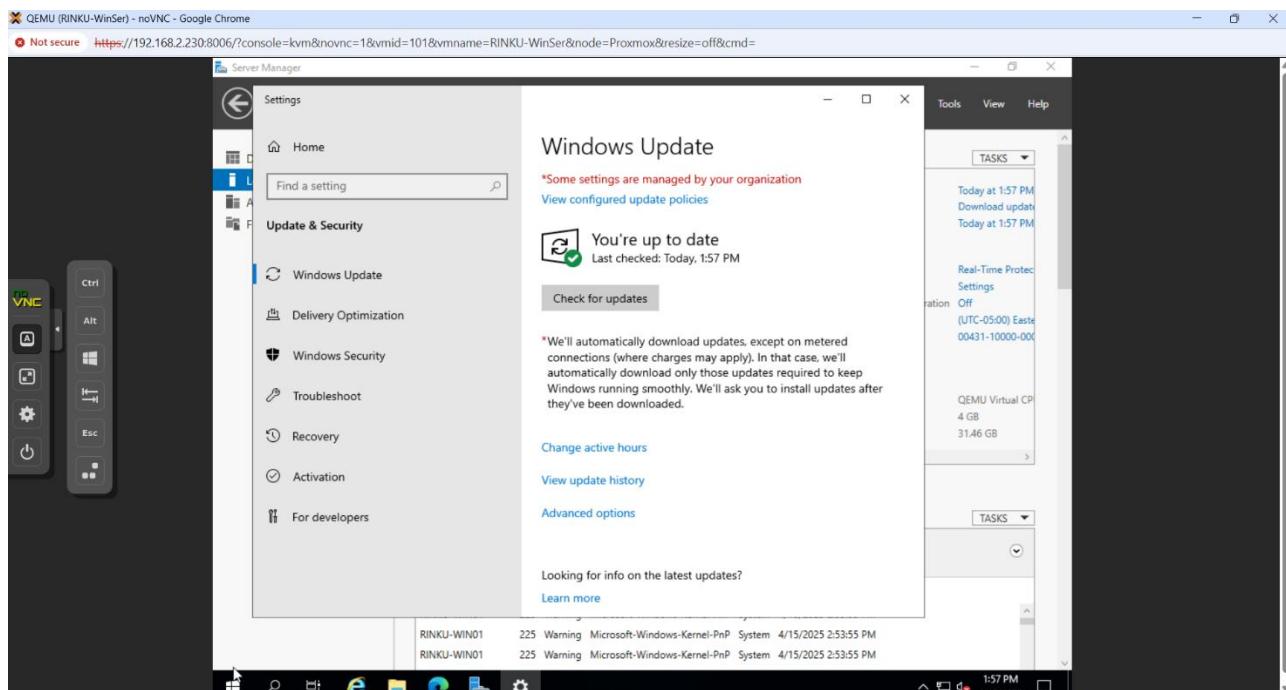
Windows Resource Protection did not find any integrity violations.

C:\Users\Administrator>sigverif
'sigverif' is not recognized as an internal or external command,
operable program or batch file.

C:\Users\Administrator>sigverif
C:\Users\Administrator>
```

The screenshot shows a Windows Server Command Prompt window and a separate "File Signature Verification" dialog box. The Command Prompt displays the results of running SFC /scannow and sigverif commands. The dialog box shows a green progress bar at 100%, indicating that files have been scanned and verified as digitally signed.

Windows Server Updates



Windows Server IP Configuration

Administrator: Command Prompt

```
Microsoft Windows [Version 10.0.17763.7136]
(c) 2018 Microsoft Corporation. All rights reserved.

C:\Users\Administrator>ipconfig

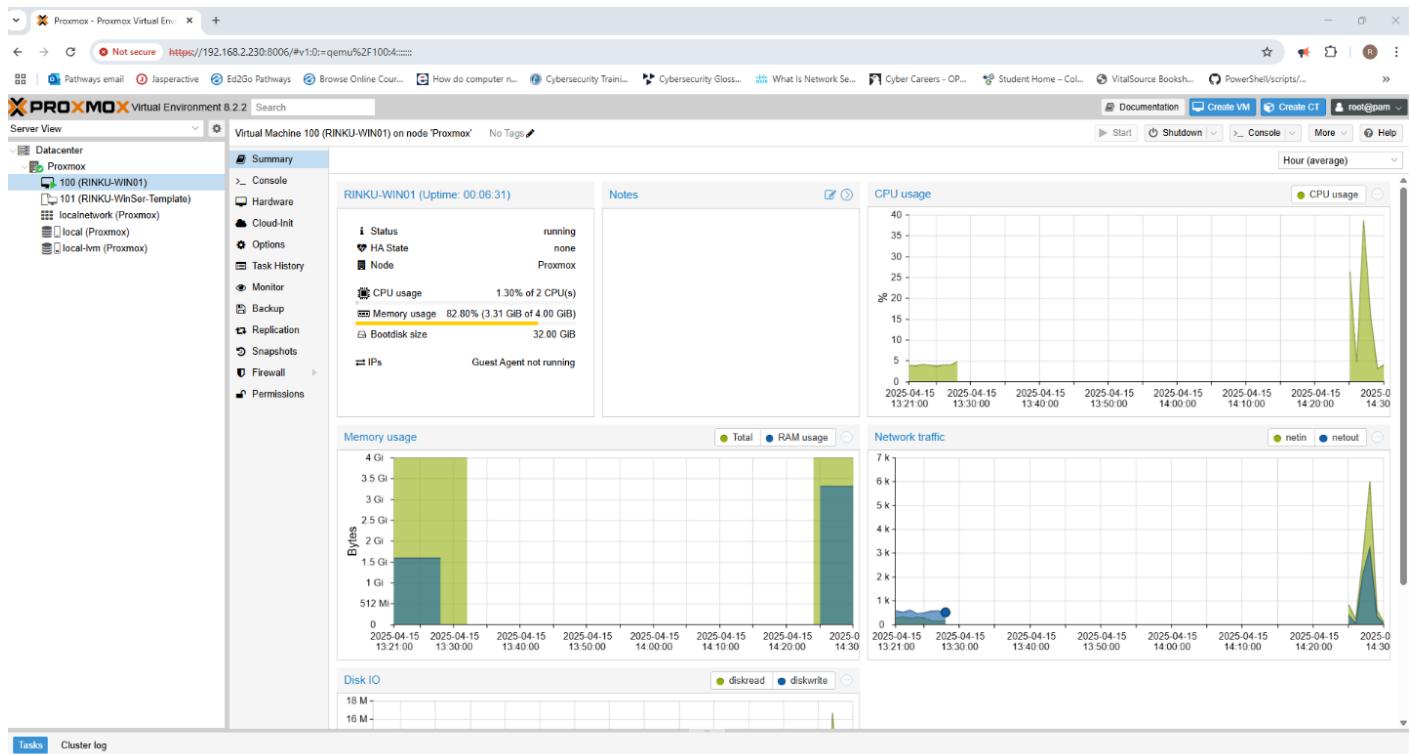
Windows IP Configuration

Ethernet adapter Ethernet:

  Connection-specific DNS Suffix . : home
  Link-local IPv6 Address . . . . . : fe80::d3f8:47c3:6501:e634%15
  IPv4 Address . . . . . : 192.168.2.232
  Subnet Mask . . . . . : 255.255.255.0
  Default Gateway . . . . . : 192.168.2.1

C:\Users\Administrator>
```

Windows Server Baseline



Windows Server Admin Center

Windows Admin Center | All connections

Microsoft

Name	Type	Last connected	Managing as	Azure Arc S...	Tags
rinku-win01 [Gateway]	Servers	Never	RINKU-WIN01\Administr...	Unknown	

Windows Server Python and Chocolatey

```
Administrator: Windows PowerShell

PS C:\Users\Administrator> python --version
Python 3.13.3
PS C:\Users\Administrator> choco --version
2.4.3
PS C:\Users\Administrator>
```

Windows Server IP Configuration and WinRm QuickConfig

```
192.168.2.232 - Remote Desktop Connection
Administrator: Windows PowerShell

Connection-specific DNS Suffix . : home
Link-local IPv6 Address . . . . . : fe80::d3f8:47c3:6501:e634%15
IPv4 Address . . . . . : 192.168.2.232
Subnet Mask . . . . . : 255.255.255.0
Default Gateway . . . . . : 192.168.2.1
PS C:\Users\Administrator> winrm enumerate winrm/config/Listener
Listener
    Address = *
    Transport = HTTP
    Port = 5985
    Hostname
    Enabled = true
    URLPrefix = wsman
    CertificateThumbprint
    ListeningOn = 127.0.0.1, 192.168.2.232, ::1, fe80::d3f8:47c3:6501:e634%15

PS C:\Users\Administrator> winrm quickconfig
WinRM service is already running on this machine.
WinRM is not set up to allow remote access to this machine for management.
The following changes must be made:

Configure LocalAccountTokenFilterPolicy to grant administrative rights remotely to local users.

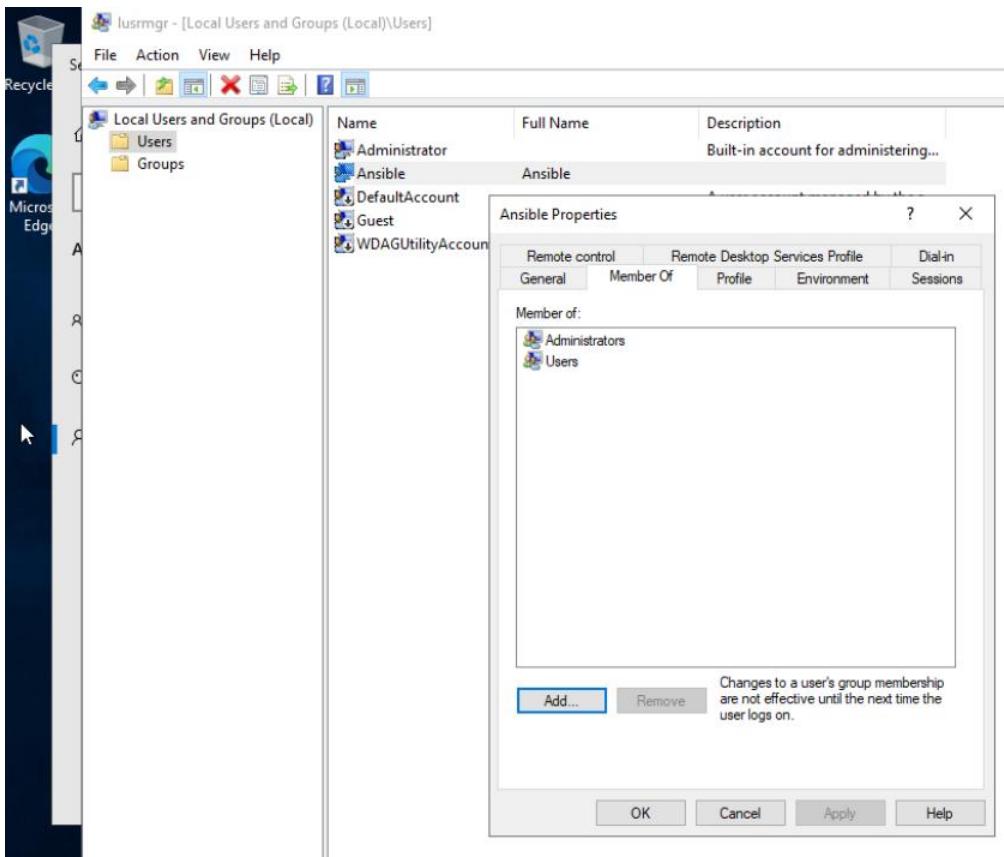
Make these changes [y/n]? y

WinRM has been updated for remote management.

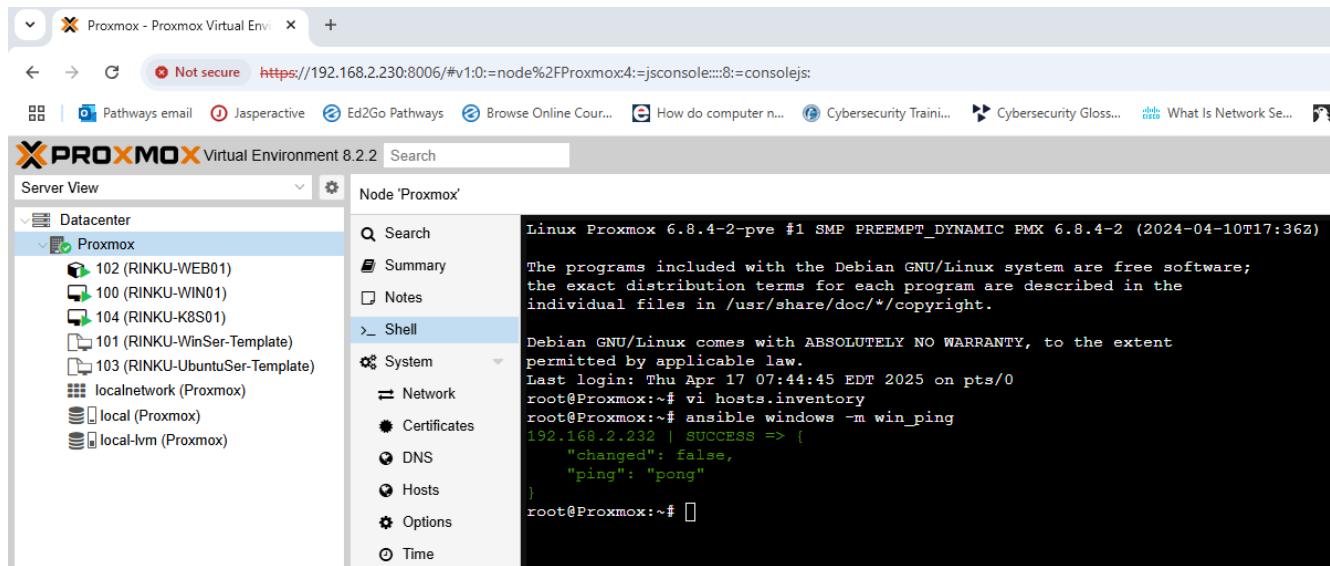
Configured LocalAccountTokenFilterPolicy to grant administrative rights remotely to local users.
PS C:\Users\Administrator> Set-ExecutionPolicy unrestricted

Execution Policy Change
The execution policy helps protect you from scripts that you do not trust. Changing the execution policy might expose you to the security risks described in the about_Execution_Policies help topic at https://go.microsoft.com/fwlink/?LinkID=135170. Do you want to change the execution policy?
[Y] Yes [A] Yes to All [N] No [L] No to All [S] Suspend [?] Help (default is "N"): A
PS C:\Users\Administrator>
```

Windows Server Add Ansible User



Windows Server Ansible Win_Ping Success



Windows Server Managewindows.yml and IIS Web Page

```
Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Fri Apr 25 20:38:58 EDT 2025 on pts/0
root@Proxmox:~# vi managewindows.yml
root@Proxmox:~# cat managewindows.yml
---
- name: Install web server
  hosts: windows

  tasks:
  - name: Install the IIS web server
    win_feature:
      state: present
      name: Web-Server

root@Proxmox:~# ansible-playbook managewindows.yml

PLAY [Install web server] *****
TASK [Gathering Facts] *****
[WARNING]: Error when collecting bios facts: New-Object : Cannot find function 'Win32Error' in the current scope. At line:2 char:1
FullyQualifiedErrorId : ConstructorInvokedThrowException,Microsoft.PowerShell.Commands.NewObjectCommand
[WARNING]: Error when collecting platform facts: New-Object : Cannot find function 'Win32Error' in the current scope. At line:2 char:1
FullyQualifiedErrorId : ConstructorInvokedThrowException,Microsoft.PowerShell.Commands.NewObjectCommand
[WARNING]: Error when collecting processor facts: New-Object : Cannot find function 'Win32Error' in the current scope. At line:2 char:1
FullyQualifiedErrorId : ConstructorInvokedThrowException,Microsoft.PowerShell.Commands.NewObjectCommand
[WARNING]: Error when collecting virtual facts: New-Object : Cannot find function 'Win32Error' in the current scope. At line:2 char:1
FullyQualifiedErrorId : ConstructorInvokedThrowException,Microsoft.PowerShell.Commands.NewObjectCommand
ok: [192.168.2.232]

TASK [Install the IIS web server] *****
ok: [192.168.2.232]

PLAY RECAP *****
192.168.2.232 : ok=2    changed=0    unreachable=0    failed=0    skipped=0    rescued=0    ignored=0
root@Proxmox:~#
```

Windows Server Remote Desktop Connection Success



Linux Kubernetes VM

RINKU-K8S01	Ubuntu 24.04 + K3s	192.168.2.236	Ansible	3 GB Memory	2 Core
-------------	--------------------	---------------	---------	-------------	--------

Ubuntu Server Installation Configuration

The screenshot shows the Proxmox VE 8.2.2 interface. On the left, the 'Server View' sidebar lists the Datacenter, Proxmox, and various hosts (102, 100, 101). The main area displays 'Node 'Proxmox''. A 'Create: Virtual Machine' dialog is open, showing the configuration for a new VM named 'RINKU-K8S01'. The 'Network' tab is selected. Key configuration parameters include:

Key	Value
balloon	0
cores	2
cpu	x86-64-v2-AES
ide2	cdrom,media=cdrom
memory	3072
name	RINKU-K8S01
net0	virtio,bridge=vmbr0,firewall=1
nodename	Proxmox
numa	0
ostype	l26
scsi0	local-lvm:32,iothread=on
scsihw	virtio-scsi-single
sockets	1
vmid	103

Ubuntu Server Installation Success and IP Configuration

```
Ubuntu 24.04.2 LTS rinku-k8s01 tty1
rinku-k8s01 login: ansible
Password:
Welcome to Ubuntu 24.04.2 LTS (GNU/Linux 6.8.0-57-generic x86_64)

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

System information as of Wed Apr 16 06:32:23 PM UTC 2025

System load:  0.0          Processes:           107
Usage of /:   36.2% of 14.66GB  Users logged in:     0
Memory usage: 6%           IPv4 address for ens18: 192.168.2.236
Swap usage:   0%

Expanded Security Maintenance for Applications is not enabled.

54 updates can be applied immediately.
To see these additional updates run: apt list --upgradable

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

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.

ansible@rinku-k8s01:~$
```

Ubuntu Server Updates and IP Configuration

RINKU-K8S01) on node 'Proxmox' No Tags ↗

```
Running kernel seems to be up-to-date.

Restarting services...
systemctl restart multipathd.service polkit.service udisks2.service

Service restarts being deferred:
systemctl restart ModemManager.service
/etc/needrestart/restart.d/dbus.service
systemctl restart systemd-logind.service
systemctl restart unattended-upgrades.service

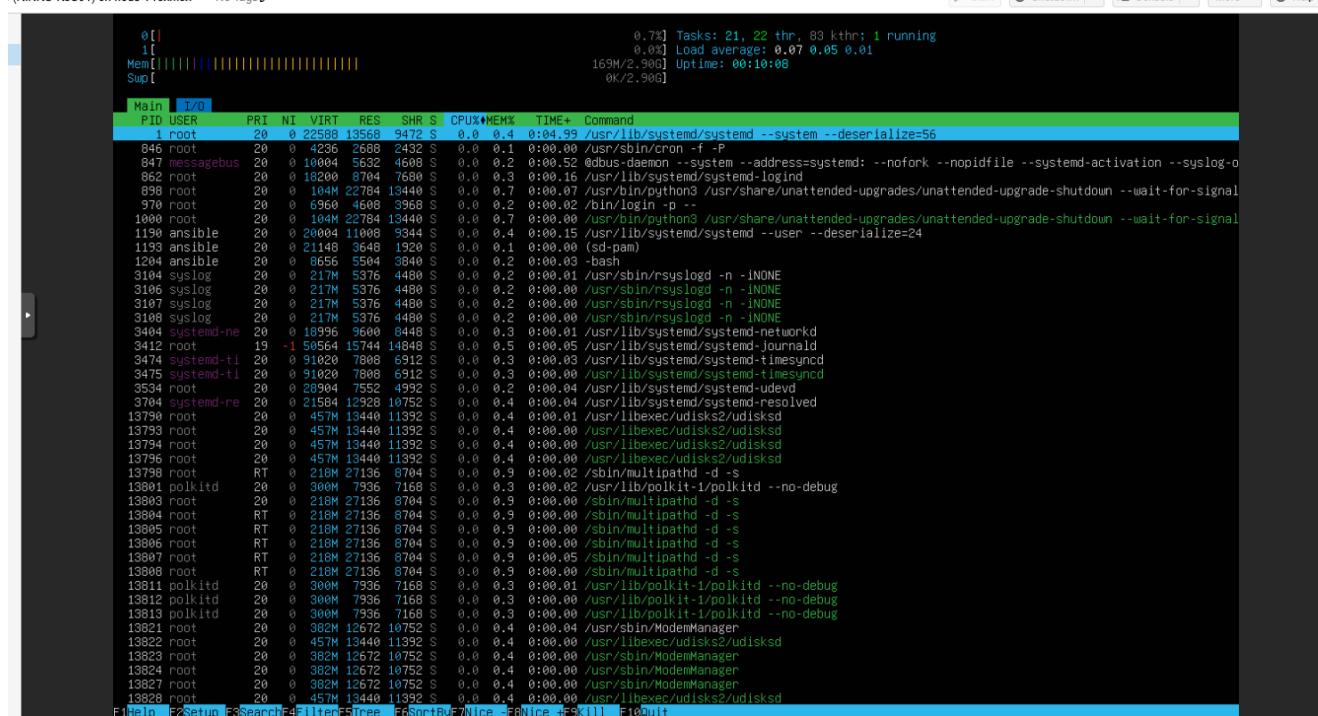
No containers need to be restarted.

User sessions running outdated binaries:
ansible @ session #1: apt[1528], login[970]
ansible @ user manager service: systemd[1190]

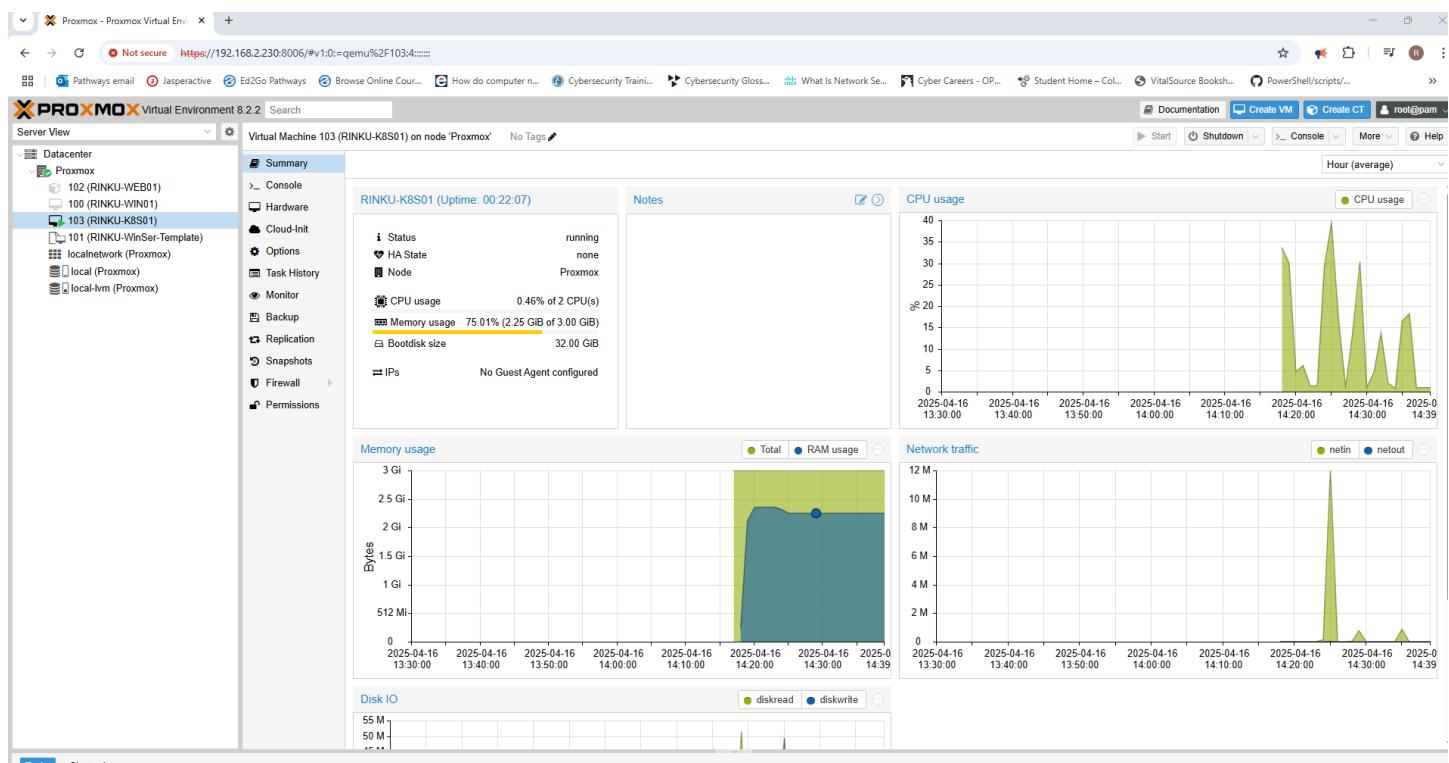
No VM guests are running outdated hypervisor (qemu) binaries on this host.
ansible@rinku-k8s01:"$ sudo apt update
Hit:1 http://ca.archive.ubuntu.com/ubuntu noble InRelease
Hit:2 http://security.ubuntu.com/ubuntu noble-security InRelease
Hit:3 http://ca.archive.ubuntu.com/ubuntu noble-updates InRelease
Hit:4 http://ca.archive.ubuntu.com/ubuntu noble-backports InRelease
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
1 package can be upgraded. Run 'apt list --upgradable' to see it.
ansible@rinku-k8s01:"$ sudo apt upgrade -y
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
Calculating upgrade... Done
The following upgrades have been deferred due to phasing:
  ubuntu-drivers-common
0 upgraded, 0 newly installed, 0 to remove and 1 not upgraded.
ansible@rinku-k8s01:"$ ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
        valid_lft forever preferred_lft forever
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
2: ens18: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether bc:24:11:3c:00:d4 brd ff:ff:ff:ff:ff:ff
        valid_lft 258945sec preferred_lft 258945sec
    inet 192.168.2.236/24 metric 100 brd 192.168.2.255 scope global dynamic ens18
        valid_lft 258945sec preferred_lft 258945sec
    inet6 fe80::be24:11ff:fe3c:d4/64 scope link
        valid_lft forever preferred_lft forever
ansible@rinku-k8s01:"$
```

Ubuntu Server Htop

i (RINKU-K8S01) on node 'Proxmox' No Tags ↗



Ubuntu Server Baseline



Ubuntu Server Add Ansible User

RINKU-K8S01 on node 'Proxmox' No Tags

```
Ubuntu 24.04.2 LTS RINKU-K8S01 tty1

RINKU-K8S01 login: ansible
Password:
Welcome to Ubuntu 24.04.2 LTS (GNU/Linux 6.8.0-57-generic x86_64)

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

System information as of Thu Apr 17 01:22:41 AM UTC 2025

System load: 0.06      Processes:          111
Usage of /: 36.5% of 14.66GB   Users logged in: 0
Memory usage: 6%        IPv4 address for ens18: 192.168.2.236
Swap usage:  0%

Expanded Security Maintenance for Applications is not enabled.

0 updates can be applied immediately.

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

ansible@RINKU-K8S01:~$ sudo usermod -aG sudo ansible
[sudo] password for ansible:
ansible@RINKU-K8S01:~$ grep sudo /etc/group
sudo:x:27:ansible
ansible@RINKU-K8S01:~$ grep "%sudo" /etc/sudoers
grep: /etc/sudoers: Permission denied
ansible@RINKU-K8S01:~$ sudo grep "%sudo" /etc/sudoers
%sudo  ALL=(ALL:ALL)  ALL
ansible@RINKU-K8S01:~$ ip addr
1: lo <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
        inet6 ::1/128 scope host noprefixroute
            valid_lft forever preferred_lft forever
2: ens18: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether bc:24:11:73:a3:04 brd ff:ff:ff:ff:ff:ff
    altname enp0s18
    inet 192.168.2.236/24 metric 100 brd 192.168.2.255 scope global dynamic ens18
        valid_lft 256890sec preferred_lft 256890sec
        inet6 fe80::be24:11ff:fe73:a304/64 scope link
            valid_lft forever preferred_lft forever
ansible@RINKU-K8S01:~$
```

Ubuntu Server Firewall

RINKU-K8S01) on node 'Proxmox' No Tags

```
Ubuntu 24.04.2 LTS Ubuntu-Server tty1

Ubuntu-Server login: ansible
Password:
Welcome to Ubuntu 24.04.2 LTS (GNU/Linux 6.8.0-57-generic x86_64)

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

System information as of Thu Apr 17 01:08:01 AM UTC 2025

 System load: 0.0          Processes:          109
 Usage of /: 36.4% of 14.66GB  Users logged in: 0
 Memory usage: 6%           IPv4 address for ens18: 192.168.2.236
 Swap usage: 0%

Expanded Security Maintenance for Applications is not enabled.

0 updates can be applied immediately.

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

ansible@Ubuntu-Server:~$ sudo apt install ufw -y
[sudo] password for ansible:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
Ufw is already the newest version (0.36.2-6).
Ufw set to manually installed.
0 upgraded, 0 newly installed, 0 to remove and 1 not upgraded.
ansible@Ubuntu-Server:~$ sudo ufw allow openSSH
Rules updated
Rules updated (v6)
ansible@Ubuntu-Server:~$ sudo ufw enable
Firewall is active and enabled on system startup
ansible@Ubuntu-Server:~$ sudo ufw allow 80
Rule added
Rule added (v6)
ansible@Ubuntu-Server:~$ sudo ufw allow 443
Rule added
Rule added (v6)
ansible@Ubuntu-Server:~$ _
```

Ubuntu Server Putty SSH Ansible Login

RINKU-K8S01) on node 'Proxmox' No Tags

```
Running kernel seems to be up-to-date.

Restarting services...
systemctl restart multipathd.service polkit.service udisks2.service

Service restarts being deferred:
systemctl restart ModemManager.service
/etc/needrestart/restart.d/dbus.service
systemctl restart systemd-logind.service
systemctl restart unattended-upgrades.service

No containers need to be restarted.

User sessions running outdated binaries:
ansible @ session #1: apt[1528], login[970]
ansible @ user manager service: systemd[1190]

No VM guests are running outdated hypervisor (qemu) binaries on this host.
ansible@rinku-k8s01:~$ sudo apt update
Hit:1 http://ca.archive.ubuntu.com/ubuntu noble InRelease
Hit:2 http://security.ubuntu.com/ubuntu noble-security InRelease
Hit:3 http://ca.archive.ubuntu.com/ubuntu noble-updates InRelease
Hit:4 http://ca.archive.ubuntu.com/ubuntu noble-backports InRelease
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
1 package can be upgraded. Run 'apt list --upgradable' to see it.
ansible@rinku-k8s01:~$ sudo apt upgrade -y
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
Calculating upgrade... Done
The following upgrades have been deferred due to phasing:
  ubuntu-drivers-common
0 upgraded, 0 newly installed, 0 to remove and 1 not upgraded.
ansible@rinku-k8s01:~$ ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host noprefixroute
        valid_lft forever preferred_lft forever
2: ens18: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether bc:24:1f:3c:00:04 brd ff:ff:ff:ff:ff:ff
    altname enp0s18
    inet 192.168.2.236/24 metric 100 brd 192.168.2.255 scope global dynamic ens18
        valid_lft 258945sec preferred_lft 258945sec
    inet6 fe80::be24:1fff:fe3c:d4/64 scope link
        valid_lft forever preferred_lft forever
```

The following steps have been used to deploys a Python web application on Kubernetes using k3s, a lightweight distribution, ensuring the app is scalable and externally accessible. It covers installing Kubernetes, creating an isolated namespace, deploying the app, scaling replicas for availability, exposing the service via NodePort, and configuring autoscaling based on CPU usage. The setup is efficient and provides flexibility for resource management and further customization.

Step	Description	Command
Step 1	Install k3s	curl -sfL https://get.k3s.io sh -
Step 2	Verify Kubernetes Node	kubectl get node
Step 3	Check All Pods Across Namespaces	kubectl get pod -A
Step 4	Create Namespace for the Application	kubectl create namespace pyapp
Step 5	Deploy the Python Web App	kubectl create deployment pyapp --image=jasoneckert/hello-world-python-x86 -n pyapp
Step 6	Scale the Deployment to 3 Replicas	kubectl scale deployment pyapp --replicas=3 -n pyapp
Step 7	Expose the Deployment as a NodePort Service	kubectl expose deployment pyapp --type=NodePort --port=3333 -n pyapp
Step 8	Get Service Details to Check the Assigned NodePort	kubectl get service -n pyapp
Step 9	Edit Deployment Configuration (Optional)	kubectl edit deployment pyapp -n pyapp
Step 10	Enable Autoscaling with Minimum and Maximum Replicas	kubectl autoscale deployment pyapp --min=3 --max=6 --cpu-percent=80 -n pyapp
Step 11	Verify Horizontal Pod Autoscaler	kubectl get hpa -n pyapp

Ubuntu Server Deploy Pyapp and IP configuration

```
[root@RINKU-K8S01: ~]
[INFO] systemd: Starting k3s
root@RINKU-K8S01:#
root@RINKU-K8S01:#
root@RINKU-K8S01:#
root@RINKU-K8S01:#
root@RINKU-K8S01:#
root@RINKU-K8S01:#
root@RINKU-K8S01:~# kubectl get node
NAME           STATUS    ROLES          AGE   VERSION
rlink-k8s01     Ready     control-plane,master  45m   v1.32.3+k3sl
root@RINKU-K8S01:~# kubectl get pod -A
NAMESPACE      NAME                READY   STATUS    RESTARTS   AGE
kube-system    coredns-ff8999cc5-vdcfn        1/1     Running   0          46m
kube-system    helm-install-traefik-crd-dd4jj   0/1     Completed  0          46m
kube-system    helm-install-traefik-qwqdn       0/1     Completed  2          46m
kube-system    local-path-provisioner-774c6665dc-csv5z 1/1     Running   0          46m
kube-system    metrics-server-6f4c6675d5-jzj92    1/1     Running   0          46m
kube-system    svc1b-traefik-8f52a793-sb8zc      2/2     Running   0          45m
kube-system    traefik-67fb46dcb-vcpdb         1/1     Running   0          45m
root@RINKU-K8S01:~# kubectl create namespace pyapp
namespace/pyapp created
root@RINKU-K8S01:~# kubectl create deployment pyapp --image=jasoneckert/hello-world-python-x86 -n pyapp
deployment.apps/pyapp created
root@RINKU-K8S01:~# kubectl scale deployment pyapp --replicas=3 -n pyapp
deployment.apps/pyapp scaled
root@RINKU-K8S01:~# kubectl get deploy pyapp -n pyapp
NAME      READY   UP-TO-DATE   AVAILABLE   AGE
pyapp     3/3     3           3           3m26s
root@RINKU-K8S01:~# kubectl expose deployment pyapp --type=NodePort --port=3333 -n pyapp
service/pyapp exposed
root@RINKU-K8S01:~# kubectl get service -n pyapp
NAME      TYPE      CLUSTER-IP      EXTERNAL-IP      PORT(S)        AGE
pyapp     NodePort   10.43.82.165   <none>          3333:31223/TCP  13s
root@RINKU-K8S01:~# ip a show | grep inet
inet 127.0.0.1/8 scope host lo
  inet6 ::1/128 scope host noprefixroute
inet 192.168.2.236/24 metric 100 brd 192.168.2.255 scope global dynamic ens18
  inet6 fe80::be24:11ff:fe73:a304/64 scope link
  inet 10.42.0.0/32 scope global flannel.1
  inet6 fe80::80b3:b3ff:fe99:6608/64 scope link
  inet6 fe80::cc52:c4ff:fe0f:22d/64 scope link
  inet6 fe80::280d:a4ff:fe63:cbb3/64 scope link
  inet6 fe80::c8b0:e8ff:fe20:2c58/64 scope link
  inet6 fe80::e0a6:9fff:fe85:af5d/64 scope link
  inet6 fe80::4471:9fff:fec8:6360/64 scope link
  inet6 fe80::2c8a:5aff:fe9a:3382/64 scope link
  inet6 fe80::5c42:ecff:fe04:f64d/64 scope link
  inet6 fe80::a977:d5ff:fe50:5d5/64 scope link
root@RINKU-K8S01:~# curl 192.168.2.236:31223
  ▶ 192.168.2.236:31223
  ▶ Not secure 192.168.2.236:31223
  ▶ Pathways email ① Jasperactive ② Ed2Go Pathways ③ Browse Online
Pretty-print □
"Hello World!"
```

Ubuntu Server AutoScale Deployment Pyapp, Get Node, Get HPA, Get Pod, Get Service, Get Namespaces

```

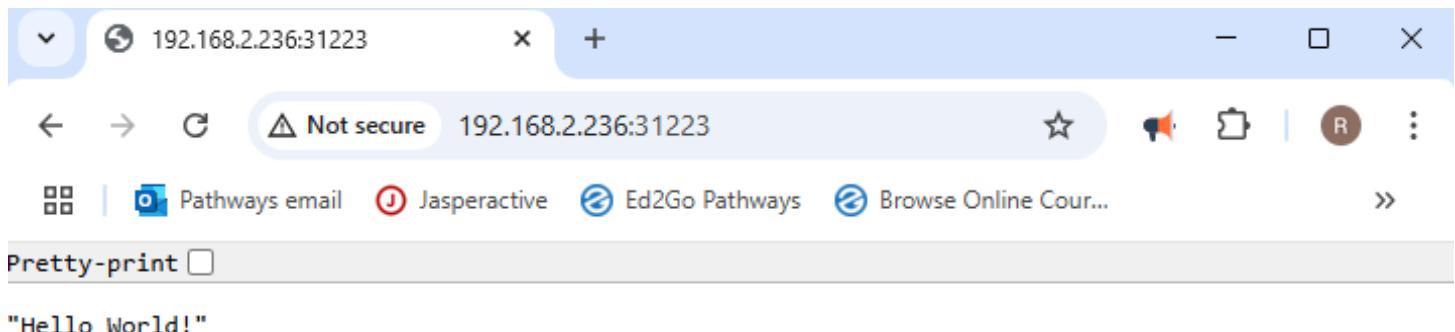
root@RINKU-K8S01:~# kubectl edit deployment pyapp -n pyapp
deployment.apps/pyapp edited
root@RINKU-K8S01:~# kubectl edit deployment pyapp -n pyapp
Edit cancelled, no changes made.
root@RINKU-K8S01:~# kubectl autoscale deployment pyapp --min=3 --max=6 --cpu-percent=80 -n pyapp
horizontalpodautoscaler.autoscaling/pyapp autoscaled
root@RINKU-K8S01:~# kubectl get hpa -n pyapp
NAME      REFERENCE      TARGETS      MINPODS   MAXPODS   REPLICAS   AGE
pyapp    Deployment/pyapp  cpu: <unknown>/80%  3          6          0          9s
root@RINKU-K8S01:~# kubectl get node
NAME      STATUS      ROLES      AGE      VERSION
rlink-k8s01  Ready      control-plane,master  71m      v1.32.3+k3s1
root@RINKU-K8S01:~# kubectl get pod -A
NAMESPACE      NAME      READY      STATUS      RESTARTS      AGE
kube-system    coredns-ff8999cc5-vdcfn      1/1      Running      0          72m
kube-system    helm-install-traefik-crd-dd4jj      0/1      Completed      0          72m
kube-system    helm-install-traefik-qwqdn      0/1      Completed      2          72m
kube-system    local-path-provisioner-774c6665dc-csv5z      1/1      Running      0          72m
kube-system    metrics-server-6f4c6675d5-jzj92      1/1      Running      0          72m
kube-system    svclb-traefik-8f52a793-sb8zc      2/2      Running      0          71m
kube-system    traefik-67bfb46dcb-vcpdb      1/1      Running      0          71m
pyapp        pyapp-5678d9f847-7gvr5      1/1      Running      0          2m50s
pyapp        pyapp-5678d9f847-fvw25      1/1      Running      0          2m48s
pyapp        pyapp-5678d9f847-nzh51      1/1      Running      0          2m46s
root@RINKU-K8S01:~# kubectl get service -n pyapp
NAME      TYPE      CLUSTER-IP      EXTERNAL-IP      PORT(S)      AGE
pyapp    NodePort      10.43.82.165      <none>      3333:31223/TCP      24m
root@RINKU-K8S01:~# kubectl get namespaces
NAME      STATUS      AGE
default    Active      77m
kube-node-lease  Active      77m
kube-public   Active      77m
kube-system    Active      77m
pyapp        Active      31m

```

Ubuntu Server Deploy Pyapp Configuration

```
root@RINKU-K8S01: ~
Please edit the object below. Lines beginning with a '#' will be ignored,
# and an empty file will abort the edit. If an error occurs while saving this file will be
# reopened with the relevant failures.
#
apiVersion: apps/v1
kind: Deployment
metadata:
  annotations:
    deployment.kubernetes.io/revision: "2"
  creationTimestamp: "2025-04-26T02:05:37Z"
  generation: 3
  labels:
    app: pyapp
  name: pyapp
  namespace: pyapp
  resourceVersion: "2198"
  uid: f5cc48b6-b37a-4297-8b81-43cdb69352de
spec:
  progressDeadlineSeconds: 600
  replicas: 3
  revisionHistoryLimit: 10
  selector:
    matchLabels:
      app: pyapp
  strategy:
    rollingUpdate:
      maxSurge: 25%
      maxUnavailable: 25%
    type: RollingUpdate
  template:
    metadata:
      creationTimestamp: null
      labels:
        app: pyapp
    spec:
      containers:
        - image: jasoneckert/hello-world-python-x86
          imagePullPolicy: Always
          name: hello-world-python-x86
          resources:
            requests:
              cpu: 100m
              memory: 128Mi
          terminationMessagePath: /dev/termination-log
          terminationMessagePolicy: File
        dnsPolicy: ClusterFirst
        restartPolicy: Always
        schedulerName: default-scheduler
        securityContext: {}
-
/tmp/kubectl-edit-1275464791.yaml 1/70 1%
```

Ubuntu Server Web Page



Oracle Cloud VM

RINKU-OCI01	Oracle Cloud Linux VM/ Canonical Ubuntu 20.04 Minimal	Public IP 129.153.49.245 Private IP 10.0.0.58	Ubuntu	1 GB Memory	1 Core
-------------	---	--	--------	----------------	--------

Ubuntu Cloud VM Configurations

RINKU-OCI01 Running

Instance details

Details Networking Storage Security Management OS Management Monitoring Work requests Tags

General information		Launch options	
Availability domain	AD-1	NIC attachment type	PARAVIRTUALIZED
Fault domain	FD-3	Remote data volume	PARAVIRTUALIZED
Region	ca-toronto-1	Firmware	UEFI_64
OCID	...ronto-1.an2g6ljrwp7o4ficyikbyqwloori2cylh4ezilhpmeswqraxq2js6zasq	Boot volume type	PARAVIRTUALIZED
Launched	Thu, May 08, 2025, 00:38:13 UTC	In-transit encryption	Disabled
Compartment	rinkupatel (root)	Secure Boot	Disabled
Capacity type	On-demand	Measured Boot	Disabled
		Trusted Platform Module	Disabled
		Confidential computing	Disabled

Instance access

You [connect to a running Linux instance](#) using a Secure Shell (SSH) connection. You'll need the private key from the SSH key pair [attached to this instance](#).

Public IP address	129.153.49.245	...
Username	ubuntu	

Instance details

Virtual cloud network	vcn-project	
Maintenance reboot	—	
Launch mode	PARAVIRTUALIZED	
Instance metadata service	Versions 1 and 2	Edit
	The instance metadata service provides metadata about the instance. Applications can use this metadata to bootstrap or do other tasks.	

Image details

Operating system	Canonical Ubuntu
Version	20.04 Minimal
Image	Canonical-Ubuntu-20.04-Minimal-2025.03.28-0

Shape	VM.Standard.E2.1.Micro
	This shape does not support resizing. Learn more
OCPU count	1
Network bandwidth (Gbps)	0.48
Memory (GB)	1
Local disk	Block storage only

Disaster recovery

The list of [Disaster Recovery Protection Groups](#) that have this instance as a member. This | insufficient policy permissions access to a group or groups.

Full stack DR	Not enabled
---------------	-------------

Ubuntu Cloud RINKU-OCI01 Instance

Instances

An [instance](#) is a compute host. Choose between virtual machines (VMs) and bare metal instances. The image that you use to launch an instance defines the configuration of your instance.

Search and Filter

Applied filters Compartment rinkupatel (root)

Create instance Actions

	Name ↑	State ↑	Public IP ↑	Private IP ↑	Shape ↑	OCPUs
<input type="checkbox"/>	RINKU-OCI01 Always Free	Running	129.153.49.245	10.0.0.58	VM.Standard.E2.1.Micro	1
<input type="checkbox"/>	UbuntuServer2 Always Free	Terminated	-	-	VM.Standard.E2.1.Micro	1
<input type="checkbox"/>	UbuntuServer1 Always Free	Running	129.153.53.34	10.0.0.9	VM.Standard.E2.1.Micro	1

Ubuntu Cloud VCN Configuration and Ubuntu Cloud Subnet Configuration

← vcn-project

subnet-project Available

Subnet

vcn-project Available

Virtual Cloud Network

Details IP administration Subnets Gateways Routing Security VLANs

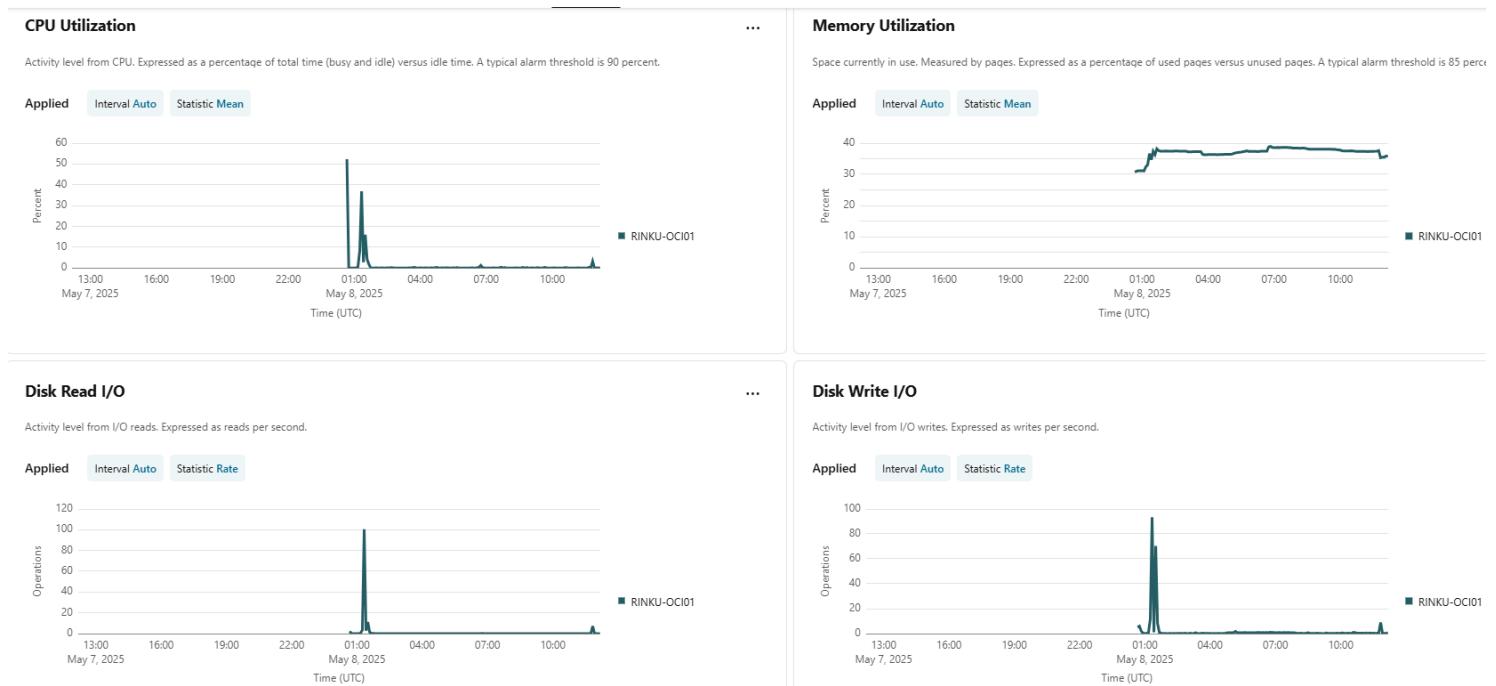
VCN Information

Compartment	rinkupatel (root)
Created	Apr 30, 2025, 13:27 UTC
IPv4 CIDR Block	10.0.0.0/16
IPv6 Prefix	—
OCID	...nto-1.amaaaaaawp7o4fiadx5thyyzzhtc6lbrhfvsoxqgi4pgcip
DNS Resolver	vcn-project
Default Route Table	Default Route Table for vcn-project
DNS Domain Name	vcn04300927.oraclevcn.com

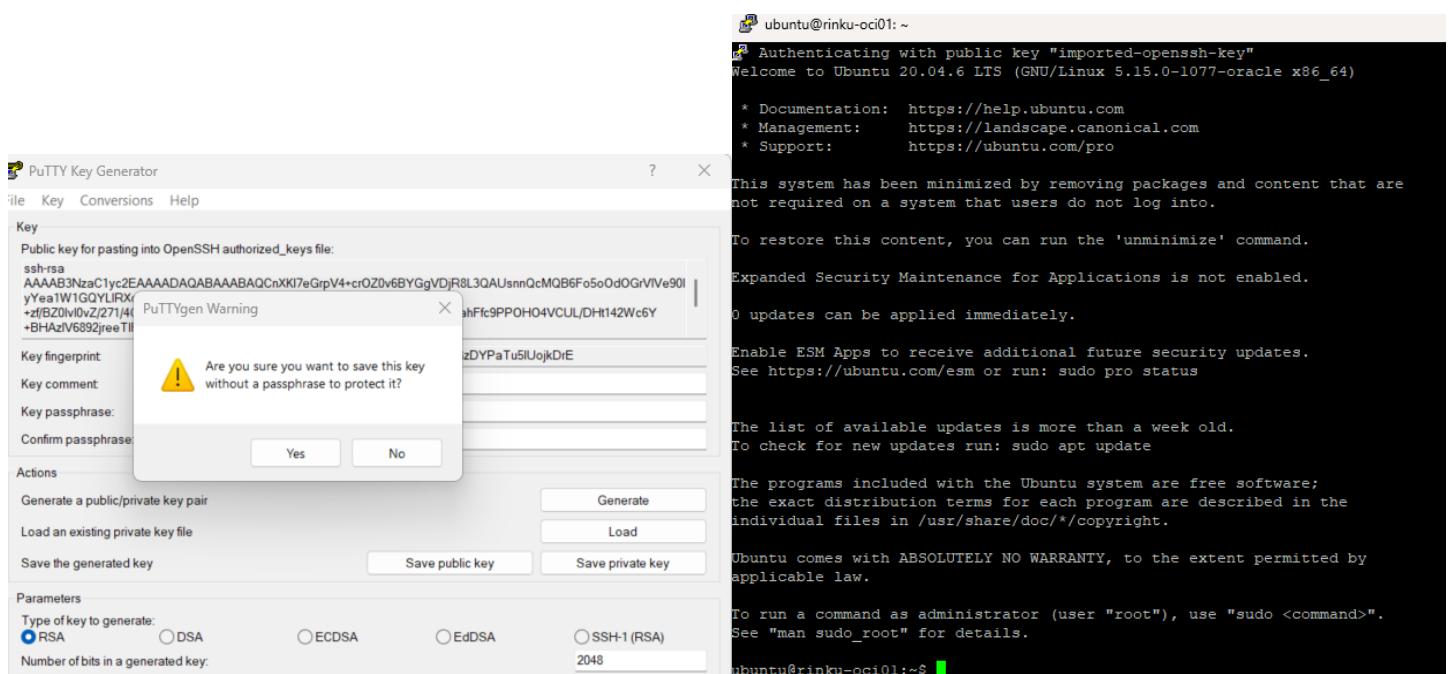
Subnet Information

OCID	...aaaovbegdk34av5aqvhoybiz4ygryd77gafebmlmna2c5mt3uwkd2qa
IPv4 CIDR Block	10.0.0.0/24
IPv6 Prefix	—
Virtual Router MAC Address	00:00:17:16:A3:80
Subnet Type	Regional
Availability Domain	—
Compartment	rinkupatel (root)
DNS Domain Name	subnet04300927.vcn04300927.oraclevcn.com
Subnet Access	Public Subnet
DHCP Options	Default DHCP Options for vcn-project
Route Table	Default Route Table for vcn-project

Ubuntu Cloud Baselines



Ubuntu Cloud Puttygen Key Conversion and Login with SSH with Putty



Ubuntu Cloud Hostname, IP configuration, Ping google.ca

```
root@rinku-oci01:~#
root@rinku-oci01:~# hostname
rinku-oci01
root@rinku-oci01:~# ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group
0
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: ens3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 9000 qdisc pfifo_fast state
t qlen 1000
    link/ether 02:00:17:03:65:94 brd ff:ff:ff:ff:ff:ff
    altnet enp0s3
    inet 10.0.0.58/24 metric 100 brd 10.0.0.255 scope global ens3
        valid_lft forever preferred_lft forever
    inet6 fe80::17ff:fe03:6594/64 scope link
        valid_lft forever preferred_lft forever
root@rinku-oci01:~# ping google.ca
PING google.ca (172.217.165.3): 56 data bytes
64 bytes from 172.217.165.3: icmp_seq=0 ttl=118 time=1.486 ms
64 bytes from 172.217.165.3: icmp_seq=1 ttl=118 time=1.588 ms
64 bytes from 172.217.165.3: icmp_seq=2 ttl=118 time=1.560 ms
^C--- google.ca ping statistics ---
3 packets transmitted, 3 packets received, 0% packet loss
round-trip min/avg/max/stddev = 1.486/1.545/1.588/0.043 ms
root@rinku-oci01:~#
```

Ubuntu Cloud Updates

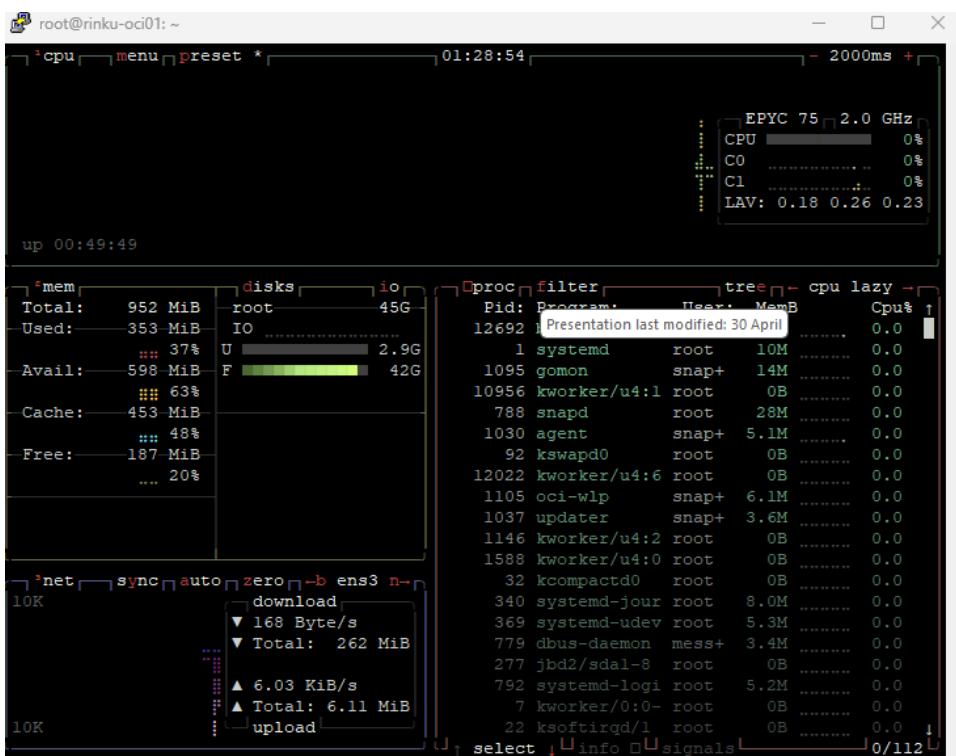
```
done
root@rinku-oci01:~# apt update
Hit:1 http://security.ubuntu.com/ubuntu focal-security InRelease
Hit:2 http://ca-toronto-1-ad-1.clouds.archive.ubuntu.com/ubuntu focal InRelease
Hit:3 http://ca-toronto-1-ad-1.clouds.archive.ubuntu.com/ubuntu focal-updates InRelease
Hit:4 http://ca-toronto-1-ad-1.clouds.archive.ubuntu.com/ubuntu focal-backports InRelease
Reading package lists... Done
Building dependency tree
Reading state information... Done
All packages are up to date.
root@rinku-oci01:~# apt upgrade
Reading package lists... Done
Building dependency tree
Reading state information... Done
Calculating upgrade... Done
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
root@rinku-oci01:~#
```

Ubuntu Cloud Neofetch

```
Processing triggers for libgdk-pixbuf2.0-common (2.40.0-14.14.1ubuntu0.1) ...
root@rinku-oci01:~# neofetch
./+ooooooooo+-.
`:+ssssssssssssssssss+-+
 +ssssssssssssssssssyyssss+-+
 .ossssssssssssssssssdMMMyssssso.
 /ssssssssssshdmNNmmyNMMMNhsssssss/
 +ssssssssssshmydMMMMMMMddddyssssss+-+
 /ssssssssshNMMMyhyyyyhmNMMMNhsssssss/
 .ssssssssdMMMNhssssssssshhNMMDssssssss.
 +sssshhhNMMNyssssssssssssyNMMMyssssss+-+
 .ssssssssdMMMNhssssssssshhNMMDssssssss.
 /ssssssssshNMMMyhyyyyhdMMMNhsssssss/
 +ssssssssssshmydMMMMMMMddddyssssss+-+
 /sssssssssshdmNNNmyNMMMNhsssssss/
 .ossssssssssssssssssdMMMyssssso.
 -+ssssssssssssssssyyssss+-+
 `:+ssssssssssssssss+-+
 ./+ooooooooo+-.

root@rinku-oci01
-----
OS: Ubuntu 20.04.6 LTS x86_64
Host: KVM/QEMU (Standard PC (i440FX + PIIX, 19
Kernel: 5.15.0-1077-oracle
Uptime: 49 mins
Packages: 506 (dpkg), 6 (snap)
Shell: bash 5.0.17
Resolution: 1280x800
CPU: AMD EPYC 7551 (2) @ 1.996GHz
Memory: 202MiB / 952MiB
```

Ubuntu Cloud Btop



Ubuntu Cloud Firewall Iptables-Rules

```
root@rinku-oci01:~# iptables -L
Chain INPUT (policy ACCEPT)
target     prot opt source          destination
           prot opt source          destination

Chain FORWARD (policy ACCEPT)
target     prot opt source          destination
           prot opt source          destination

Chain OUTPUT (policy ACCEPT)
target     prot opt source          destination
           prot opt source          destination

Chain InstanceServices (0 references)
target     prot opt source          destination
root@rinku-oci01:~# netfilter-persistent save
run-parts: executing /usr/share/netfilter-persistent/plugins.d/15-ip4tables save
run-parts: executing /usr/share/netfilter-persistent/plugins.d/25-ip6tables save
root@rinku-oci01:~#
```

Ubuntu Cloud Ingress Rules

Ingress Rules

Ingress Rules								
Ingress Rules								
Actions	Edit							
	Stateless	Source	IP Protocol	Source Port Range	Destination Port Range	Type and Code	Allows	Description
<input type="checkbox"/>	No	0.0.0.0/0	TCP	All	22			TCP traffic for ports: 22 SSH Remote Login Protocol
<input type="checkbox"/>	No	0.0.0.0/0	ICMP		3..4			ICMP traffic for: 3..4 Destination Unreachable: Fragmentation Needed and Don't Fragment was Set
<input type="checkbox"/>	No	10.0.0.0/16	ICMP		3			ICMP traffic for: 3 Destination Unreachable
<input type="checkbox"/>	No	0.0.0.0/0	TCP	All	80			Allow inbound HTTP
<input type="checkbox"/>	No	0.0.0.0/0	TCP	All	443			Allow inbound HTTPS

Ubuntu Cloud Apache2

The screenshot shows a web browser window with the title "Apache2 Ubuntu Default Page". The page features the Ubuntu logo and the text "It works!". Below this, there is a message about the default welcome page and instructions to replace the index.html file. The browser's address bar shows "Not secure 129.153.49.245". The toolbar includes icons for back, forward, search, and refresh.

Ubuntu Cloud SSH Login Proxmox

```
root@Proxmox:~# ssh ubuntu@129.153.49.245
Welcome to Ubuntu 20.04.6 LTS (GNU/Linux 5.15.0-1077-oracle x86_64)

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

 * Strictly confined Kubernetes makes edge and IoT secure. Learn how MicroK8s
 just raised the bar for easy, resilient and secure K8s cluster deployment.

 https://ubuntu.com/engage/secure-kubernetes-at-the-edge

This system has been minimized by removing packages and content that are
not required on a system that users do not log into.

To restore this content, you can run the 'unminimize' command.

Expanded Security Maintenance for Applications is not enabled.

0 updates can be applied immediately.

4 additional security updates can be applied with ESM Apps.
Learn more about enabling ESM Apps service at https://ubuntu.com/esm

New release '22.04.5 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

*** System restart required ***
Last login: Thu May  8 12:40:12 2025 from 174.95.195.13
ubuntu@rinku-oci01:~$
```

Ubuntu Cloud Ping Success

```
root@Proxmox:~# ansible -i hosts.inventory all -m ping
129.153.49.245 | SUCCESS => {
    "ansible_facts": {
        "discovered_interpreter_python": "/usr/bin/python3"
    },
    "changed": false,
    "ping": "pong"
```

Security & Authentication

Two-Factor Authentication (2FA) on RINKU-PX01

The screenshot shows the Proxmox Virtual Environment (VE) interface. On the left, the "Datacenter" tree view shows several virtual machines: 102 (RINKU-WEB01), 100 (RINKU-WIN01), 104 (RINKU-K8S01), 101 (RINKU-WinSer-Template), and 103 (RINKU-UbuntuSer-Template). The main panel displays a table for Two-Factor Authentication (TFA) users. A row for "root@pam" is selected, showing "Enabled: Yes", "TFA Type: totp", "Created: 2025-05-01 22:23:43", and "Description: Two-Factor Authentication on RINKU-PX01". The table has columns for User, Enabled, TFA Type, Created, and Description.

System Templates

Windows Server Template

The screenshot shows the Proxmox Virtual Environment 8.2.2 interface. On the left, the 'Server View' sidebar lists several virtual machines and storage configurations under the 'Datacenter' section. The '101 (RINKU-WinSer-Template)' item is selected. The main panel displays the configuration for 'Virtual Machine 101 (RINKU-WinSer-Template) on node 'Proxmox''. The 'Hardware' tab is active, showing the following specifications:

Setting	Value
Memory	4.00 GiB [balloon=0]
Processors	2 (1 sockets, 2 cores) [x86-64-v2-AES]
BIOS	Default (SeaBIOS)
Display	Default
Machine	pc-i440fx-8.1
SCSI Controller	VirtIO SCSI single
CD/DVD Drive (ide0)	local:iso/virtio-win-0.1.266.iso,media=cdrom,size=707456K
CD/DVD Drive (ide2)	cdrom,media=cdrom
Hard Disk (scsi0)	local-lvm:base-101-disk-1,iothread=1,size=32G
Network Device (net0)	virtio=BC:24:11:27:1F:9F,bridge=vmbr0,firewall=1
TPM State	local-lvm:base-101-disk-1,size=4M,version=v2.0

Ubuntu Server Template

The screenshot shows the Proxmox Virtual Environment 8.2.2 interface. The 'Server View' sidebar lists several virtual machines and storage configurations under the 'Datacenter' section. The '103 (RINKU-UbuntuSer-Template)' item is selected. The main panel displays the configuration for 'Virtual Machine 103 (RINKU-UbuntuSer-Template) on node 'Proxmox''. The 'Hardware' tab is active, showing the following specifications:

Setting	Value
Memory	3.00 GiB [balloon=0]
Processors	2 (1 sockets, 2 cores) [x86-64-v2-AES]
BIOS	Default (SeaBIOS)
Display	Default
Machine	Default (i440fx)
SCSI Controller	VirtIO SCSI single
CD/DVD Drive (ide2)	cdrom,media=cdrom
Hard Disk (scsi0)	local-lvm:base-103-disk-0,iothread=1,size=32G
Network Device (net0)	virtio=BC:24:11:3C:00:D4,bridge=vmbr0,firewall=1

Proxmox Backup Process (SMB/CIFS Setup)

Backup_Storage	SMB/CIFS Backup Storage		backup_user	Proxmox_Backups
----------------	-------------------------	--	-------------	-----------------

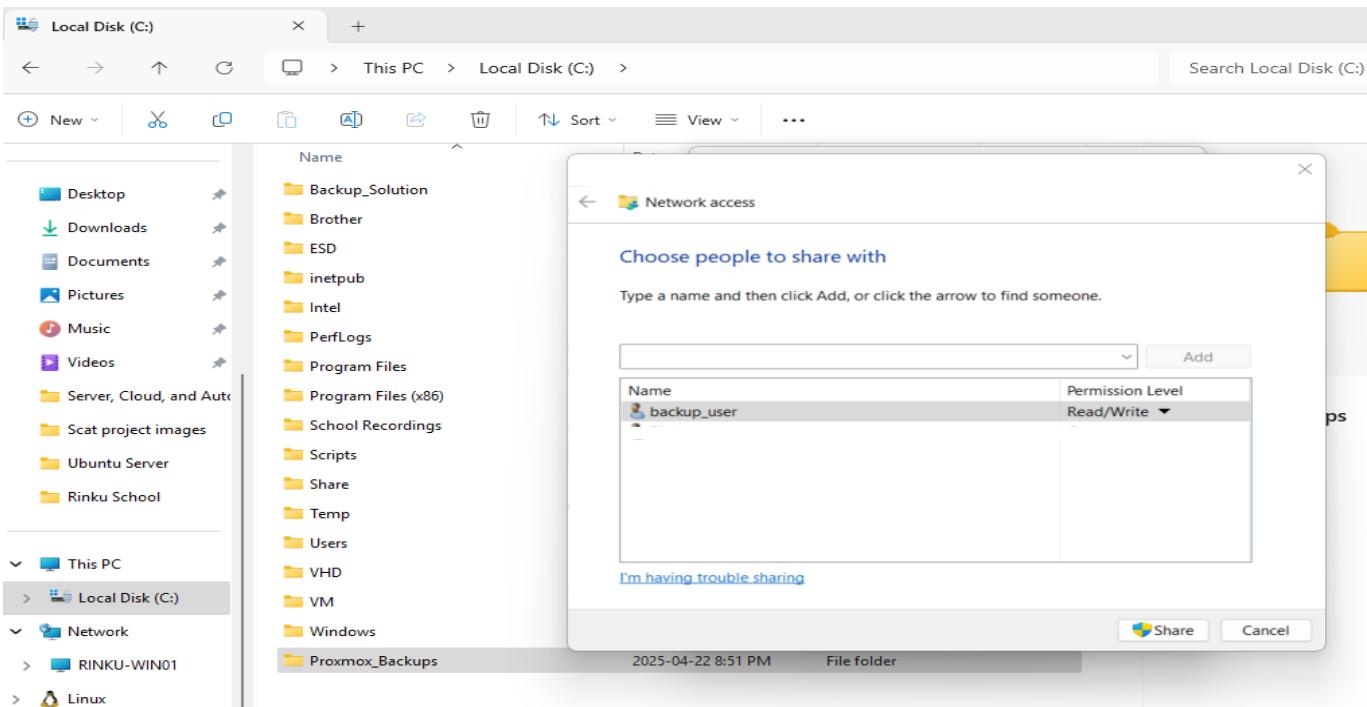
Backup IP Configuration

```
Administrator: Command Prompt
Subnet Mask . . . . . : 255.255.0.0
Default Gateway . . . . . :

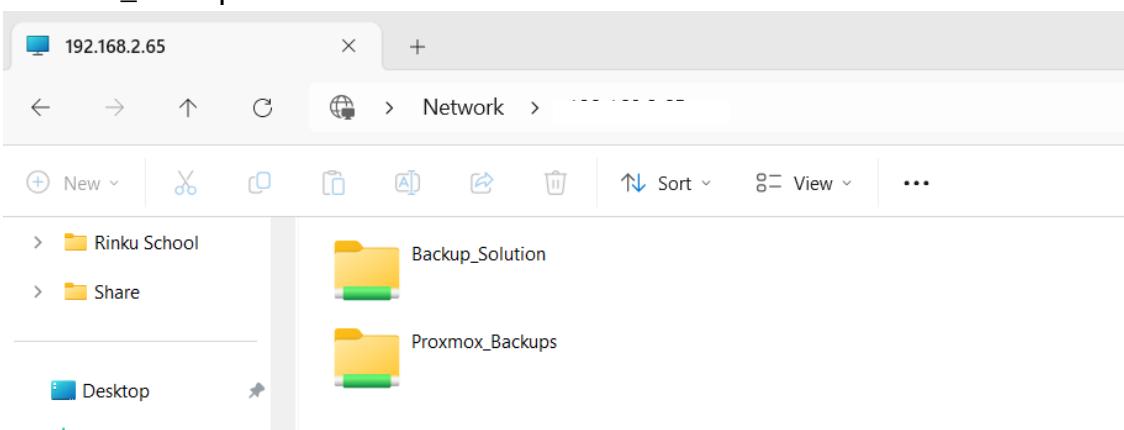
Ethernet adapter vEthernet (External):

Connection-specific DNS Suffix . . . . . :
Link-local IPv6 Address . . . . . :
IPv4 Address . . . . . :
Subnet Mask . . . . . :
Default Gateway . . . . . :
```

Proxmox_Backups Folder and Backup_User Configuration



Proxmox_Backups Folder



Proxmox Backup_Storage Configuration

Add: SMB/CIFS

General **Backup Retention**

ID:	Backup_Storage	Nodes:	All (No restrictions)
Server:	[REDACTED]	Enable:	<input checked="" type="checkbox"/>
Username:	backup_user	Content:	VZDump backup file
Password:	[REDACTED]	Domain:	[REDACTED]
Share:	Proxmox_Backups	Subdirectory:	/some/path

Preallocation: Default

Help **Advanced** **Add**

Proxmox Backup_Storage Added

ID	Type	Content	Path/Target	Shared	Enabled
Backup_Storage	SMB/CIFS	VZDump backup file	/mnt/pve/Backup_Storage	Yes	Yes
local	Directory	VZDump backup file, ISO Image, Container template	/var/lib/vz	No	Yes
local-lvm	LVM-Thin	Disk image, Container		No	Yes

Proxmox_Backups Folder

Virtual Machine 100 (RINKU-WIN01) on node 'Proxmox' No Tags

Name	Date modified	Type
vzdump-qemu-100-2025_04_18-03_47_38.vma.gz	2025-04-22 9:21 PM	Text Document
vzdump-lxc-102-2025_04_18-03_39_20.tar	2025-04-18 3:39 AM	Compressed Archive Fo..
vzdump-lxc-102-2025_04_18-03_39_20.tar.gz.notes	2025-04-22 9:21 PM	NOTES File
vzdump-qemu-100-2025_04_18-03_47_38	2025-04-22 9:39 PM	Text Document
vzdump-qemu-100-2025_04_18-03_47_38.vma.gz.notes	2025-04-18 3:47 AM	Compressed Archive Fo..
vzdump-qemu-100-2025_04_18-03_47_38.vma.gz	2025-04-22 9:39 PM	NOTES File
vzdump-qemu-104-2025_04_18-03_42_15	2025-04-22 9:26 PM	Text Document
vzdump-qemu-104-2025_04_18-03_42_15.vma.gz	2025-04-18 3:42 AM	Compressed Archive Fo..
vzdump-qemu-104-2025_04_18-03_42_15.vma.gz.notes	2025-04-22 9:26 PM	NOTES File

Conclusion

This hybrid cloud project successfully integrates Proxmox, Kubernetes, and Oracle Cloud Infrastructure (OCI) to create a scalable, efficient, and highly resilient environment for hosting and managing applications. By combining on-premises virtualization with cloud-based solutions, the project ensures flexibility, automation, and improved performance. The implementation of Ansible for configuration management streamlines system deployment, while Kubernetes (k3s) enhances container orchestration and scalability. The integration of Proxmox Backup further strengthens data security and recovery strategies.

Key Findings & Learnings

- **Hybrid Cloud Efficiency:** The combination of private and public cloud components balances cost, security, and scalability.
- **Automation & Management:** Using Ansible simplifies infrastructure provisioning and configuration.
- **Containerization with Kubernetes:** K3s provides a lightweight, effective solution for deploying and managing applications.
- **Security Enhancements:** Enabling Two-Factor Authentication (2FA) on Proxmox adds an extra layer of protection for system access.

Future Enhancements

- **Advanced Monitoring:** Implement Prometheus & Grafana for real-time performance insights.
- **Infrastructure as Code (IaC):** Expand Ansible playbooks for fully automated deployments.
- **Cloud Optimization:** Further refine OCI configurations for improved resource allocation.
- **Networking Enhancements:** Introduce Ingress and Load Balancing for optimized traffic handling.

Through strategic integration of virtualization, automation, and containerization, this hybrid cloud infrastructure is both future-ready and adaptable, ensuring a robust foundation for scaling and extending functionality.