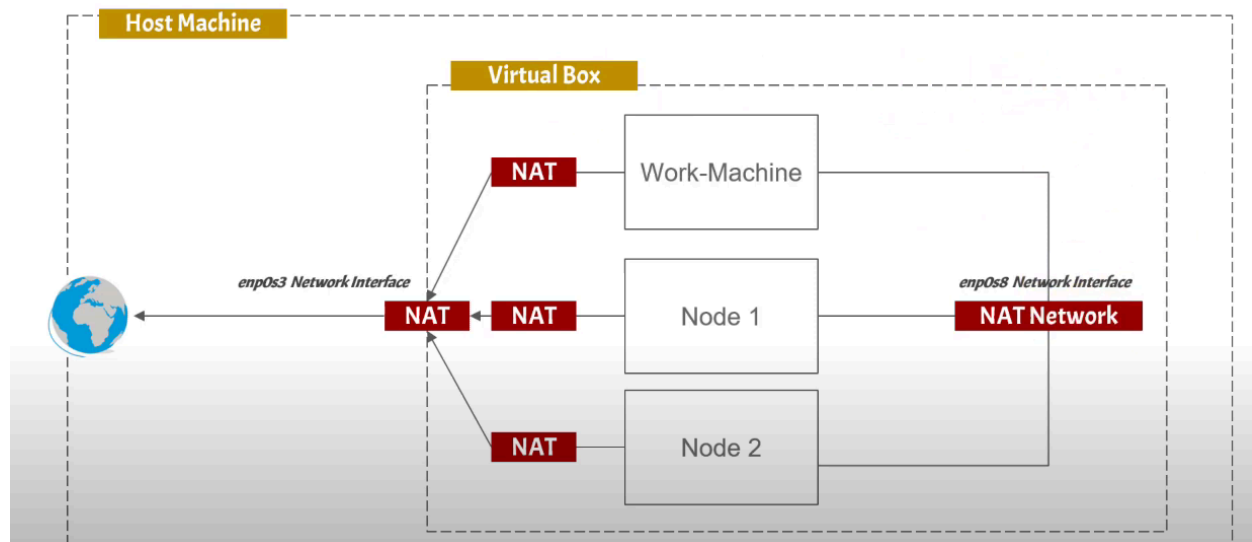Guide to setting up your three-node Ubuntu cluster (control-server, work-server-1, work-server-2) in VirtualBox with internet access (NAT) and a private internal network (192.168.1.x) for secure command and control via passwordless SSH.

Network Setup

Goal: Create 3 Ubuntu VMs (ctrl-node, work-node-1, work-node-2) where:

- Each VM can access the internet independently.
- VMs communicate with each other over a private network (192.168.1.0/24).
- master-ctrl-node can SSH into work-node-1 and work-node-2 without a password.

Current Date: Monday, April 7, 2025

Phase 0: Prerequisites & Planning

1. **Software:**
   - Oracle VirtualBox installed on your host machine.
   - Ubuntu Server ISO image downloaded (Recommended: Latest LTS version, e.g., 22.04 or 24.04). Using Server edition is more lightweight.
2. **Naming & User:**
   - VM/Hostnames: ctrl-node, work-node-1, work-node-2
   - Consistent Username: Choose a username for administration on all nodes (e.g., clusteradmin).
3. **IP Addressing Scheme:**
   - **Adapter 1 (Internet):** Will use **NAT** mode. VirtualBox provides DHCP (typically 10.0.2.x). No static configuration needed within Ubuntu for this adapter.

- ○ **Adapter 2 (Internal):** Will use **Internal Network** mode named cluster-net. Static IPs will be assigned within Ubuntu:
  - ctrl-node: 192.168.1.100
  - work-node-1: 192.168.1.150
  - work-node-2: 192.168.1.200
  - Subnet Mask: 255.255.255.0 (represented as /24)
4. **(CRITICAL) Check for Host IP Conflict:**
   - ○ On your *host* machine (Windows/Mac/Linux), check your own network IP address (ipconfig or ip addr).
   - ○ **If your host machine's network already uses 192.168.1.x:** You MUST choose a *different* private range for your internal network (e.g., 192.168.100.100, 192.168.100.150, 192.168.100.200 with /24). If you proceed with 192.168.1.x in this case, you *will* have network problems. Adjust the static IPs in the steps below if necessary.

Phase 1: VirtualBox Network Setup (Internal Network Identifier)

- While the "Internal Network" is created implicitly when you use its name in VM settings, ensure you use the *exact same name* for all VMs. Let's call it cluster-net. No specific IP configuration is done at the global VirtualBox level for Internal Networks.

Phase 2: Virtual Machine Creation & Initial Configuration

(Repeat these steps for EACH of the 3 VMs: master-node, slave-node-1, slave-node-2)

1. **Open VirtualBox Manager.**
2. Click **New**.
3. **Name:** Enter the specific VM name (e.g., master-node).
4. **ISO Image:** Select your downloaded Ubuntu Server ISO.
5. **(Optional but Recommended):** Check "Skip Unattended Installation" to have full control during install.
6. **Hardware:**
   - ○ **Base Memory:** Allocate sufficient RAM (e.g., 2048 MB or more).
   - ○ **Processors:** Allocate 2 CPUs if possible.
7. **Virtual Hard Disk:**
   - ○ Create a new virtual hard disk.
   - ○ Set size (e.g., 25 GB or more). Use default VDI type and Dynamically allocated is fine.
8. **Review Summary & Click Finish.**

9. **Configure Network Adapters (BEFORE first boot):**
   - Select the newly created VM in VirtualBox Manager.
   - Click **Settings** -> **Network**.
   - **Adapter 1 Tab:**
     - Check **Enable Network Adapter**.
     - **Attached to:** Select **NAT**.
   - **Adapter 2 Tab:**
     - Check **Enable Network Adapter**.
     - **Attached to:** Select **Internal Network**.
     - **Name:** Enter cluster-net (must be identical for all 3 VMs).
   - Click **OK**.

Phase 3: Ubuntu Installation

(Perform these steps on EACH of the 3 VMs, starting them one by one)

1. **Start the VM.** It should boot from the selected ISO.
2. Select "Try or Install Ubuntu Server".
3. **Language Selection:** Choose your language.
4. **Keyboard Configuration:** Select your keyboard layout.
5. **Installation Type:** Choose "Ubuntu Server" (not minimized, unless you prefer).
6. **Network Connections:**
   - The installer should show *two* network interfaces (e.g., enp0s3 and enp0s8).
   - One interface (enp0s3, connected to NAT) should automatically get an IP address via DHCP (like 10.0.2.15/24). This is correct and needed for the installation process.
   - The other interface (enp0s8, connected to Internal Network) will likely show no IP configuration. This is also correct for now.
   - **Do not make changes here.** Select **Done**.
7. **Configure Proxy:** Leave blank unless you use one. Select **Done**.
8. **Configure Ubuntu Archive Mirror:** Use the default mirror. Select **Done**.
9. **Storage Configuration:**
   - Select "Use an entire disk".
   - Select the virtual disk created earlier.
   - Ensure "Set up this disk as an LVM group" is **unchecked** for simplicity (unless you need LVM).
   - Select **Done**. Confirm the destructive action in the next prompt.
10. **Profile Setup:**
    - **Your name:** Enter your name.
    - **Your server's name:** Enter the correct hostname (ctrl-node, work-node-1, work-node-2).

- ○ **Pick a username:** Enter your chosen admin username (e.g., clusteradmin).
- ○ **Choose a password:** Enter a strong password.
- ○ **Confirm your password:** Re-enter the password.
- ○ Select **Done**.
11. **SSH Setup:**
    - ○ **IMPORTANT:** Check the box for **Install OpenSSH server**.
    - ○ Do *not* import SSH identities at this stage.
    - ○ Select **Done**.
12. **Server Snaps:** Select any desired snaps (optional, can be added later). Select **Done**.
13. **Installation:** Wait for the installation process to complete.
14. **Reboot:** When installation finishes, select **Reboot Now**. VirtualBox may prompt you to "remove the installation medium" - press Enter if so.

Phase 4: Post-Installation Configuration (Static IPs & Host Resolution)

(Perform these steps on EACH of the 3 VMs after logging in)

1. Log in using the clusteradmin username and password created during installation.
2. **Identify Network Interface Names:**
   - ○ Run: ip a
   - ○ Note the names of your two interfaces. Typically enp0s3 (for NAT, has 10.0.2.x IP) and enp0s8 (for Internal Network, currently unconfigured or APIPA). **Use your actual interface names in the next step.**
3. **Configure Netplan for Static Internal IP:**
   - ○ Find the netplan config file: ls /etc/netplan/ (often 00-installer-config.yaml).
   - ○ Edit the file: sudo nano /etc/netplan/00-installer-config.yaml (replace filename if different).
   - ○ Make the file content match the template below, **adjusting the interface names (enp0s3, enp0s8) and the static IP address** for each specific node.

Template (Modify IP and Interface Names per node): YAML

```yaml
# This is the network config written by 'subiquity'
network:
  ethernets:
    enp0s3: # <<< YOUR NAT INTERFACE NAME (e.g., enp0s3)
      dhcp4: true
    enp0s8: # <<< YOUR INTERNAL NETWORK INTERFACE NAME (e.g., enp0s8)
      dhcp4: no
      addresses:
        - 192.168.1.100/24 # <<< USE .100 for master, .150 for work-server-1, .200 for work-server-2
      # Note: No gateway is configured for the internal interface
  version: 2
```

4. **Apply Netplan Changes:**
   - Save the file (Ctrl+O, Enter in nano) and Exit (Ctrl+X).
   - Apply: sudo netplan apply (Watch for errors).
5. **Verify IP Configuration:**
   - Run ip a again. Check that your internal interface (enp0s8) now has the correct static IP (192.168.1.100, .150, or .200). The NAT interface (enp0s3) should still have its DHCP address (10.0.2.x).
6. **Configure Hostname Resolution:**
   - Edit the hosts file: sudo nano /etc/hosts
   - Add these three lines (below the existing 127.0.0.1 localhost line):
     192.168.1.100 ctrl-node
     192.168.1.150 work-node-1
     192.168.1.200 work-node-2
     (Use your chosen internal IP range if you changed it due to conflicts).
   - Save and exit. **Ensure this /etc/hosts update is done on ALL THREE nodes.**

Setup Hostname
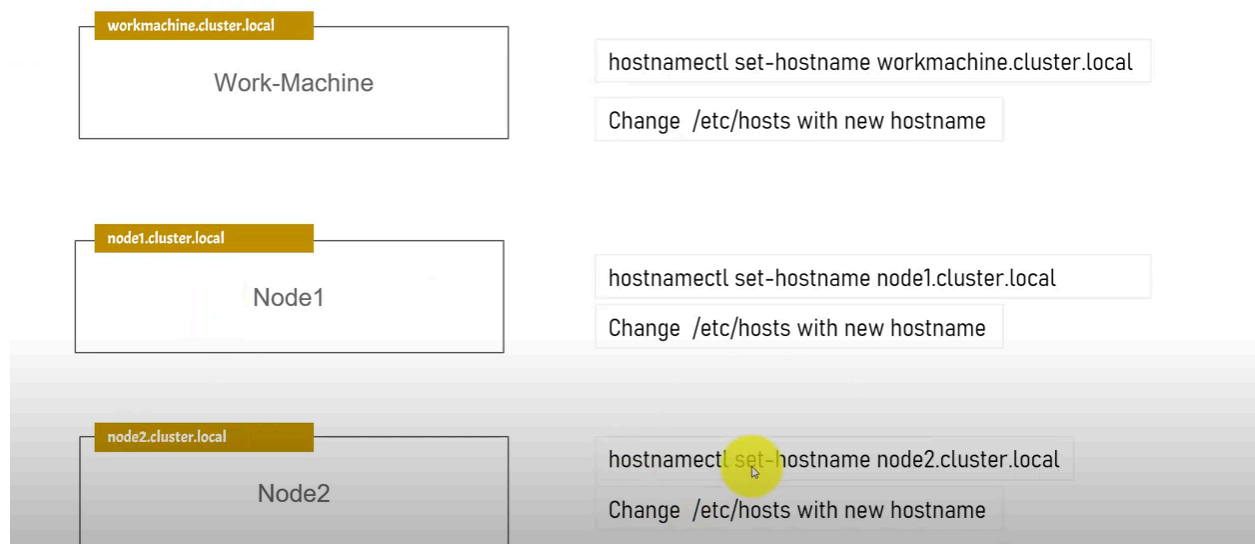
Phase 5: SSH Configuration (Passwordless Access from Master)

(Perform these steps ONLY on master-node)

1. Log in to master-node as clusteradmin.
2. **Generate SSH Key Pair:**
   - Run: ssh-keygen -t rsa -b 4096

- Press Enter to accept the default file location (~/.ssh/id_rsa).
- Press Enter twice to create the key **with no passphrase**.
3. **Copy Public Key to Slaves:**
   - Copy to slave-node-1:
     Bash
     ```
     ssh-copy-id clusteradmin@work-node-1
     ```

     - Type yes if prompted to trust the host key.
     - Enter the clusteradmin password for work-node-1 when prompted.
   - Copy to work-node-2:
     Bash
     ```
     ssh-copy-id clusteradmin@work-node-2
     ```

     - Type yes if prompted.
     - Enter the clusteradmin password for work-node-2 when prompted.

SSH Setup

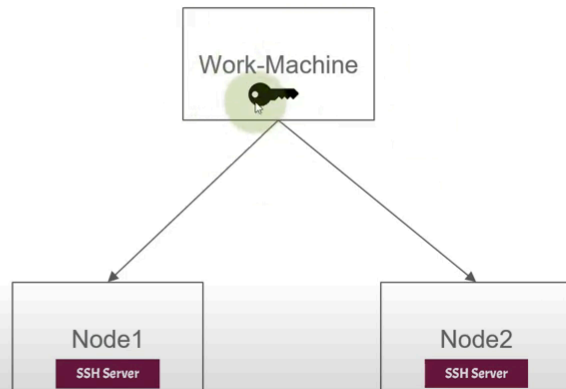Work Machine should be able to ssh to all the other nodes

Install SSH Server on Node1 and Node 2

```
sudo apt install openssh-server
```
```
sudo systemctl status ssh
```
```
sudo systemctl enable ssh
```

Generate SSH key for work machine

Work-Machine

Node1 — SSH Server

Node2 — SSH Server

Phase 6: Verification & Testing

1. **IP Configuration Check:** On each node, run ip a to confirm interfaces (enp0s3 or similar with 10.0.2.x IP, enp0s8 or similar with correct static 192.168.1.x IP).
2. **Internet Access Check:** On each node: ping -c 3 google.com (Should succeed).
3. **Internal Network Ping (IP):**

- From master-ctrl-node: ping -c 3 192.168.1.150 and ping -c 3 192.168.1.200 (Should succeed).
4. **Internal Network Ping (Hostname):**
   - From ctrl-node: ping -c 3 work-node-1 and ping -c 3 work-node-2 (Should succeed).
   - From work-node-1: ping -c 3 ctrl-node (Should succeed).
5. **Passwordless SSH Check:**
   - From master-ctrl-node:

     Bash
     ```
     ssh clusteradmin@work-node-1 'hostname'
     ssh clusteradmin@work-node-2 'hostname'
     ```

     - Each command should immediately return the hostname of the respective work servers (work-node-1 or work-node-2) **without asking for a password**.
6. **(Optional) Basic Security:** Consider enabling the UFW firewall on each node: sudo ufw enable, then sudo ufw allow from 192.168.1.0/24 to any port 22 proto tcp (to ensure SSH still works over the internal network). Keep systems updated: sudo apt update && sudo apt upgrade -y.

Conclusion:

If all verification steps are successful, you now have a working 3-node Ubuntu cluster in VirtualBox. master-ctrl-node can securely control work-node-1 and work-node-2 via passwordless SSH over the dedicated 192.168.1.x internal network, and all nodes retain internet access via their separate NAT interface. You are ready to deploy your cluster applications.