

Linux Cluster System

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Ref: Tzu-Wen Wang

Chih-Yu Hsieh, Shih-Rou Cheng, Wei-Chih Huang

Outline

- BMC Introduction
- PVE Introduction
- Cluster Topology
- Linux Installation
 - Prepare images
 - Partition
- Network Setup
- Linux File Hierarchy
- NFS
- User Authentication

BMC Introduction

Baseboard Management Controller

- An independent chip on server's motherboard
- Power control
- Fan speed control
- Virtual media: iso redirect
- **Console redirection**

Proxmox Virtual Environment (PVE)

- Open-source platform for virtualization
- Built-in web interface
- Easily manage VMs and containers, software-defined storage and networking.
- We use PVE in this training camp.
- Each group will have five virtual machine host on our PVE server.

VPN



Connect to PVE

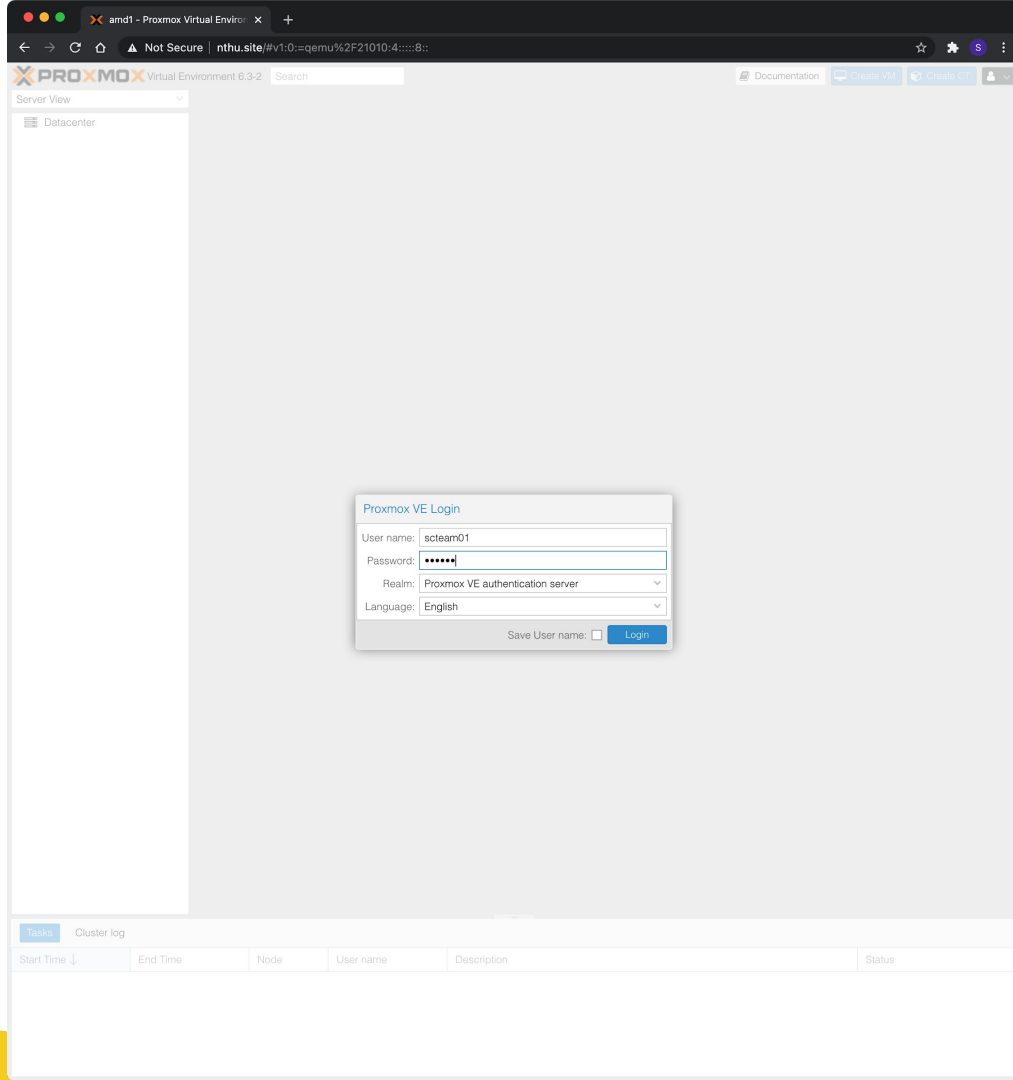
wifi: HPC Camp 1 5G

Password : 20240127

Visit pve.nthu.site

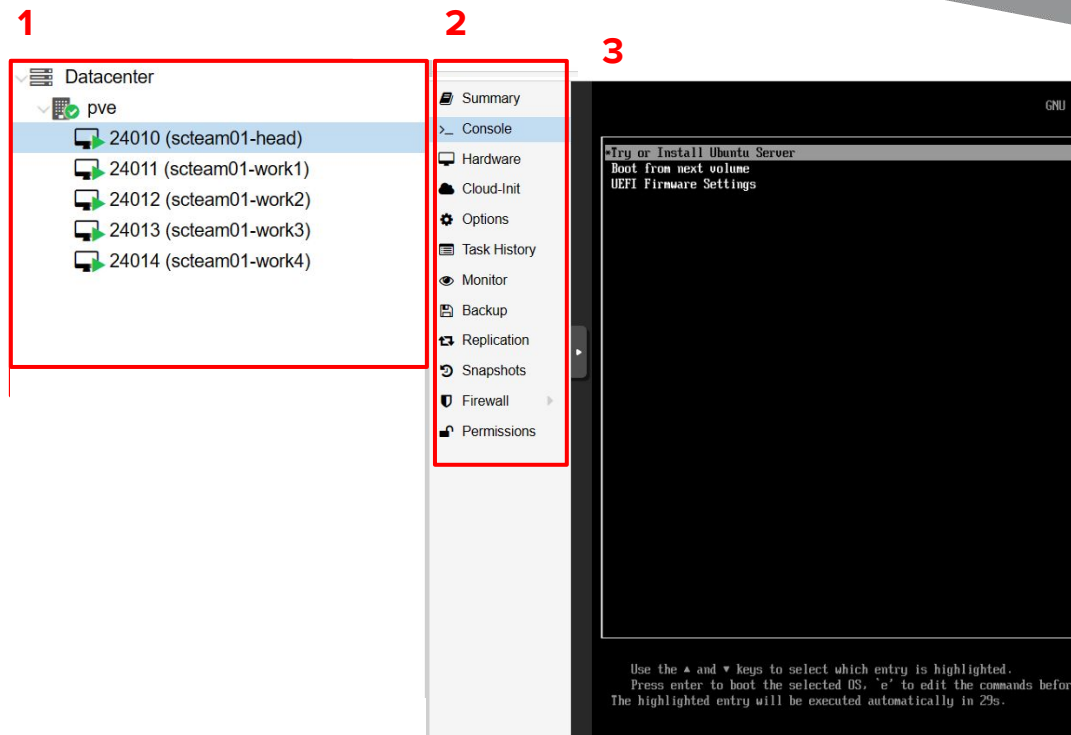
Login to PVE

- Account: scteam0X
 - X is your team number
- Password: nthusc24



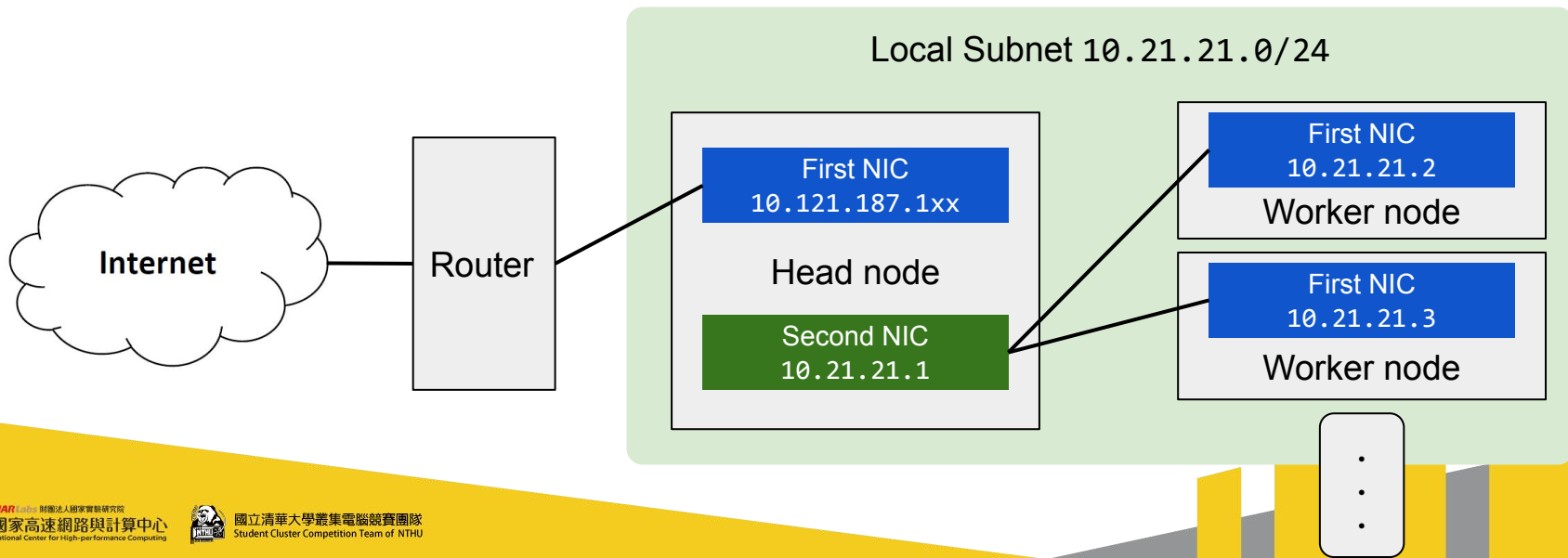
Interface

1. Your five VM here
2. VM's detail
 - a. Console: VNC console
 - b. Hardware: Hardware spec
3. VNC console: We will use this interface to install Linux before we setup ssh.



Cluster Topology

- There are two node each group.
- Head node is the login node. It's responsible for hold userdata (/home), NIS server and forward IP.



Linux Installation

Linux Installation

- We have already prepare the image for you.
- Please select English. This will save time debugging language issues.
- You can choose your own hostname (E.g. bigmac01, bigmac02) or simply use VM id (E.g. vm23XX0, vm23XX1)

Steps

1. Try to install ubuntu
2. Select English
3. Continue without updating
4. No need to change “keyboard configuration”
5. No need to change “type of install”
6. Set up network
 - a. [Head node](#)
 - b. [Work node](#)

Network Configuration

- Use static IPv4
- There are two NIC on head node (net0, net1), one on worker node (net0).
- For head node, please set net0 IP to **10.121.187.11X**
 - Netmask: **255.255.255.0**
 - Gateway: **10.121.187.254**
 - X is your team number. (2~7)
 - For example, team2 should set head node net0 IP to 10.121.187.12
- Set head node net1 IP to **10.21.21.1**
- Set worker node net0 IP to **10.21.21.2~10.21.21.5**

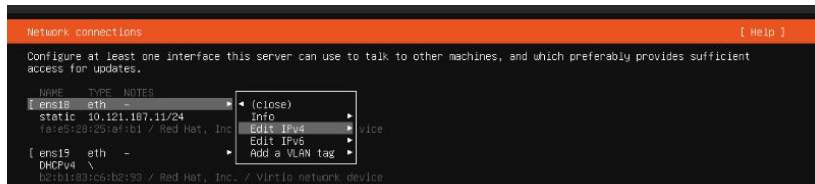
Network-head



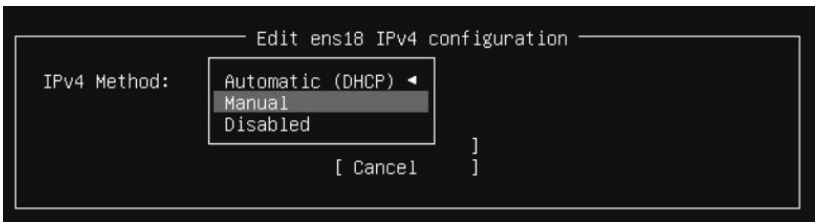
Network configuration

ens18 -> Edit IPv4 -> Manual

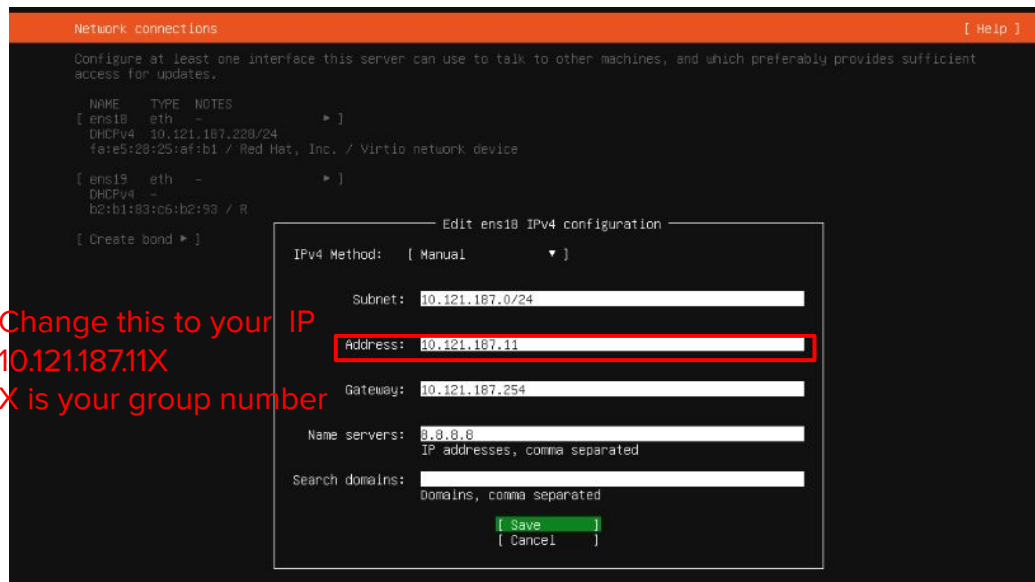
1



2



3



Change this to your IP
10.121.187.11X
X is your group number

ens19-> Edit IPv4 -> Manual

```
Network connections

Configure at least one interface this server can use to talk to other machines, and which preferably provides sufficient
access for updates.

NAME    TYPE  NOTES
[ ens18  eth  -                ▶ ]
static  10.121.187.11/24
fa:e5:28:25:af:b1 / Red Hat, Inc. / Virtio

[ ens19  eth  -                ▶ ]
static  10.21.21.1/24
b2:b1:83:c6:b2:93 / Red Hat, Inc. / Virtio

[ Create bond ▶ ]
```

Network connections [Help]

Configure at least one interface this server can use to talk to other machines, and which preferably provides sufficient access for updates.

NAME	TYPE	NOTES
[ens18	eth	- ▶]
static 10.121.187.11/24		
fa:e5:28:25:af:b1 / Red Hat, Inc. / Virtio network device		
[ens19	eth	- ▶]
DHCPv4 \		
b2:b1:83:c6:b2:93 / R		
[Create bond ▶]		

Edit ens19 IPv4 configuration

IPv4 Method: [Manual ▼]

Subnet: 10.21.21.0/24

Address: 10.21.21.1

Gateway:

Name servers: IP addresses, comma separated

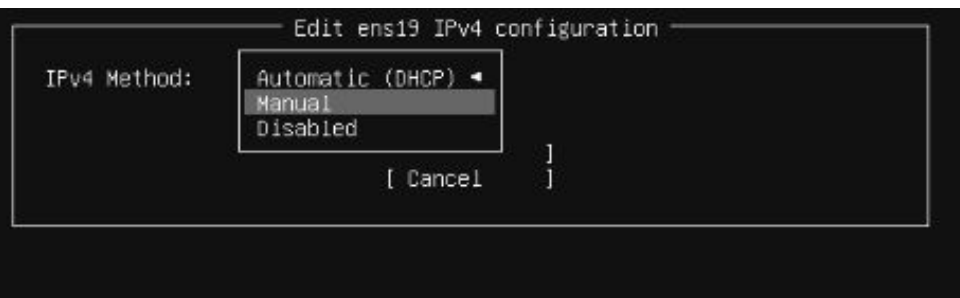
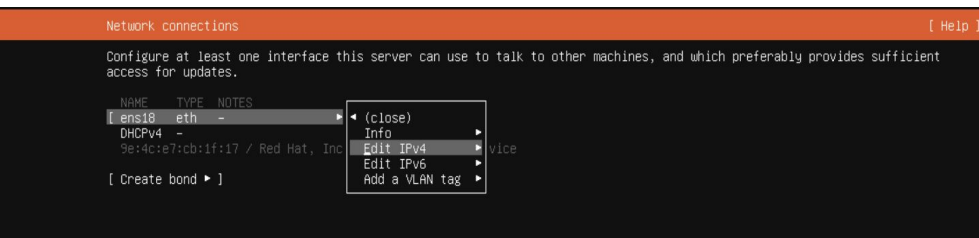
Search domains: Domains, comma separated

[Save]

[Cancel]

Network-work





Net0 in work node(Take work1 for example)

Edit ens18 IPv4 configuration

IPv4 Method: [Manual ▼]

Subnet: 10.21.21.0/24

Address: 10.21.21.2

Gateway: 10.21.21.1

Name servers: 8.8.8.8
IP addresses, comma separated

Search domains:
Domains, comma separated

[Save]
[Cancel]

Address

Work2 :10.21.21.3

Work3:10.21.21.4

work4:10.21.21.5

Steps

1. Select English
2. Continue without updating
3. Set up network
4. No need to set proxy.
5. Use default mirror site.
6. Guided storage configuration: Use an entire disk (default). Or you can set your own partition if you want.
7. NO need to change storage configuration
8. Confirm destructive action =>continue

Profile setup

{username}@{server's name}

Profile setup [Help]

Enter the username and password you will use to log in to the system. You can configure SSH access on the next screen but a password is still needed for sudo.

Your name: shirou

Your server's name: head,work1,work2,work3,work4
the name it uses when it talks to other computers.

Pick a username: scteam01

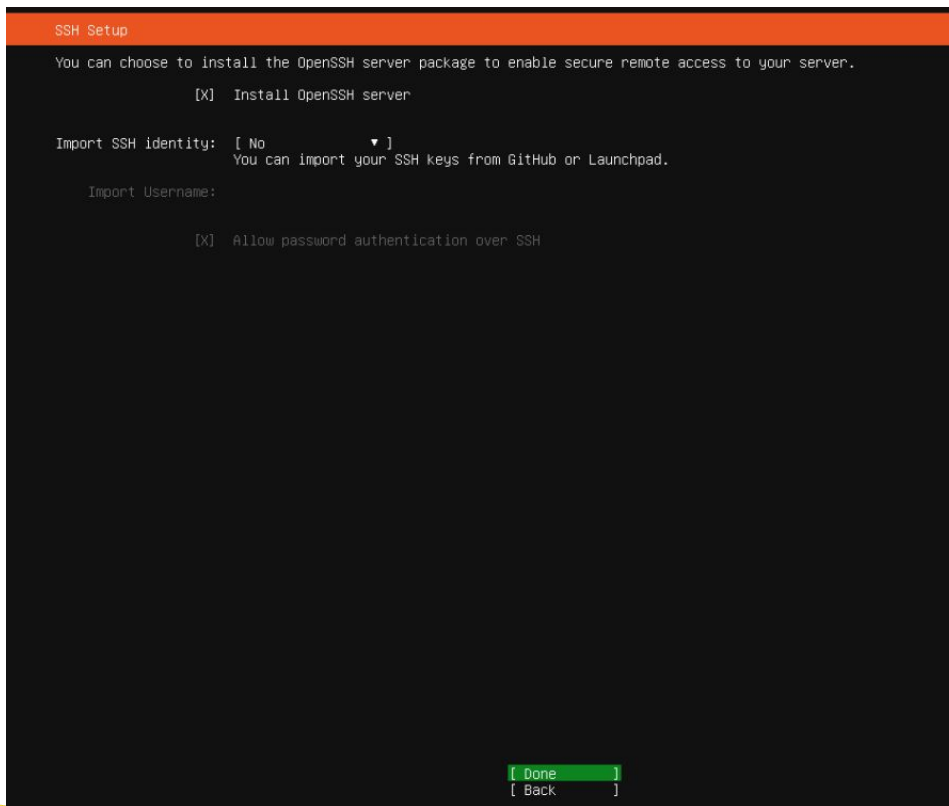
Choose a password: ****

Confirm your password: ****

Set username:scteam0X
X is your team number

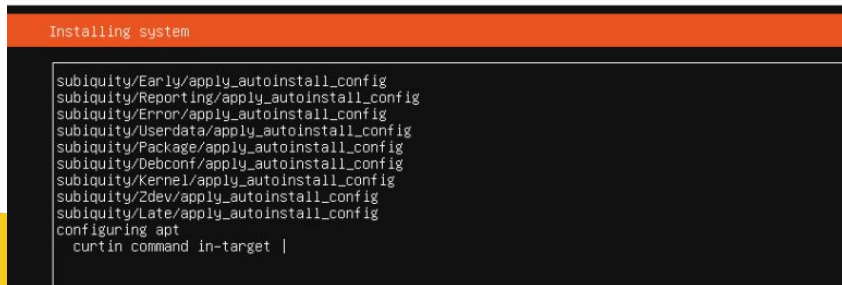
SSH Setup

ens18 -> Edit IPv4 -> Manual



Steps

1. Select English
2. Continue without updating
3. Set up network
4. No need to set proxy.
5. Use default mirror site.
6. Guided storage configuration: Use an entire disk (default). Or you can set your own partition if you want.
7. NO need to change storage configuration
8. Confirm destructive action =>continue
9. No need to change Third-parity drivers
10. No need to set Features Server Snaps
11. Start installing



```
Installing system

subiquity/Early/apply_autoinstall_config
subiquity/Reporting/apply_autoinstall_config
subiquity/Error/apply_autoinstall_config
subiquity/Userdata/apply_autoinstall_config
subiquity/Package/apply_autoinstall_config
subiquity/Debconf/apply_autoinstall_config
subiquity/Kernel/apply_autoinstall_config
subiquity/2dev/apply_autoinstall_config
subiquity/Late/apply_autoinstall_config
configuring apt
curtin command in-target |
```

```
    configuring format: format-2
    configuring mount: mount-2
    configuring mount: mount-1
    configuring mount: mount-0
writing install sources to disk
  running 'curtin extract'
    curtin command extract
      acquiring and extracting image from cp:///tmp/tmp3o8l0o7u/mount
configuring installed system
  running 'mount --bind /cdrom /target/cdrom'
  running 'curtin curthooks'
    curtin command curthooks
      configuring apt
      configuring apt
      installing missing packages
      Installing packages on target system: ['efibootmgr', 'grub-efi-amd64', 'grub-efi-amd64-signed', 'shim-signed']
      configuring iscsi service
      configuring raid (mdadm) service
      installing kernel
      setting up swap
      apply networking config
      writing etc/fstab
      configuring multipath
      updating packages on target system
      configuring pollinate user-agent on target
      updating initramfs configuration
      configuring target system bootloader
      installing grub to target devices
finalizing installation
  running 'curtin hook'
    curtin command hook
  executing late commands
final system configuration
  configuring cloud-init
  calculating extra packages to install
  installing openssh-server
    curtin command system-install
  downloading and installing security updates
    curtin command in-target
  restoring apt configuration
    curtin command in-target
subiquity/Late/run
```

[\[View full log \]](#)[\[Reboot Now \]](#)

Profile Setup – Take head for example

“Your name” is optional

- You can choose whatever you want for your “**server’s name**”, “**username**”, and “**password**”
- However, for your convenience, you might want to **set username and passwd to be the same** :D

Enter a name and password you will use to log in to the system. You can configure ssh access to the system. A password is still needed for sudo.

Your name: shirou

Your server's name: scteam01head

The name it uses when it talks to other computers.

Pick a username: scteam01

Choose a password: ****

Confirm your password: ****

It's installing!

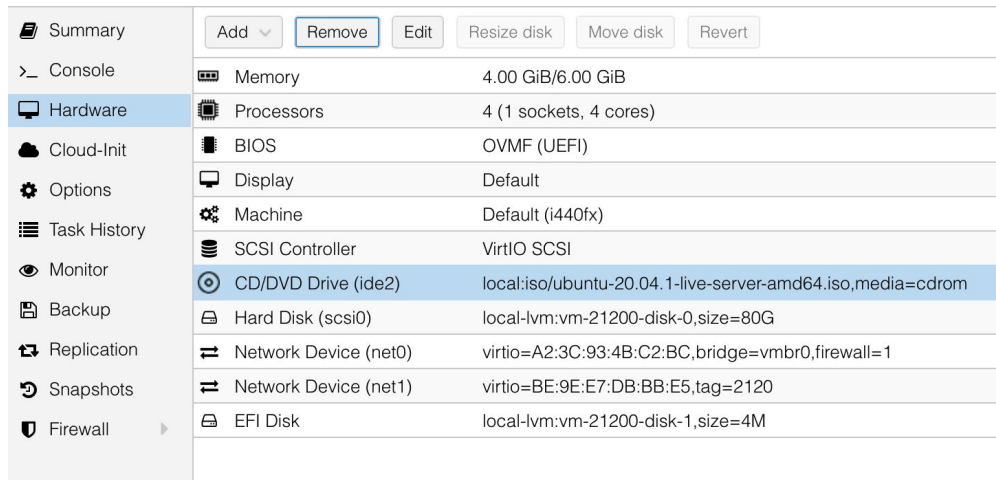
Installing system

[Help]

```
subiquity/Early/apply_autoinstall_config
subiquity/Reporting/apply_autoinstall_config
subiquity/Error/apply_autoinstall_config
subiquity/Userdata/apply_autoinstall_config
subiquity/Package/apply_autoinstall_config
subiquity/Debconf/apply_autoinstall_config
subiquity/Kernel/apply_autoinstall_config
subiquity/Zdev/apply_autoinstall_config
subiquity/Late/apply_autoinstall_config
configuring apt
  curtin command in-target \
```

Remove Disk

- In Hardware page.
- Double click CD/DVD.
- Choose **Do not use**.
- Then **reboot**.



Hardware Configuration	
Memory	4.00 GiB/6.00 GiB
Processors	4 (1 sockets, 4 cores)
BIOS	OVMF (UEFI)
Display	Default
Machine	Default (i440fx)
SCSI Controller	VirtIO SCSI
CD/DVD Drive (ide2)	local:iso/ubuntu-20.04.1-live-server-amd64.iso,media=cdrom
Hard Disk (scsi0)	local-lvm:vm-21200-disk-0,size=80G
Network Device (net0)	virtio=A2:3C:93:4B:C2:BC,bridge=vmbr0,firewall=1
Network Device (net1)	virtio=BE:9E:E7:DB:BB:E5,tag=2120
EFI Disk	local-lvm:vm-21200-disk-1,size=4M

click"reboot"

```
Install complete! [ Help ]

configuring format: format-2
configuring mount: mount-2
configuring mount: mount-1
configuring mount: mount-0
writing install sources to disk
running 'curtin extract'
curtin command extract
  acquiring and extracting image from cp:///tmp/tmpyucf6pr7/mount
configuring installed system
running 'mount --bind /cdrom /target/cdrom'
running 'curtin curthooks'
curtin command curthooks
  configuring apt configuring apt
  installing missing packages
  installing packages on target system: ['efibootmgr', 'grub-efi-amd64', 'grub-efi-amd64-signed', 'shim-signed']
  configuring iscsi service
  configuring raid (mdadm) service
  installing kernel
  setting up swap
  apply networking config
  writing etc/fstab
  configuring multipath
  updating packages on target system
  configuring pollinate user-agent on target
  updating initramfs configuration
  configuring target system bootloader
  installing grub to target devices
finalizing installation
  running 'curtin hook'
  curtin command hook
  executing late commands
final system configuration
  configuring cloud-init
  calculating extra packages to install
  installing openssh-server
  curtin command system-install
  downloading and installing security updates
  curtin command in-target
  restoring apt configuration
  curtin command in-target
subiquity/Late/run
```

[View full log]
[Reboot Now]

Click “enter”

```
Unmounting /tmp/tmpjpkx_3sx/ubutu-server-minimal.squashfs.dir...
[FAILED] Failed unmounting /cdrom.
[ OK ] Unmounted /media/filesystem.
[ OK ] Unmounted /media/minimal.
[ OK ] Unmounted /rofs.
[ OK ] Unmounted /run/credentials/systemd-sysusers.service.
[ OK ] Unmounted Mount unit for core20, revision 1405.
[ OK ] Unmounted /target/boot/efi.
[ OK ] Unmounted /tmp/tmpjpkx_3sx/ubutu-server-minimal.squashfs.dir.
[ OK ] Unmounted /tmp/tmpjpkx_3sx/ubutu-server-minimal.ubuntu-server.squashfs.dir.
Unmounting /target/boot...
[ OK ] Unmounted /media/full.
[ OK ] Unmounted Mount unit for lxd, revision 22923.
[ OK ] Unmounted Mount unit for snapd, revision 15534.
[ OK ] Unmounted Mount unit for subiquity, revision 3359.
[ OK ] Unmounted /target/boot.
Unmounting /target...
[ OK ] Unmounted /run/snapd/ns/lxd.mnt.
Unmounting /run/snapd/ns...
[ OK ] Unmounted /run/snapd/ns.
[ OK ] Unmounted /tmp/tmpjpkx_3sx/root.dir.
Unmounting /tmp...
[ OK ] Unmounted /tmp.
[ OK ] Stopped target Swaps.
[ OK ] Unmounted /target.
[ OK ] Stopped target Preparation for Local File Systems.
[ OK ] Reached target Unmount All Filesystems.
Stopping Monitoring of LVM2 mirrors, snapshots etc. using dmeventd or progress polling...
Stopping Device-Mapper Multipath Device Controller...
[ OK ] Stopped Create Static Device Nodes in /dev.
[ OK ] Stopped Create System Users.
[ OK ] Stopped Device-Mapper Multipath Device Controller.
[ OK ] Stopped Remount Root and Kernel File Systems.
[ OK ] Stopped Monitoring of LVM2 mirrors, snapshots etc. using dmeventd or progress polling.
[ OK ] Reached target System Shutdown.
Starting Shuts down the "live" preinstalled system cleanly...
Please remove the installation medium, then press ENTER:
Unmounting /cdrom...
[FAILED] Failed unmounting /cdrom.
```

Install successfully!Login!

Virtual Machine 24084 (scteam08-work4) on node 'pve'

Start

Shutdown

Console

More

Help

Summary

Console

Hardware

Cloud-Init

Options

Task History

Backup

Replication

Snapshots

Firewall

Ubuntu 22.04 LTS work4 tty1

```
[ 65.554806] cloud-init[1481]: Cloud-init v. 22.1-14-g2e17a0d6-0ubuntu1~22.04.5 running 'modules:config' at Wed, 27 Mar 2024 05:16:00 +0000. Up 65.50 seconds
[ 65.606882] cloud-init[1481]: Generating locales (this might take a while)...
[ 66.873678] cloud-init[1481]:   en_US.UTF-8... done
[ 66.874536] cloud-init[1481]: Generation complete.
[ 67.352027] cloud-init[1520]: Cloud-init v. 22.1-14-g2e17a0d6-0ubuntu1~22.04.5 running 'modules:final' at Wed, 27 Mar 2024 05:16:02 +0000. Up 67.30 seconds.
ci-info: no authorized SSH keys fingerprints found for user scteam08.
<14>Mar 27 05:16:02 cloud-init: #####
<14>Mar 27 05:16:02 cloud-init: -----BEGIN SSH HOST KEY FINGERPRINTS-----
<14>Mar 27 05:16:02 cloud-init: 1024 SHA256:UZ/F2N8Q/uZ2cNbLPMD013Hm/1kYx0fjRoQTi09fsu4 root@work4 (DSA)
<14>Mar 27 05:16:02 cloud-init: 256 SHA256:XRChCUvva3Qaw6Lirx2rUdgazgY5Xz0+9MTLZcT2iY root@work4 (ECDSA)
<14>Mar 27 05:16:02 cloud-init: 256 SHA256:UGJWEtUdBUpYvcJlB1ioPuZnx0Dbptc6a090qvvg6E root@work4 (ED25519)
<14>Mar 27 05:16:02 cloud-init: 3072 SHA256:JngHu07+QBg0qgBLPuZW/M/J4NudyH9674az2VaFUBs root@work4 (RSA)
<14>Mar 27 05:16:02 cloud-init: -----END SSH HOST KEY FINGERPRINTS-----
<14>Mar 27 05:16:02 cloud-init: #####
-----BEGIN SSH HOST KEY KEYS-----
rsa-sha2-nistp256 AAAAE2VjZHNhLXNoYTItbmlzdHAyNTYAAAAIbmlzdHAyNTYAAABBBPm9I145+X6GS71nPKKw1kryS6PcerNCKI9VaewJFa5JLHpvh0R1lvjQQfx+sAn8k2uC+dI7HKpQf8p10ma1qA=
root@work4
ssh-ed25519 AAAAC3NzaC1l2DI1NTE5AAAAIjL9U5kRunIs1bwE4TAHR9EaWr6L2n7g1zbXUM/Pha4C root@work4
ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAQgQCQJECsseh8tUwT8SGJQ/3pkesT1/gQ9TzL2Bb16YxV+0hclUhf1jY0qJ/hTTGMIBqnYBSgkYNaFRG65M9vDQUS9450shMzgm1b0kwe1xu18e4d4hhJE90AE0i
XBMeVogDIT8B32IhwJp8CkXuv+o2BwMg+ghk2U6Kmxk4j7VhQ5R9IY2HqUSns0dpuyjJEL4Nvf130DNUf1YQpVGxsP1FexxP/qT7RVyh1PfosugHLgre9W/fL1rJXG2Yq61MSaLjS0/jdUDVG4aCHoc0Z/KWu
FxruYXRHGTSMB1H6Cyfb26XFNntdfcoHniJkKha20px0yJnSdauwMS2qTgIA0sHpxhL6z0V4nMU6gEmFeYsUBbjpM2D0AcVmmCHuu6796AIMdeSjBgPshB90LoZcJwCftFV/qLc+g1NzyuwAV1MgEJaBfDvDSU
zacIS1D120hmXKfHfTJH13bFzeUI3LRckG0pFmS20BNphNHVpy+Eqp2X01bFmPpl1yUa1c= root@work4
-----END SSH HOST KEY KEYS-----
[ 67.442393] cloud-init[1520]: Cloud-init v. 22.1-14-g2e17a0d6-0ubuntu1~22.04.5 finished at Wed, 27 Mar 2024 05:16:02 +0000. Datasource DataSourceNone. Up 67.43 seconds
[ 67.442681] cloud-init[1520]: 2024-03-27 05:16:02,317 - cc_final_message.py[WARNING]: Used fallback datasource
work4 login: scteam
```

Network (con't)

Head node net1

Network connections

[Help]

Configure at least one interface this server can use to talk to other machines, and which preferably provides sufficient access for updates.

NAME	TYPE	NOTES
[ens18 eth - ▶]		
static 10.121.187.120/24		
a2:3c:93:4b:c2:bc / Red Hat, Inc. / Virtio network device		
[ens19 eth - ▶]		
DHCPv4 1		
be:9e:e7:		

Create bond ▶

Edit ens19 IPv4 configuration

IPv4 Method: [Manual ▼]

Subnet: 10.21.21.0/24

Address: 10.21.21.1

Gateway:

Name servers: IP addresses, comma separated

Search domains: Domains, comma separated

[Save]

[Cancel]

[Done]

[Back]

Worker node net0

Network connections

[Help]

Configure at least one interface this server can use to talk to other machines, and which preferably provides sufficient access for updates.

NAME	TYPE	NOTES
[ens18 eth - ▶]		
DHCPv4 10.0.2.15/24		
8a:3e:2b:19:72:69 / Red Hat, Inc. / Virtio network device		
[Create bond ▶]		

Edit ens18 IPv4 configuration

IPv4 Method: [Manual ▼]

Subnet: 10.21.21.0/24

Address: 10.21.21.2

Gateway: 10.21.21.1

Name servers: 8.8.8.8
IP addresses, comma separated

Search domains: Domains, comma separated

[Save]

[Cancel]

[Done]

[Back]

Ubuntu Server (con't)

Format disk

Storage configuration [Help]

FILE SYSTEM SUMMARY

MOUNT POINT	SIZE	TYPE	DEVICE TYPE
/	39.24GB	new ext4	new LVM logical volume ▶
/boot	1.00GB	new ext4	new partition of local disk ▶
/boot/efi	512.00MB	new fat32	new partition of local disk ▶

AVAILABLE DEVICES

DEVICE	TYPE	SIZE
[ubuntu-vg (new)	LVM volume group	78.49GB ▶
free space		39.24GB

[Create so
[Create vo

USED DEVICE

DEVICE
[ubuntu-vg
ubuntu-lv

[ODEMU_OEM
partition
partition
partition

Confirm destructive action

Selecting Continue below will begin the installation process and result in the loss of data on the disks selected to be formatted.

You will not be able to return to this or a previous screen once the installation has started.

Are you sure you want to continue?

[No]
[Continue]

[Done]
[Reset]
[Back]

Set username and password.

Profile setup [Help]

Enter the username and password you will use to log in to the system. You can configure SSH access on the next screen but a password is still needed for sudo.

Your name: Steven Wang

Your server's name: vm21200
The name it uses when it talks to other computers.

Pick a username: ensline210

Choose a password: *****

Confirm your password: *****

[Done]

Steps (con't)

1. Select English
2. Continue without updating
3. Set up network
4. No need to set proxy.
5. Use default mirror site.
6. Storage configuration: Use an entire disk (default). Or you can set your own partition if you want.
7. Check install OpenSSH server.
8. Do not select anything on Feature Server Snap.
9. Remove disk
10. Reboot

Change Boot Order (if needed)

- Options -> Boot Order

Virtual Machine 24010 (scteam01-head) on node 'pve' No Tags

Start

Summary Edit Revert

Console Name scteam01-head

Hardware Start at boot Yes

Cloud-Init Start/Shutdown order order=any

Options OS Type Linux 6.x - 2.6 Kernel

Task History

Monitor

Backup

Replication

Snapshots

Firewall

Permissions

Edit: Boot Order

#	Enabled	Device	Description
1	<input checked="" type="checkbox"/>	scsi0	lvm-thin:vm-24010-disk-1,discard=on,mbps_rd=200,mbp...
2	<input checked="" type="checkbox"/>	ide2	none,media=cdrom
3	<input checked="" type="checkbox"/>	net0	virtio=FA:E5:28:25:AF:B1,bridge=vmbr0,firewall=1
4	<input type="checkbox"/>	net1	virtio=B2:B1:83:C6:B2:93,bridge=vmbr1,tag=2101

Drag and drop to reorder

Help OK Reset

Troubleshooting – failed unmounting /cdrom

- It's fine, just press enter

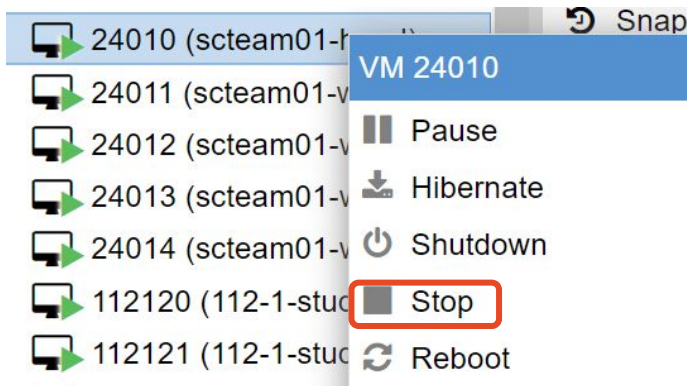
```
Starting Shuts down the "live" preinstalled system cleanly...  
Please remove the installation medium, then press ENTER:  
Unmounting /cdrom..  
[FAILED] Failed unmounting /cdrom.
```

Troubleshooting – UEFI

```
UEFI Interactive Shell v2.2
EDK II
UEFI v2.70 (EFI Development Kit II / DUMF, 0x00010000)
Mapping table
  FS0: Alias(s) :HD1a0b::BLK2:
      PciRoot (0x0) /Pci (0x5,0x0) /Scsi (0x0,0x0) /HD (1,GPT,80EA7463-B8AB-43AD-9EEA-9186C38A7F33,0x800,0x219800)
  BLK0: Alias(s) :
      PciRoot (0x0) /Pci (0x1,0x1) /Ata (0x0)
  BLK1: Alias(s) :
      PciRoot (0x0) /Pci (0x5,0x0) /Scsi (0x0,0x0)
  BLK3: Alias(s) :
      PciRoot (0x0) /Pci (0x5,0x0) /Scsi (0x0,0x0) /HD (2,GPT,FC878FA7-F180-4F7D-B544-ACEEB0DFF914,0x21A000,0x400000)
  BLK4: Alias(s) :
      PciRoot (0x0) /Pci (0x5,0x0) /Scsi (0x0,0x0) /HD (3,GPT,F2ECD095-027D-4330-B5FF-A73C25002A17,0x61A000,0x5DE5800)
Press ESC in 1 seconds to skip startup.nsh or any other key to continue.
Shell> _
```

Troubleshooting – UEFI (con't)

- Restart your VM (stop -> start)
- When booting, keep pressing ESC (like 狂按) to enter BIOS
- Select Boot Manager -> UEFI QEMU QEMU HARDDISK



Other Settings

Steps

1. IP Forward (head)

IP Forward-Head node

- Worker node access internet through head node.
- Head node need to setup IP forward rule.
- We use iptables here (or you can choose anything you familiar with)
- Sudo -i

```
#!/bin/sh
EIF="ens18" # WAN interface (use "ip a" to check)
IIF="ens19" # LAN interface (use "ip a" to check)
INNET="10.21.21.0/24" # LAN subnet
# forwarding
echo "net.ipv4.conf.all.forwarding = 1" >> /etc/sysctl.conf
sysctl -p

# NAT
iptables -t nat -A POSTROUTING -o $EIF -s $INNET -j MASQUERADE
apt-get install iptables-persistent
iptables-save > /etc/iptables/rules.v4
systemctl enable iptables.service
```


Steps

1. IP Forward (head)
2. NFS
 - a. [Head Node](#)
 - b. [Work Node](#)

Linux File Hierarchy

- /: Root directory
- /bin: Essential binary executables. e.g. cat, ls, cp.
- /dev: Device files. e.g. /dev/sda
- **/etc: Configuration file, most application configuration can be found here.**
- /home: Home directory, user data.
- /lib: Libraries for /bin and /sbin.
- /mnt: Temporarily mounted filesystem. We usually mount USB here.
- /opt : Optional application software packages.

NFS (Network File System)

File sharing across nodes

- normal files
- environment config files (.bashrc, .vimrc)
- libraries & executables (MPI)

NFS Installation

- Install NFS packages
 - Ubuntu: <https://ubuntu.com/server/docs/service-nfs>
 - CentOS: <https://www.opencli.com/linux/rhel-centos-7-install-nfs-server>
 - Arch Linux: <https://wiki.archlinux.org/index.php/NFS>
- Share /home
- Configure NFS server (edit /etc/exports) then restart nfs server.
 - /home 10.21.21.0/24(rw,async,no_root_squash)
 - /opt 10.21.21.0/24(rw,async,no_root_squash,no_subtree_check)
- Client mount NFS (edit /etc/fstab) then reboot.
 - 10.21.21.1:/home /home nfs4 soft,intr,bg 0 0
 - 10.21.21.1:/opt /opt nfs4 soft,intr,bg 0 0
- Change subnet IP according to your cluster's setting!
- Do not simply copy-and-paste!

NFS Installation (Head)

- Install some package (help check whether successfully implement NFS)
 - wget
<https://download.open-mpi.org/release/open-mpi/v5.0/openmpi-5.0.1.tar.gz>
- Install NFS packages
 - Ubuntu: `sudo apt install nfs-kernel-server`
- Create /opt and set the permission
 - `sudo mkdir /opt`
 - `sudo chmod -R 777 /opt`
- Configure NFS server (`sudo vim /etc/exports`)
 - `/home 10.21.21.0/24(rw,async,no_root_squash)`
 - `/opt 10.21.21.0/24(rw,async,no_root_squash,no_subtree_check)`
- Then restart nfs server.
 - `sudo systemctl enable nfs-server`
 - `sudo systemctl restart nfs-server`
- Do not simply copy-and-paste!

NFS Installation (Worker)

- Install NFS packages
 - Worker: `sudo apt install nfs-common`
 - CentOS: <https://www.opencli.com/linux/rhel-centos-7-install-nfs-server>
 - Arch Linux: <https://wiki.archlinux.org/index.php/NFS>
- Client mount NFS (edit /etc/fstab)
 - `10.21.21.1:/home /home nfs4 soft,intr,bg,timeo=600 0 0`
 - `10.21.21.1:/opt /opt nfs4 soft,intr,bg,timeo=600 0 0`
- Mount the filesystem(NFS)
 - `sudo mount -a`
 - `cd`
- Do not simply copy-and-paste!

if you don't want to type IP when ssh

- `sudo vim /etc/hosts`

```
# /etc/hosts
```

```
# ....
```

```
10.21.21.1 head
```

```
10.21.21.2 work1
```

```
10.21.21.3 work2
```

```
10.21.21.4 work3
```

```
10.21.21.5 work4
```

Steps

1. IP Forward (head)
2. NFS
 - a. Head Node
 - b. Work Node
3. SSH KEY

SSH (Laptop to head node)

After you finish installation and configure network, you can use SSH to connect to your VM's terminal.

- Linux and Max:
ssh username@10.121.187.11x (x is your team number)
- Windows: [MobaXterm](#) / VScode / ...

Useful tips:

- ssh-keygen -m PEM -t rsa
- ssh-copy-id <username>@<head_node_ip>
 - In Windows:
ssh public key is in C:/Users/user/.ssh/id_rsa.pub

Now, we can connect to head node without password

SSH (head node -> worker node, say work1)

On headnode:

- Generate key
 - `ssh-keygen -m PEM -t rsa`
 - `ssh-keygen -t ed25519`
- Copy public key in other machine
 - `ssh-copy-id <username>@10.21.21.2 # work 1's ip`
 - `cat ~/.ssh/id_ed25519.pub > ~/.ssh/authorized_keys(after NFS)`

Now, we can connect to worker node without password
(It's important step for OpenMPI.)

User Authentication

- User account information sharing
- Objective:

```
[root@node1 ~] useradd -m alice  
[alice@node1 ~] ssh alice@node1  
[alice@node1 ~] pwd  
/home/alice  
[alice@node1 ~]
```

Solution

- NIS
 - LDAP
 - Arch Linux: [minos](#)
- Or... Just create user for each node in the same sequence

Install software on Linux

1. Package Manager provide by Linux distribution (APT) -> binary-install
2. Install-script provided by software development company
3. Package Manager for HPC (Spack) -> source-code-install
4. Compile from source

安裝方便: $1 > 3 = 2 > 4$

管理方便: $3 = 1 > 2 > 4$

自由度高: $4 > 3 > 2 > 1$

Week 5 homework

<https://hackmd.io/@9jNKJjQJQ-GI9NPpBTJO3A/HkUjfvpAa>