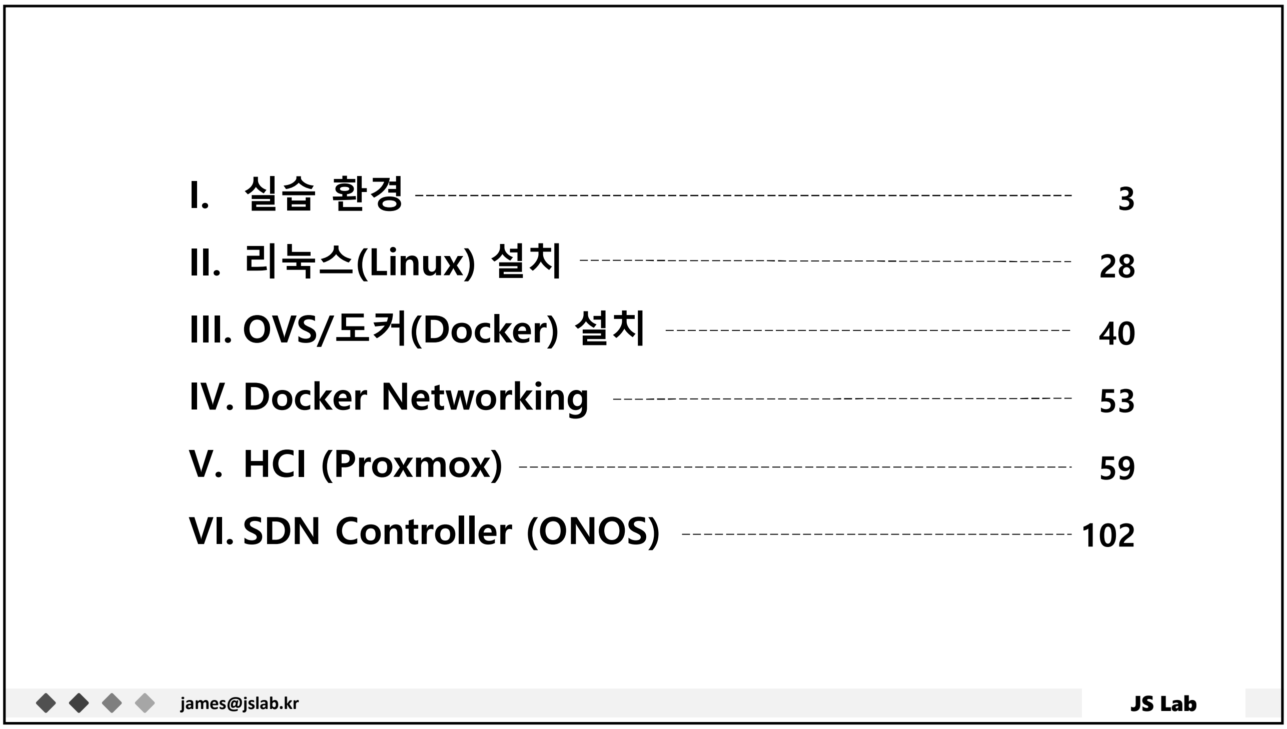
서버 가상화와 SDN (실습)

V2.1

안종석

james@jslab.kr



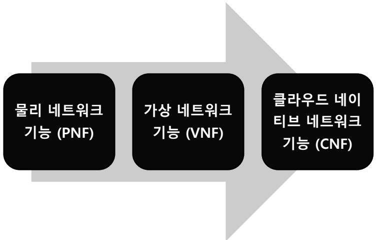
I. 실습 환경

- 개요
- 시장 기술 변화 고려 실습
- 실습 준비

I. 실습 환경

❖ 가상화 네트워크는 클라우드 네이티브로 진화중 (Evolving to Cloud Native)

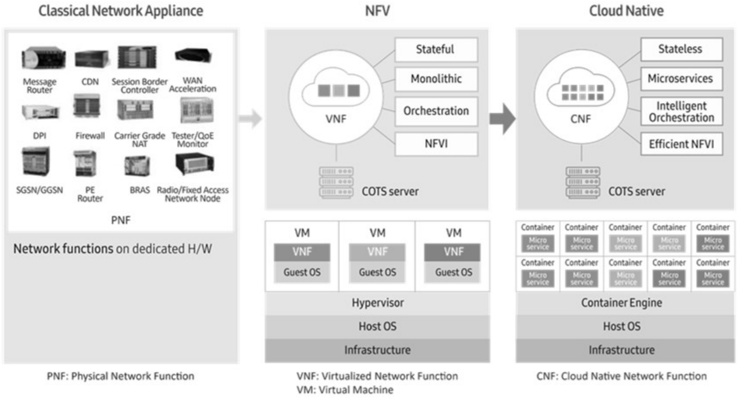
- PNF(Physical Network Function): 하드웨어 어플라이언스 기반
- VNF(Virtualized Network Function): 가상머신 VM(Virtual Machine) 기반
- CNF(Cloud Native Network Function): 클라우드 네이티브는 컨테이너 기반, VM 등을 수용



물리 네트워크 기능 (PNF)

가상 네트워크 기능 (VNF)

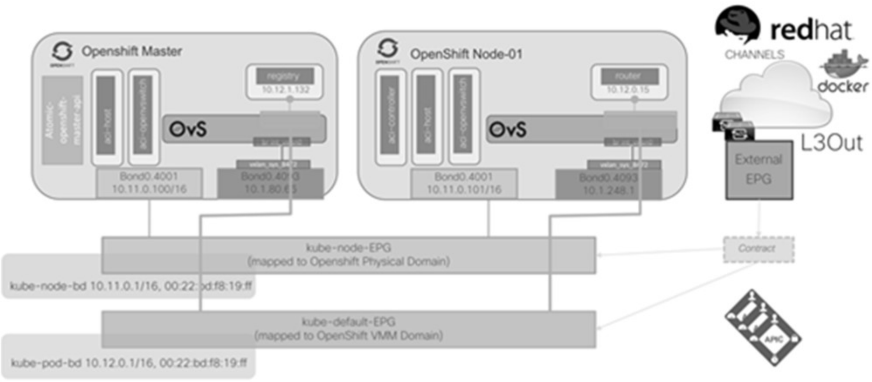
클라우드 네이티브 네트워크 기능 (CNF)



I. 실습 환경

❖ 제조사 솔루션 연동

- 제조사들의 멀티클라우드 기반 아키텍처에 오픈소스 네트워킹 기술 채택
- Red Hat, Cisco, VMware 등



Source: https://www.cisco.com/c/en/us/td/docs/switches/datacenter/aci/apic/white_papers/Cisco-ACI-CNI-Plugin-for-OpenShift-Architecture-and-Design-Guide.html

I. 실습 환경

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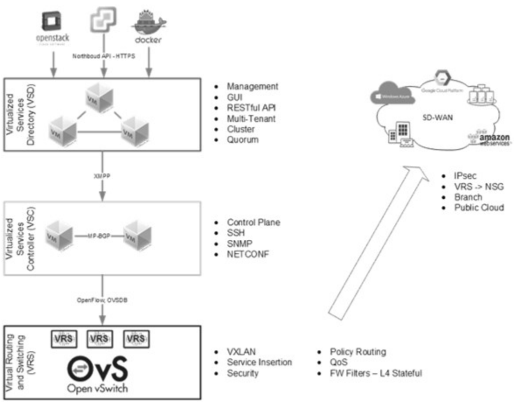
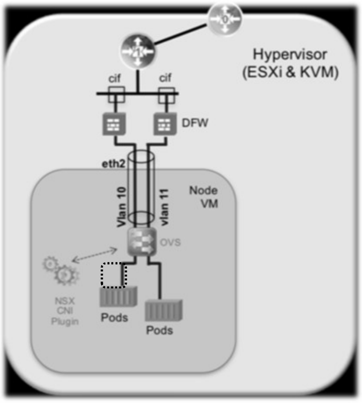




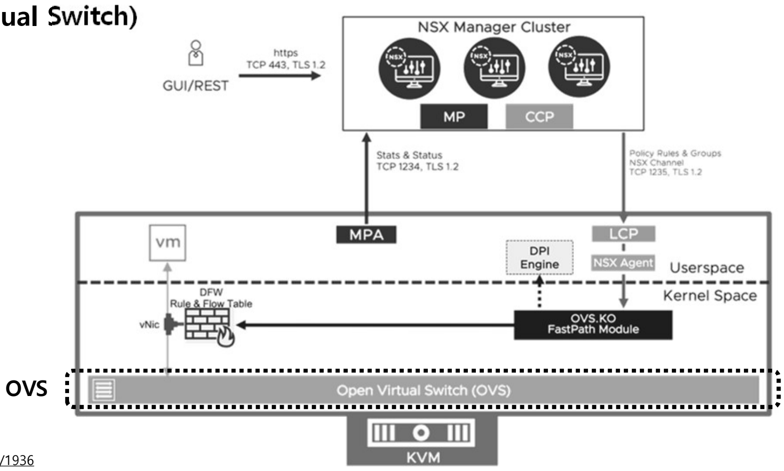
Source: https://thedataplumber.net/nsx-t-vs-nsx-v-and-a-little-bit-of-nuage-vsp/

Source: https://www.routetocloud.com/category/nsx-t/

I. 실습 환경

❖ VMware NSX-T의 OVS 적용 (예)

- KVM을 위한 OVS(Open Virtual Switch)

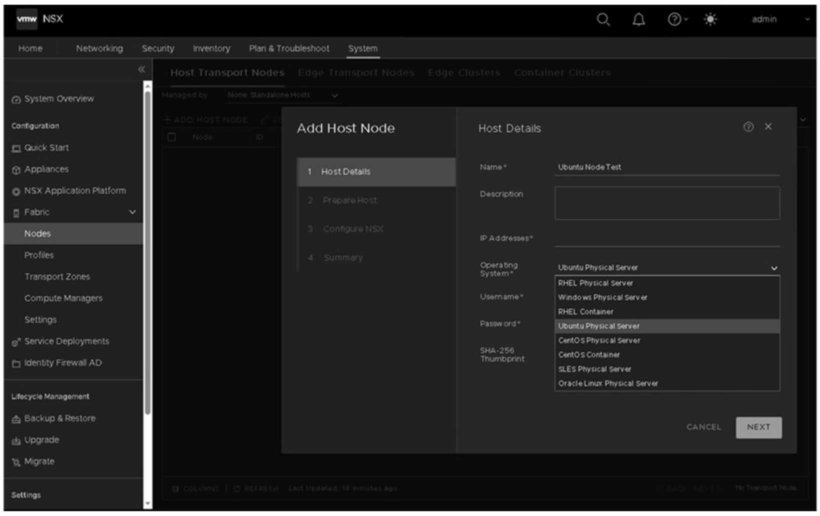


VMware HOL: https://labs.hol.vmware.com/HOL/catalogs/catalog/1936

Source: https://nsx.techzone.vmware.com/resource/nsx-t-reference-design-guide-3-0#_Toc503250673

I. 실습 환경

❖ VMware NSX Data Center(version 4.0)의 Linux Host Node 추가



Add Host Node

1 Host Details
2 Prepare Host
3 Configure NSX
4 Summary

Host Details

Name* Ubuntu Node Test

Description

IP Addresses*

Operating System* Ubuntu Physical Server

- RHEL Physical Server
- Windows Physical Server
- RHEL Container
- Ubuntu Physical Server
- CentOS Physical Server
- CentOS Container
- SLES Physical Server
- Oracle Linux Physical Server

Username*

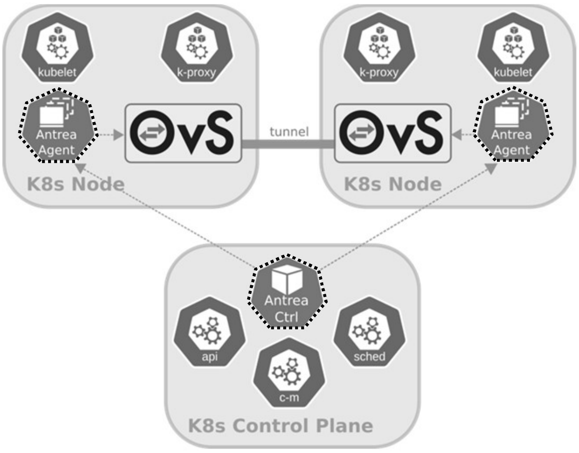
Password*

SHA-256 Thumbprint

CANCEL NEXT

I. 실습 환경

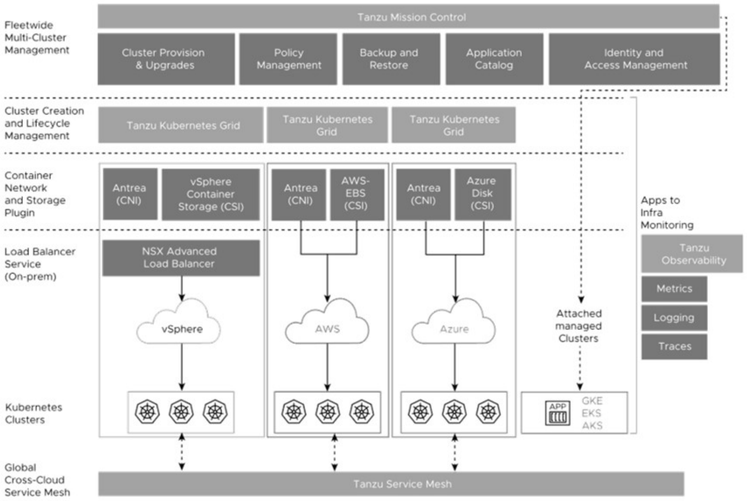
❖ **Antrea is a Kubernetes networking solution intended to be Kubernetes native. It operates at Layer 3/4 to provide networking and security services for a Kubernetes cluster, leveraging.**



Source: https://antrea.io/docs/v1.8.0/

I. 실습 환경

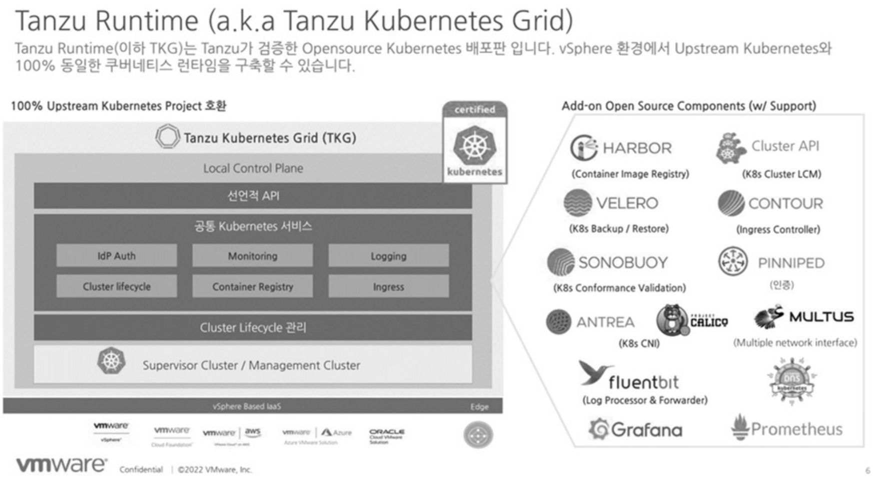
❖ **VMware Tanzu for Kubernetes Operations Reference Architecture**



Source: https://docs.vmware.com/en/VMware-Tanzu-for-Kubernetes-Operations/index.html

I. 실습 환경

❖ **VMware Tanzu Runtime**

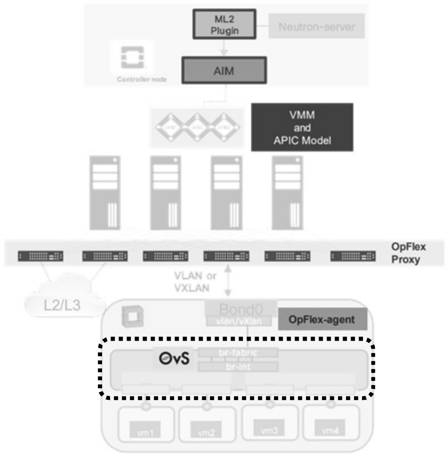


Tanzu Runtime (a.k.a Tanzu Kubernetes Grid)

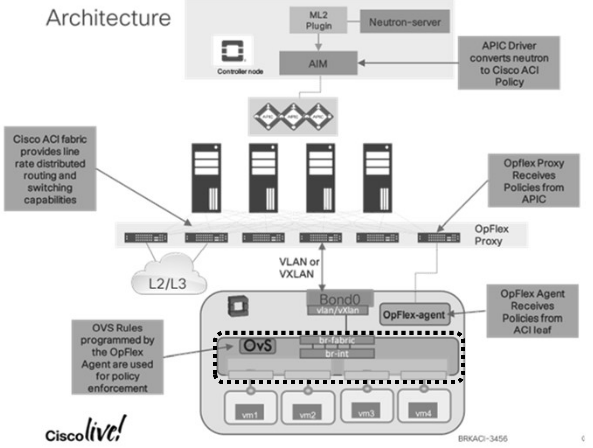
Tanzu Runtime(이하 TKG)는 Tanzu가 검증한 Opensource Kubernetes 배포판 입니다. vSphere 환경에서 Upstream Kubernetes와 100% 동일한 쿠버네티스 런타임을 구축할 수 있습니다.

I. 실습 환경

❖ **Cisco ACI Neutron Plugin + OVS 적용 (예)**



ACI + OpenStack – With OpFlex



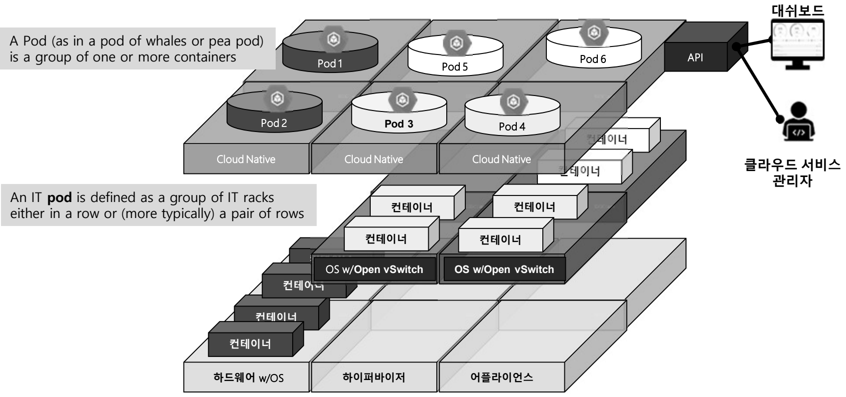
Architecture
ML2 Plugin
Neutron-server
Controller node
AIM
APIC Driver converts neutron to Cisco ACI Policy
Cisco ACI fabric provides line rate distributed routing and switching capabilities
Opflex Proxy Receives Policies from APIC
OpFlex Proxy
VLAN or VXLAN
L2/L3
Bond0
vlan/vXlan
OpFlex-agent
OpFlex Agent Receives Policies from ACI leaf
OVS Rules programmed by the OpFlex Agent are used for policy enforcement
OvS
br-fabric
br-int
vm1
vm2
vm3
vm4
Cisco live!
BRKACI-3456

Source: https://www.ciscolive.com/c/dam/r/ciscolive/emea/docs/2019/pdf/BRKACI-3456.pdf

I. 실습 환경

❖ 실습/시연 3 단계

1. 설치: 하이퍼바이저, 가상 스위치 (OVS), OVS 연결 컨테이너 단말, SDN 컨트롤러
2. SDN 컨트롤러 Operations: 3중화, Leaf-Spine 구성, 분산 SDN 컨트롤러
3. Cloud Native: 서버 클러스터링, Rancher, 쿠버네티스, Istio, Serverless



A Pod (as in a pod of whales or pea pod) is a group of one or more containers

An IT **pod** is defined as a group of IT racks either in a row or (more typically) a pair of rows

I. 실습 환경

❖ 오픈소스 사용 클라우드 인프라 실습

- SDN 가상스위치
- 하이퍼바이저 (VMware, VirtualBox)
- 컨테이너/쿠버네티스 워크로드 운영 통합 도구
- 서비스 메시 (시연)

OVS

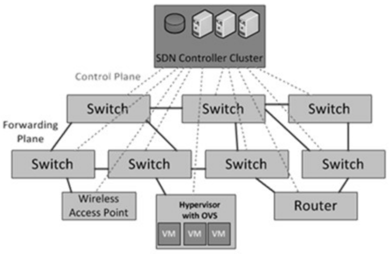
VMware Player

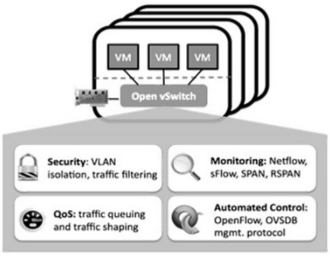
Docker Container

Rancher / Istio

❖ SDN 오픈소스 프로젝트

- SDN 제어기(Controller) ONOS 사용 (https://www.opennetworking.org/onos/)
- Open vSwitch (OVS) 사용 (http://openvswitch.org)





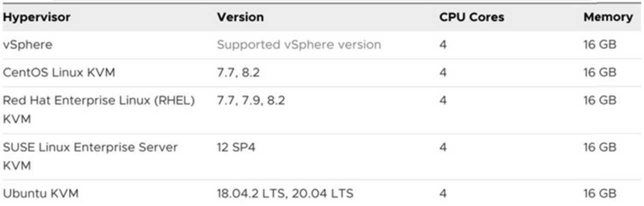
VM
VM
VM
Open vSwitch
Security: VLAN isolation, traffic filtering
Monitoring: Netflow, sFlow, SPAN, RSPAN
QoS: traffic queuing and traffic shaping
Automated Control: OpenFlow, OVSDB mgmt. protocol

I. 실습 환경

❖ 사용 소프트웨어

- **OS (Bare Metal 설치 Lab 환경 구성 고려)**
  - o **Ubuntu** 또는 Debian
  - o Fedora 또는 CentOS
  - o SDN Switch (Cumulus)
  - o 클라이언트용 윈도우 (Mac, 리눅스 지원 가능)
- **하이퍼바이저 기반 가상 네트워크 소프트웨어**
  - o 가상화 보안 어플라이언스 (방화벽, IDS, SIEM등)
  - o 가상화 네트워크 어플라이언스 (라우터, SDN 제어기등)
  - o vCenter / NSX-T (VMware)
- **Cloud Native 고려**
  - o Virtual Switch (OVS)
  - o SDN Controller (ONOS)
  - o Container (Docker)
  - o Rancher / Kubernetes (K8s)
  - o 서비스메시 (Istio) (시연)

상용 가상화 솔루션 지원 (예): VMware NSX-T 지원 하이퍼바이저



Hypervisor	Version	CPU Cores	Memory
vSphere	Supported vSphere version	4	16 GB
CentOS Linux KVM	7.7, 8.2	4	16 GB
Red Hat Enterprise Linux (RHEL) KVM	7.7, 7.9, 8.2	4	16 GB
SUSE Linux Enterprise Server KVM	12 SP4	4	16 GB
Ubuntu KVM	18.04.2 LTS, 20.04 LTS	4	16 GB

OVS

I. 실습 환경

❖ 사용 소프트웨어

- **Type 2 Hypervisor ‘VirtualBox’와 ‘VMware Workstation Player’**
  - o **VirtualBox 7.0.8**: https://www.virtualbox.org/wiki/Downloads
  - o **VMware Workstation Player 17**: https://www.vmware.com/kr/products/workstation-player/workstation-player-evaluation.html
- **Type 1 Hypervisor ‘ESXi’ **VMware 계정 필요**
  - o **ESXi 7.x** : https://customerconnect.vmware.com/en/downloads/details?downloadGroup=ESXI70U3G&productId=974&rPId=93665
- **Ubuntu 16.04.7 LTS (Xenial Xerus) → VM 이미지 생성**
  - o Bare Metal 설치 Lab 환경 구성 고려
  - o Ubuntu Server 16.04 install image 다운로드: https://releases.ubuntu.com/16.04/ubuntu-16.04.7-server-amd64.iso
- **Create bootable USB drives → BareMetal 사용시**
  - o Rufus 다운로드: https://rufus.ie/en/

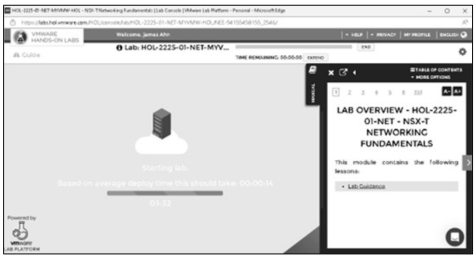
VMware Hands-on Learning & Trials: https://www.vmware.com/trials-test-drives.html

VMware NSX-T - Getting Started Hands-on Lab: https://customerconnect.vmware.com/en/evalcenter?p=nsx-t-hol-gs-22

I. 실습 환경

❖ **VMware NSX-T - Getting Started Hands-on Lab**

- **https://customerconnect.vmware.com/en/evalcenter?p=nsx-t-hol-gs-22**



HOL-2225-01-NET-MYVMW-HOL - NSX-T Networking Fundamentals | Lab Console | VMware Lab Platform - Personal - Microsoft Edge

https://labs.hol.vmware.com/HOL/console/lab/HOL-2225-01-NET-MYVMW-HOL/NEE-94155458155_2546/

Welcome, James Ahn

Lab: HOL-2225-01-NET-MYV...

TIME REMAINING: 00:00:00

Starting lab.

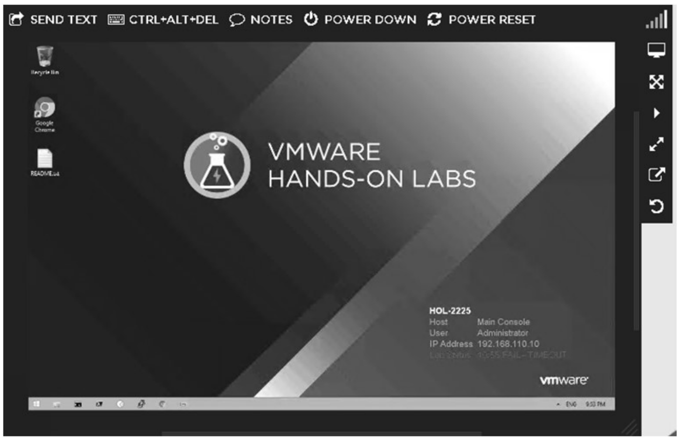
Based on average deploy time this should take: 00:00:14

03:32

LAB OVERVIEW - HOL-2225-01-NET - NSX-T NETWORKING FUNDAMENTALS

This module contains the following lessons:

- Lab Guidance

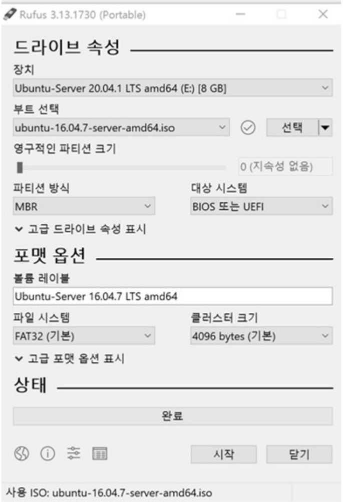


HOL-2225
Host Main Console
User Administrator
IP Address 192.168.110.10

I. 실습 환경

❖ **베어메탈 사용 가능 (선택)**

- **Bare Metal 설치 Lab 환경 구성 고려**
  - o ESXi 7.x
  - o Cumulus
  - o Ubuntu



Rufus 3.13.1730 (Portable)

드라이브 속성

장치: Ubuntu-Server 20.04.1 LTS amd64 (E:) [8 GB]

부트 선택: ubuntu-16.04.7-server-amd64.iso

영구적인 파티션 크기: 0 (지속성 없음)

파티션 방식: MBR

대상 시스템: BIOS 또는 UEFI

∨ 고급 드라이브 속성 표시

포맷 옵션

볼륨 레이블: Ubuntu-Server 16.04.7 LTS amd64

파일 시스템: FAT32 (기본)

클러스터 크기: 4096 bytes (기본)

∨ 고급 포맷 옵션 표시

상태

완료

사용 ISO: ubuntu-16.04.7-server-amd64.iso

I. 실습 환경

❖ 하드웨어

- CPU: 3GHz이상 CoreDuo이상
- HDD: 20GB이상
- 메모리: 16GB이상 (8GB시 일부 기능이 동작이 안되거나 늦을 수 있음)
- 네트워크: DHCP 유동IP 주소 할당 권장 (실습 시 VM용 2개 사용)

❖ 소프트웨어

- 운영체제: Windows/MAC/Linux 지원하나 실습 시연은 Windows 10 (64bit)으로 진행
- 관련 소프트웨어: SSH 터미널(Putty or Windows Terminal),VMware Workstation Player)

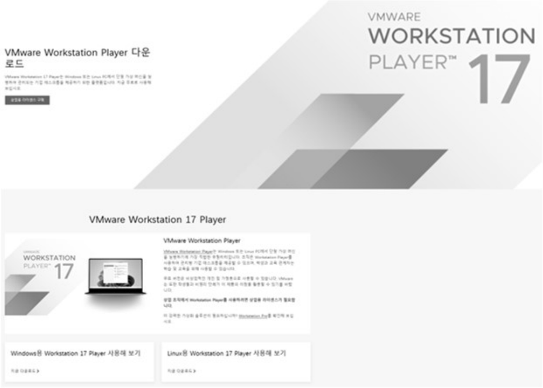
❖ 실습용 하이퍼바이저 VMware Workstation Player/VirtualBox 설치 필요:

✓ VMware Workstation Player: https://www.vmware.com/kr/products/workstation-player/workstation-player-evaluation.html
✓ VirtualBox: https://www.virtualbox.org/wiki/Downloads
✓ Ubuntu VM 이미지: https://drive.google.com/file/d/1kp6LJhkqc1mlTBgq-lVrBHyqFvI0B0c2/view?usp=sharing
✓ ESXi: https://customerconnect.vmware.com/en/downloads/details?downloadGroup=ESXI70U3G&productId=974&rPId=93665
✓ HCI ISO 이미지: https://www.proxmox.com/en/downloads/category/iso-images-pve
✓ SDN 제어기 (VirtualBox 용): https://drive.google.com/file/d/1fAUPP-8CY--u812SlsQRfbGEHfjLDjsQ/view?usp=sharing

I. 실습 환경

❖ VMware Workstation Player 설치

- VMware Workstation Player 다운로드
- 다운로드 URL: https://www.vmware.com/kr/products/workstation-player/workstation-player-evaluation.html



VMware Workstation Player 다운로드

VMWARE WORKSTATION PLAYER™ 17

VMware Workstation 17 Player

VMware Workstation Player

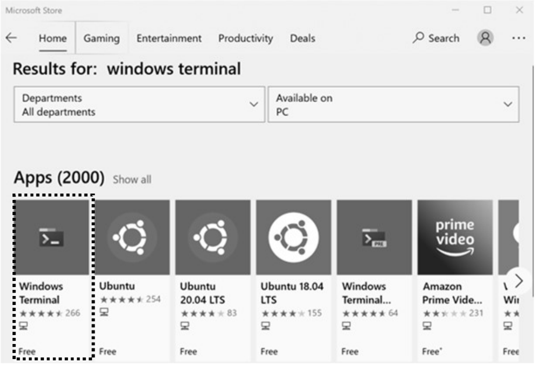
Windows용 Workstation 17 Player 사용해 보기

Linux용 Workstation 17 Player 사용해 보기

I. 실습 환경

❖ **SSH Tool 설치 ‘Windows Terminal’** (선택)

- **Microsoft Store에서 ‘Windows terminal’ 선택 설치**
- **DOS 명령 프롬프트에서 실행 가능**



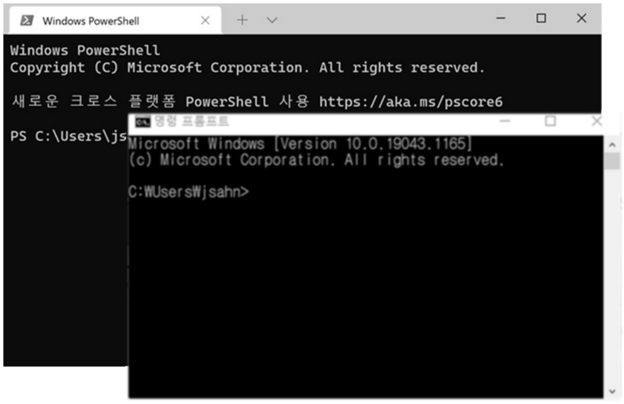
Results for: windows terminal

Departments: All departments

Available on: PC

Apps (2000) Show all

Windows Terminal	Ubuntu	Ubuntu 20.04 LTS	Ubuntu 18.04 LTS	Windows Terminal...	Amazon Prime Vide...
★★★★★ 266	★★★★★ 254	★★★★★ 83	★★★★★ 155	★★★★★ 64	★★★★★ 231
Free	Free	Free	Free	Free	Free*



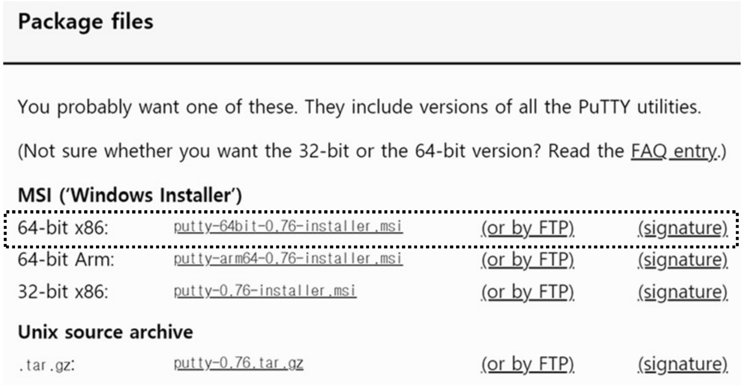
```
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

새로운 크로스 플랫폼 PowerShell 사용 https://aka.ms/pscore6

PS C:\Users\js
```

```
Microsoft Windows [Version 10.0.19043.1165]
(c) Microsoft Corporation. All rights reserved.

C:WUsersWjsahn>
```

I. 실습 환경

❖ **SSH Tool 설치 ‘Putty’** (선택)

- **‘Putty’ 다운로드**
- **다운로드 URL: https://www.chiark.greenend.org.uk/~sgtatham/putty/latest.html**
- **64-bit x86 용 선택** (윈도우 10용)



Package files

You probably want one of these. They include versions of all the PuTTY utilities.

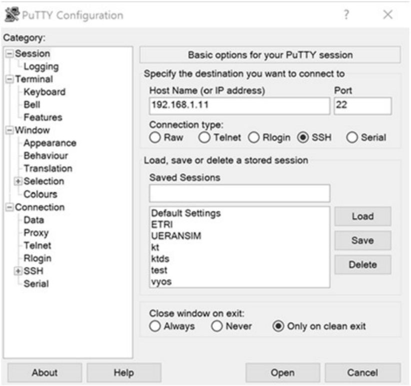
(Not sure whether you want the 32-bit or the 64-bit version? Read the FAQ entry.)

MSI (‘Windows Installer’)

64-bit x86:	putty-64bit-0.76-installer.msi	(or by FTP)	(signature)
64-bit Arm:	putty-arm64-0.76-installer.msi	(or by FTP)	(signature)
32-bit x86:	putty-0.76-installer.msi	(or by FTP)	(signature)

Unix source archive

.tar.gz:	putty-0.76.tar.gz	(or by FTP)	(signature)



Specify the destination you want to connect to

Host Name (or IP address): 192.168.1.11 Port: 22

Connection type: ○ Raw ○ Telnet ○ Rlogin ● SSH ○ Serial

Load, save or delete a stored session

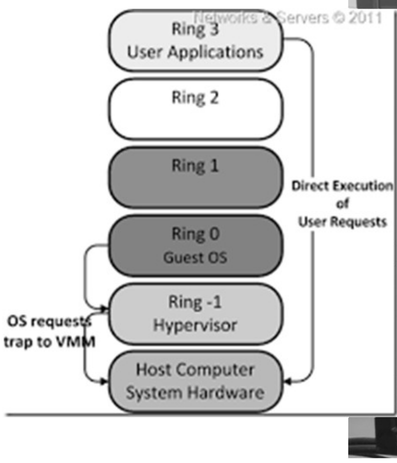
Saved Sessions

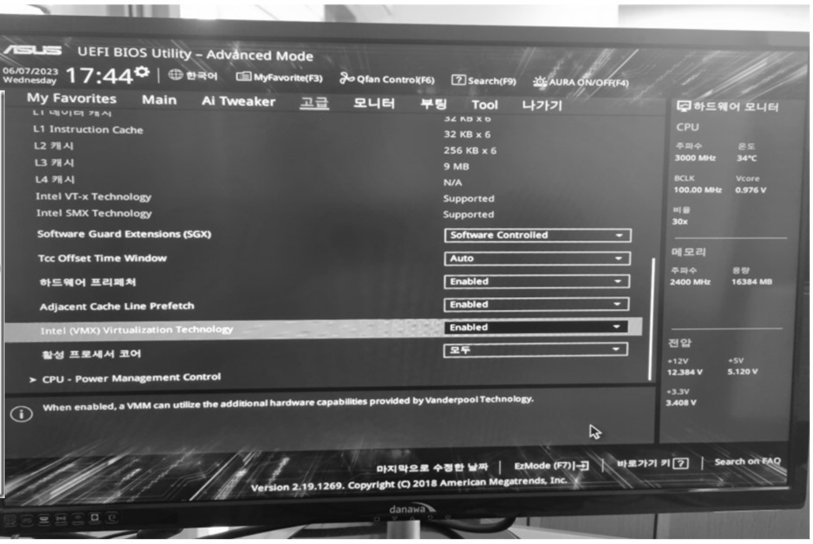
Default Settings
ETRI
UERANSIM
kt
ktds
test
vyos

Close window on exit: ○ Always ○ Never ● Only on clean exit

I. 실습 환경

❖ **BIOS 세팅(예)**




UEFI BIOS Utility – Advanced Mode

06/07/2023 Wednesday 17:44 | 한국어 | MyFavorite(F3) | Qfan Control(F6) | Search(F9) | AURA ON/OFF(F4)

My Favorites | Main | Ai Tweaker | 고급 | 모니터 | 부팅 | Tool | 나가기

L1 데이터 캐시	32 KB x 6
L1 Instruction Cache	32 KB x 6
L2 캐시	256 KB x 6
L3 캐시	9 MB
L4 캐시	N/A
Intel VT-x Technology	Supported
Intel SMX Technology	Supported
Software Guard Extensions (SGX)	Software Controlled
Tcc Offset Time Window	Auto
하드웨어 프리페처	Enabled
Adjacent Cache Line Prefetch	Enabled
Intel (VMX) Virtualization Technology	Enabled
활성 프로세서 코어	모두

> CPU - Power Management Control

When enabled, a VMM can utilize the additional hardware capabilities provided by Vanderpool Technology.

하드웨어 모니터

CPU: 주파수 3000 MHz, 온도 34°C, BCLK 100.00 MHz, Vcore 0.976 V, 비율 30x

메모리: 주파수 2400 MHz, 용량 16384 MB

전압: +12V 12.384 V, +5V 5.120 V, +3.3V 3.408 V

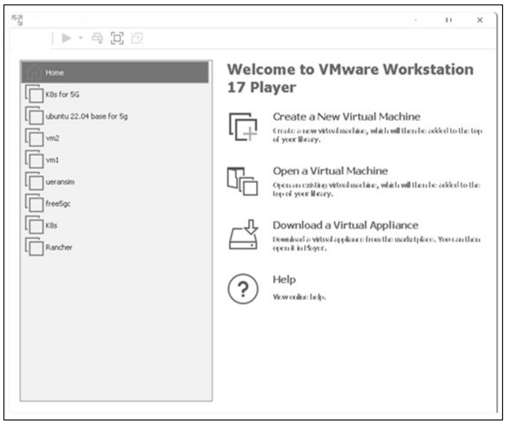
마지막으로 수정한 날짜 | EzMode (F7) | 바로가기 키 | Search on FAQ

Version 2.19.1269. Copyright (C) 2018 American Megatrends, Inc.

I. 실습 환경

❖ **하이퍼바이저 설치**

- **VMware Workstation Player 17 설치 (시연/실습)**
- **VMware ESXi 7.x 설치 (시연/실습)**


Home
K8s for 5G
ubuntu 22.04 base for 5g
vm2
vm1
ueransim
free5gc
K8s
Rancher

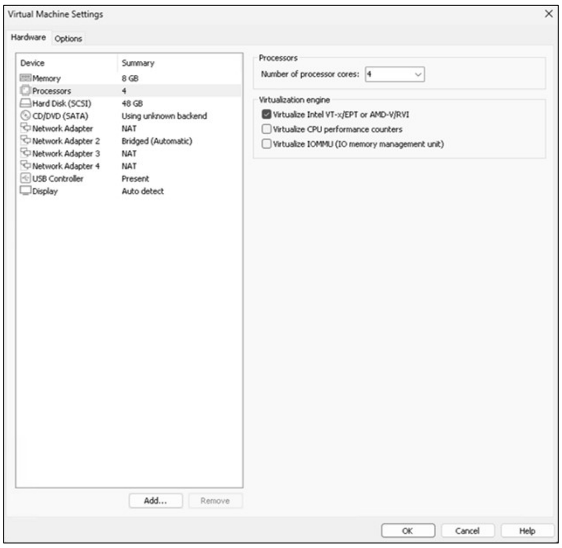
Welcome to VMware Workstation 17 Player

Create a New Virtual Machine
Create a new virtual machine, which will then be added to the top of your library.

Open a Virtual Machine
Open an existing virtual machine, which will then be added to the top of your library.

Download a Virtual Appliance
Download a virtual appliance from the marketplace. You can then open it in Player.

Help
View online help.


Virtual Machine Settings

Hardware | Options

Device	Summary
Memory	8 GB
Processors	4
Hard Disk (SCSI)	48 GB
CD/DVD (SATA)	Using unknown backend
Network Adapter	NAT
Network Adapter 2	Bridged (Automatic)
Network Adapter 3	NAT
Network Adapter 4	NAT
USB Controller	Present
Display	Auto detect

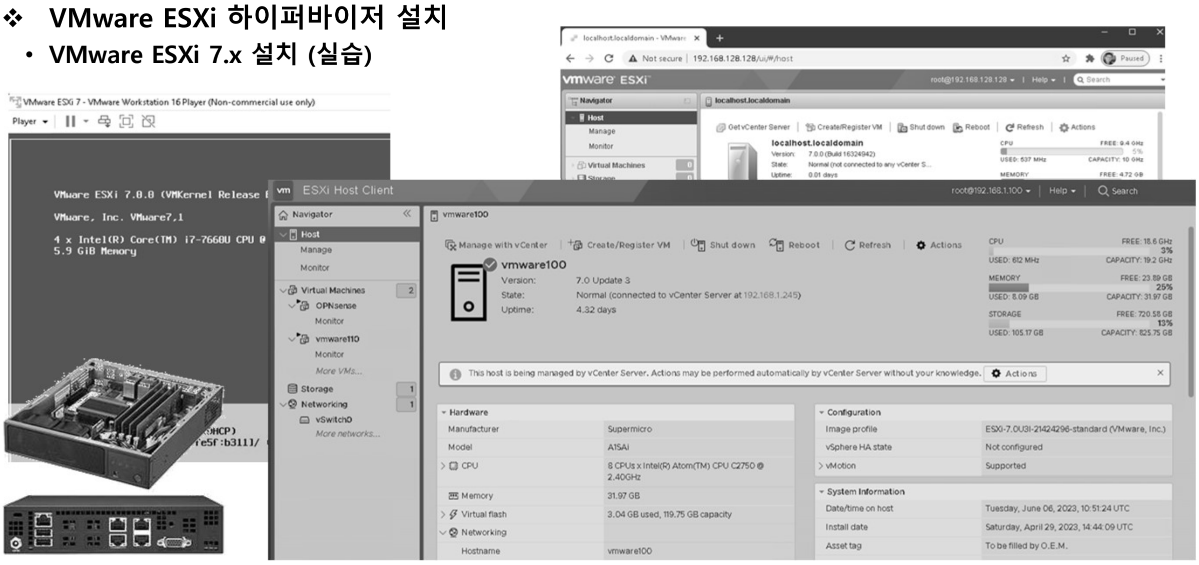
Processors
Number of processor cores: 4

Virtualization engine
☑ Virtualize Intel VT-x/EPT or AMD-V/RVI
☐ Virtualize CPU performance counters
☐ Virtualize IOMMU (IO memory management unit)

I. 실습 환경

❖ **VMware ESXi 하이퍼바이저 설치**

- **VMware ESXi 7.x 설치 (실습)**



VMware ESXi 7 - VMware Workstation 16 Player (Non-commercial use only)

```
VMware ESXi 7.0.0 (VMKernel Release B

VMware, Inc. VMware7,1

4 x Intel(R) Core(TM) i7-7660U CPU @
5.9 GiB Memory
```

localhost.localdomain - VMware

Not secure | 192.168.128.128/ui/#/host

root@192.168.128.128

localhost.localdomain

Version: 7.0.0 (Build 16324942)

State: Normal (not connected to any vCenter S...

Uptime: 0.01 days

CPU FREE: 9.4 GHz 5% USED: 537 MHz CAPACITY: 10 GHz

MEMORY FREE: 4.72 GB

root@192.168.1.100

vmware100

Version: 7.0 Update 3

State: Normal (connected to vCenter Server at 192.168.1.245)

Uptime: 4.32 days

CPU FREE: 18.6 GHz 3% USED: 612 MHz CAPACITY: 19.2 GHz

MEMORY FREE: 23.89 GB 25% USED: 8.09 GB CAPACITY: 31.97 GB

STORAGE FREE: 720.58 GB 13% USED: 105.17 GB CAPACITY: 825.75 GB

This host is being managed by vCenter Server. Actions may be performed automatically by vCenter Server without your knowledge.

Hardware	
Manufacturer	Supermicro
Model	A1SAi
CPU	8 CPUs x Intel(R) Atom(TM) CPU C2750 @ 2.40GHz
Memory	31.97 GB
Virtual flash	3.04 GB used, 119.75 GB capacity
Networking	
Hostname	vmware100

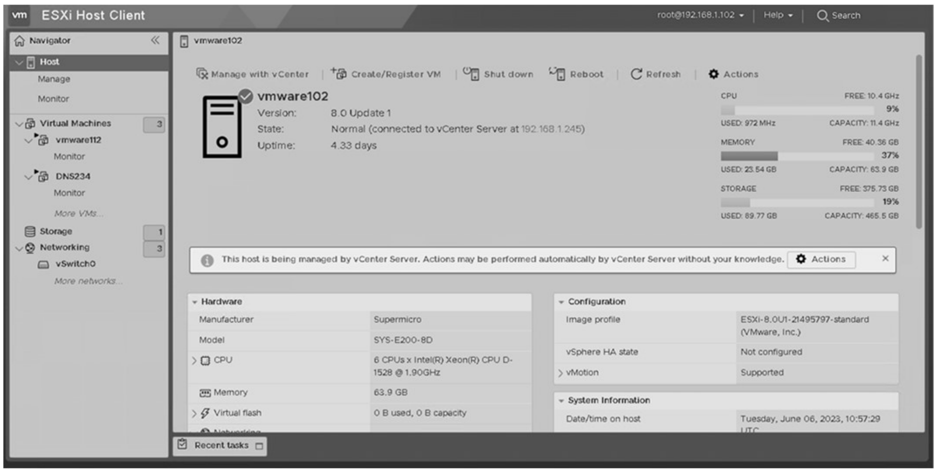
Configuration	
Image profile	ESXi-7.0U3l-21424296-standard (VMware, Inc.)
vSphere HA state	Not configured
vMotion	Supported

System Information	
Date/time on host	Tuesday, June 06, 2023, 10:51:24 UTC
Install date	Saturday, April 29, 2023, 14:44:09 UTC
Asset tag	To be filled by O.E.M.

I. 실습 환경

❖ **VMware ESXi 하이퍼바이저 설치**

- **VMware ESXi 8.x 접속 (시연)**



root@192.168.1.102

vmware102

Version: 8.0 Update 1

State: Normal (connected to vCenter Server at 192.168.1.245)

Uptime: 4.33 days

CPU FREE: 10.4 GHz 9% USED: 972 MHz CAPACITY: 11.4 GHz

MEMORY FREE: 40.36 GB 37% USED: 23.54 GB CAPACITY: 63.9 GB

STORAGE FREE: 375.73 GB 19% USED: 89.77 GB CAPACITY: 465.5 GB

This host is being managed by vCenter Server. Actions may be performed automatically by vCenter Server without your knowledge.

Hardware	
Manufacturer	Supermicro
Model	SYS-E200-8D
CPU	6 CPUs x Intel(R) Xeon(R) CPU D-1528 @ 1.90GHz
Memory	63.9 GB
Virtual flash	0 B used, 0 B capacity

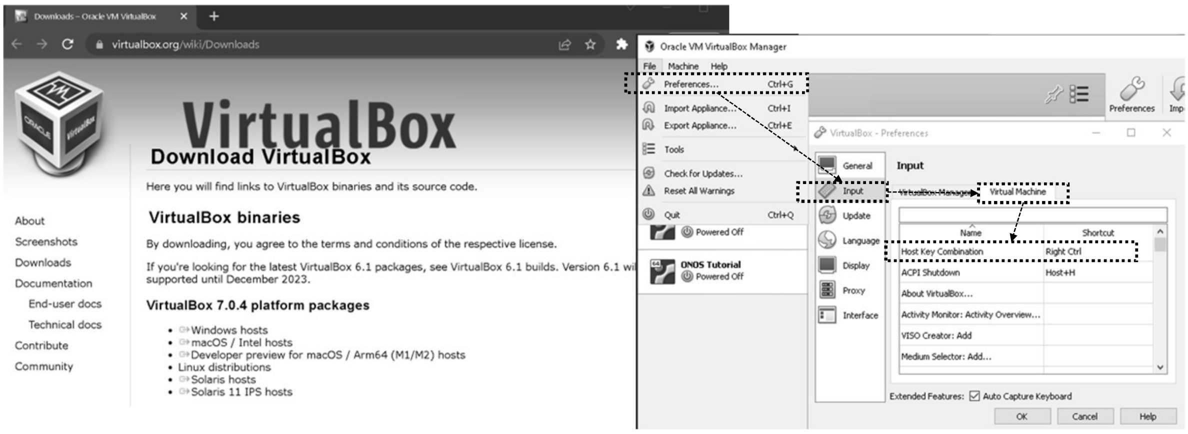
Configuration	
Image profile	ESXi-8.0U1-21495797-standard (VMware, Inc.)
vSphere HA state	Not configured
vMotion	Supported

System Information	
Date/time on host	Tuesday, June 06, 2023, 10:57:29 UTC

I. 실습 환경

❖ ONOS 실습 진행 하이퍼바이저 소프트웨어

- Type 2 Hypervisor: ‘VirtualBox’ 설치



Downloads – Oracle VM VirtualBox

virtualbox.org/wiki/Downloads

VirtualBox

Download VirtualBox

Here you will find links to VirtualBox binaries and its source code.

- About
- Screenshots
- Downloads
- Documentation
  - End-user docs
  - Technical docs
- Contribute
- Community

VirtualBox binaries

By downloading, you agree to the terms and conditions of the respective license.

If you're looking for the latest VirtualBox 6.1 packages, see VirtualBox 6.1 builds. Version 6.1 wi supported until December 2023.

VirtualBox 7.0.4 platform packages

- Windows hosts
- macOS / Intel hosts
- Developer preview for macOS / Arm64 (M1/M2) hosts
- Linux distributions
- Solaris hosts
- Solaris 11 IPS hosts

Oracle VM VirtualBox Manager

File Machine Help

Preferences...	Ctrl+G
Import Appliance...	Ctrl+I
Export Appliance...	Ctrl+E
Tools	
Check for Updates...	
Reset All Warnings	
Quit	Ctrl+Q

Powered Off

ONOS Tutorial
Powered Off

Preferences

VirtualBox - Preferences

General
Input
Update
Language
Display
Proxy
Interface

Input

VirtualBox Manager | Virtual Machine

Name	Shortcut
Host Key Combination	Right Ctrl
ACPI Shutdown	Host+H
About VirtualBox...	
Activity Monitor: Activity Overview...	
VISO Creator: Add	
Medium Selector: Add...	

Extended Features: ☑ Auto Capture Keyboard

OK Cancel Help

Source: https://www.virtualbox.org/wiki/Downloads

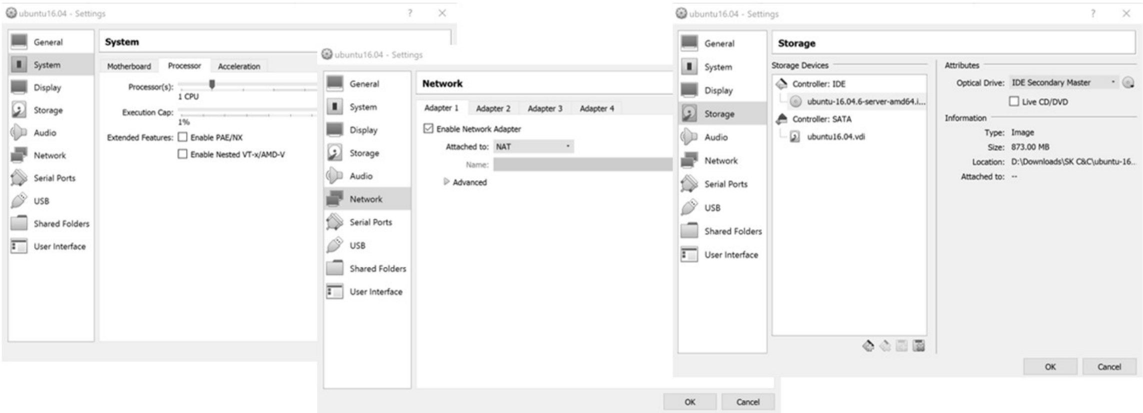
II. 리눅스(Linux) 설치

- 실습용 VM 이미지 생성

II. 리눅스(LINUX) 설치

❖ **VirtualBox – Type 2 Hypervisor (예)**

- **VirtualBox 6.x**
- **vCPU 2개, vRAM 4GB, 48 GB Storage (Dynamic)**
- **다운로드한 Ubuntu Server 16.04 ISO 파일 사용 설치**



System

Processor(s): 1 CPU

Execution Cap: 1%

Extended Features: □ Enable PAE/NX

□ Enable Nested VT-x/AMD-V

Network

Adapter 1

☑ Enable Network Adapter

Attached to: NAT

Name:

▷ Advanced

Storage

Storage Devices

Controller: IDE

ubuntu-16.04.6-server-amd64.i...

Controller: SATA

ubuntu16.04.vdi

Attributes

Optical Drive: IDE Secondary Master

□ Live CD/DVD

Information

Type: Image

Size: 873.00 MB

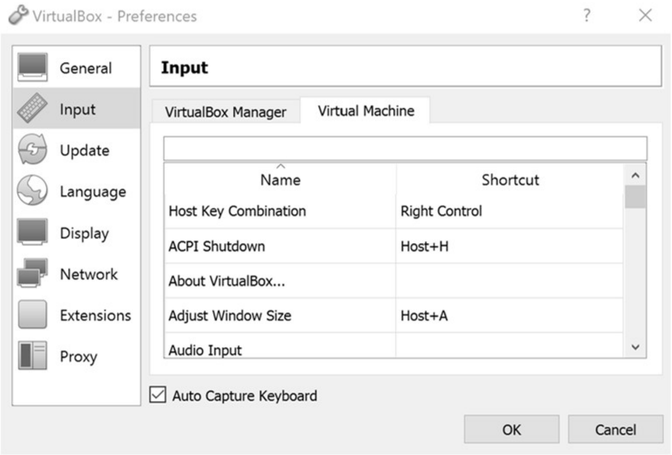
Location: D:\Downloads\SK C&C\ubuntu-16..

Attached to: --

II. 리눅스(LINUX) 설치

❖ **VirtualBox – Type 2 Hypervisor (예)**

- **Laptop 권장: Preferences for VM Shortcut**



Input

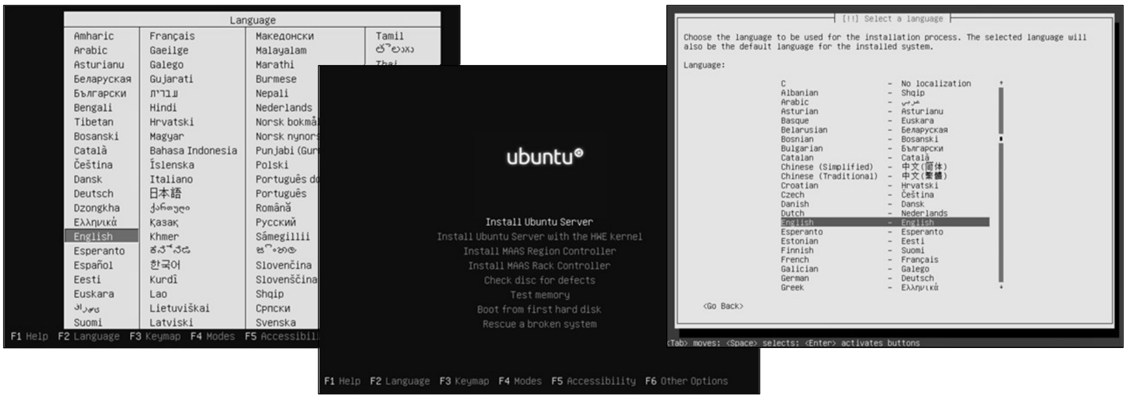
Name	Shortcut
Host Key Combination	Right Control
ACPI Shutdown	Host+H
About VirtualBox...	
Adjust Window Size	Host+A
Audio Input	

☑ Auto Capture Keyboard

II. 리눅스(LINUX) 설치

❖ **Ubuntu Server 16.04 Installation**

- **ISO 파일 선택 # 4 GB RAM / 32 GB Storage**
- **언어 선택 'Korean (한국어)' and 'Continue'**
- **선택 'Install Ubuntu Server'**



```
                              Language
 Amharic      Français           Македонски      Tamil
 Arabic       Gaeilge            Malayalam       తెలుగు
 Asturianu    Galego             Marathi         Thai
 Беларуская   Gujarati           Burmese
 Български    עברית              Nepali
 Bengali      Hindi              Nederlands
 Tibetan      Hrvatski           Norsk bokmå
 Bosanski     Magyar             Norsk nynors
 Català       Bahasa Indonesia   Punjabi (Gur
 Čeština      Íslenska           Polski
 Dansk        Italiano           Português do
 Deutsch      日本語             Português
 Dzongkha     ქართული            Română
 Ελληνικά     Қазақ              Русский
 English      Khmer              Sámegillii
 Esperanto    ಕನ್ನಡ               සිංහල
 Español      한국어             Slovenčina
 Eesti        Kurdî              Slovenščina
 Euskara      Lao                Shqip
 فارسی        Lietuviškai        Српски
 Suomi        Latviski           Svenska
F1 Help  F2 Language  F3 Keymap  F4 Modes  F5 Accessibili
```

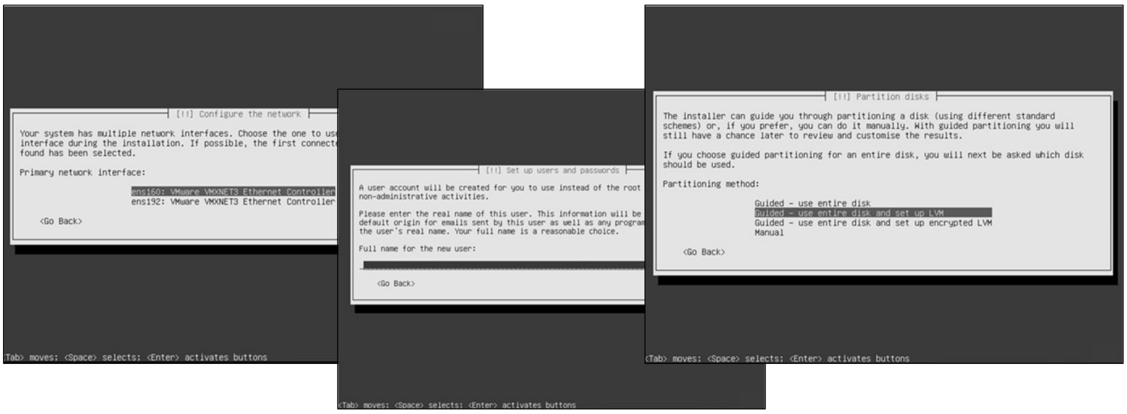
```
                          ubuntu®

                   Install Ubuntu Server
         Install Ubuntu Server with the HWE kernel
              Install MAAS Region Controller
               Install MAAS Rack Controller
                  Check disc for defects
                       Test memory
                 Boot from first hard disk
                  Rescue a broken system

F1 Help  F2 Language  F3 Keymap  F4 Modes  F5 Accessibility  F6 Other Options
```

```
┤ [!!] Select a language ├

Choose the language to be used for the installation process. The selected language will
also be the default language for the installed system.

Language:

                C                       -  No localization
                Albanian                -  Shqip
                Arabic                  -  عربي
                Asturian                -  Asturianu
                Basque                  -  Euskara
                Belarusian              -  Беларуская
                Bosnian                 -  Bosanski
                Bulgarian               -  Български
                Catalan                 -  Català
                Chinese (Simplified)    -  中文(简体)
                Chinese (Traditional)   -  中文(繁體)
                Croatian                -  Hrvatski
                Czech                   -  Čeština
                Danish                  -  Dansk
                Dutch                   -  Nederlands
                English                 -  English
                Esperanto               -  Esperanto
                Estonian                -  Eesti
                Finnish                 -  Suomi
                French                  -  Français
                Galician                -  Galego
                German                  -  Deutsch
                Greek                   -  Ελληνικά

    <Go Back>

<Tab> moves; <Space> selects; <Enter> activates buttons
```

II. 리눅스(LINUX) 설치

❖ **계정 생성**

- **Full Name 'jalsb'**
- **User name 'jslab'**
- **Password 'jslab123'**



```
┤ [!!] Configure the network ├

Your system has multiple network interfaces. Choose the one to use
interface during the installation. If possible, the first connecte
found has been selected.

Primary network interface:

                    ens160: VMware VMXNET3 Ethernet Controller
                    ens192: VMware VMXNET3 Ethernet Controller

    <Go Back>

<Tab> moves; <Space> selects; <Enter> activates buttons
```

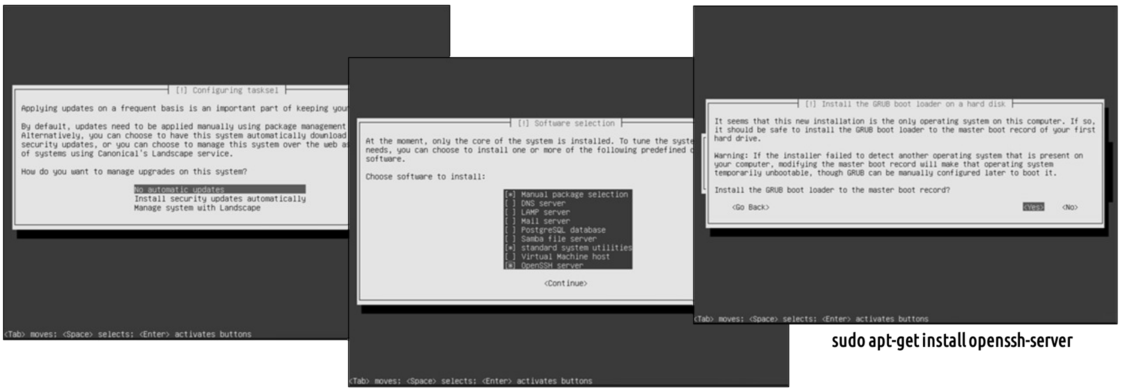
```
┤ [!!] Set up users and passwords ├

A user account will be created for you to use instead of the root
non-administrative activities.

Please enter the real name of this user. This information will be
default origin for emails sent by this user as well as any program
the user's real name. Your full name is a reasonable choice.

Full name for the new user:

_

    <Go Back>

<Tab> moves; <Space> selects; <Enter> activates buttons
```

```
┤ [!!] Partition disks ├

The installer can guide you through partitioning a disk (using different standard
schemes) or, if you prefer, you can do it manually. With guided partitioning you will
still have a chance later to review and customise the results.

If you choose guided partitioning for an entire disk, you will next be asked which disk
should be used.

Partitioning method:

                Guided - use entire disk
                Guided - use entire disk and set up LVM
                Guided - use entire disk and set up encrypted LVM
                Manual

    <Go Back>

<Tab> moves; <Space> selects; <Enter> activates buttons
```

II. 리눅스(LINUX) 설치

❖ SSH Server 설치 선택

- No automatic updates
- OpenSSH server
- User name 'jslab'



```
[!] Configuring tasksel

Applying updates on a frequent basis is an important part of keeping your

By default, updates need to be applied manually using package management
Alternatively, you can choose to have this system automatically download
security updates, or you can choose to manage this system over the web as
of systems using Canonical's Landscape service.

How do you want to manage upgrades on this system?

                No automatic updates
                Install security updates automatically
                Manage system with Landscape

<Tab> moves; <Space> selects; <Enter> activates buttons
```

```
[!] Software selection

At the moment, only the core of the system is installed. To tune the syste
needs, you can choose to install one or more of the following predefined c
software.

Choose software to install:

                [*] Manual package selection
                [ ] DNS server
                [ ] LAMP server
                [ ] Mail server
                [ ] PostgreSQL database
                [ ] Samba file server
                [*] standard system utilities
                [ ] Virtual Machine host
                [*] OpenSSH server

                        <Continue>

<Tab> moves; <Space> selects; <Enter> activates buttons
```

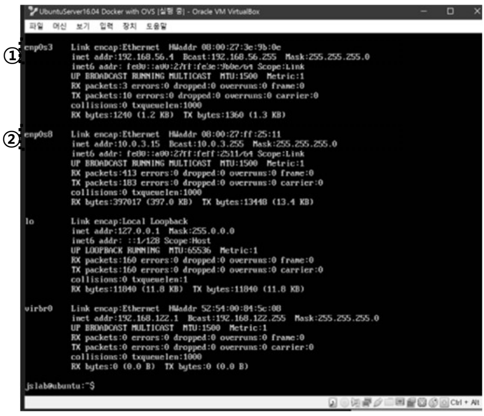
```
[!] Install the GRUB boot loader on a hard disk

It seems that this new installation is the only operating system on this computer. If so,
it should be safe to install the GRUB boot loader to the master boot record of your first
hard drive.

Warning: If the installer failed to detect another operating system that is present on
your computer, modifying the master boot record will make that operating system
temporarily unbootable, though GRUB can be manually configured later to boot it.

Install the GRUB boot loader to the master boot record?

    <Go Back>                                                  <Yes>    <No>

<Tab> moves; <Space> selects; <Enter> activates buttons
```

sudo apt-get install openssh-server

II. 리눅스(LINUX) 설치

❖ IP 확인

- 계정 사용 로그인 (ID/Password: jslab/jslab123)
- Ifconfig (또는 'ip a')
- IP 주소 확인 (네트워크 인터페이스 2개 설정시: (Bridge/호스트 어댑터/NAT)


UbuntuServer16.04 Docker with OVS [실행 중] - Oracle VM VirtualBox
파일 머신 보기 입력 장치 도움말
①
②
Ctrl + Alt

```
enp0s3    Link encap:Ethernet  HWaddr 08:00:27:3e:9b:0e
          inet addr:192.168.56.4  Bcast:192.168.56.255  Mask:255.255.255.0
          inet6 addr: fe80::a00:27ff:fe3e:9b0e/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:3 errors:0 dropped:0 overruns:0 frame:0
          TX packets:10 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:1240 (1.2 KB)  TX bytes:1360 (1.3 KB)

enp0s8    Link encap:Ethernet  HWaddr 08:00:27:ff:25:11
          inet addr:10.0.3.15  Bcast:10.0.3.255  Mask:255.255.255.0
          inet6 addr: fe80::a00:27ff:feff:2511/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:413 errors:0 dropped:0 overruns:0 frame:0
          TX packets:183 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:397017 (397.0 KB)  TX bytes:13448 (13.4 KB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:160 errors:0 dropped:0 overruns:0 frame:0
          TX packets:160 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:11840 (11.8 KB)  TX bytes:11840 (11.8 KB)

virbr0    Link encap:Ethernet  HWaddr 52:54:00:84:5c:08
          inet addr:192.168.122.1  Bcast:192.168.122.255  Mask:255.255.255.0
          UP BROADCAST MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

jslab@ubuntu:~$
```

루트계정 활성화:
sudo passwd root

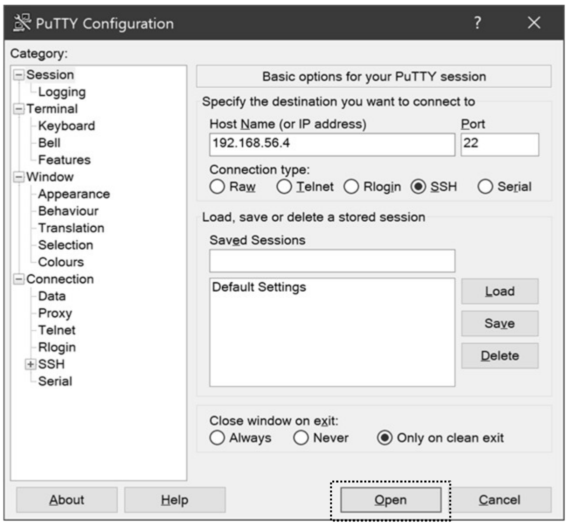
루트계정 활성화:
sudo passwd root

II. 리눅스(LINUX) 설치

❖ SSH 터미널 접속

- putty-64bit-0.70-installer.msi 설치
- SuperPuttySetup-1.4.0.9.msi 설치 (선택)
- IP 주소 설정 후 Open (호스트 어댑터 접속)

- Saved Sessions에 이름을 지정 후 Save 하여 필요시 Load 하여 사용 가능
- 윈도우 설치 Putty는 윈도우 OS 화면과 Copy(복사)/Paste(붙여넣기) 가능



Host Name (or IP address): 192.168.56.4
Port: 22

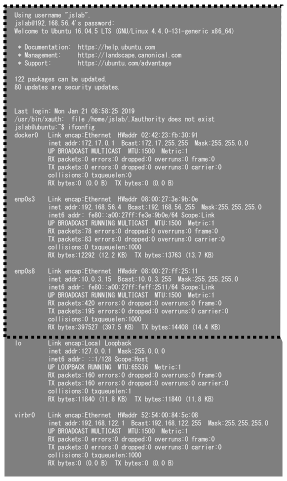
Connection type: ○ Raw ○ Telnet ○ Rlogin ● SSH ○ Serial

Close window on exit: ○ Always ○ Never ● Only on clean exit

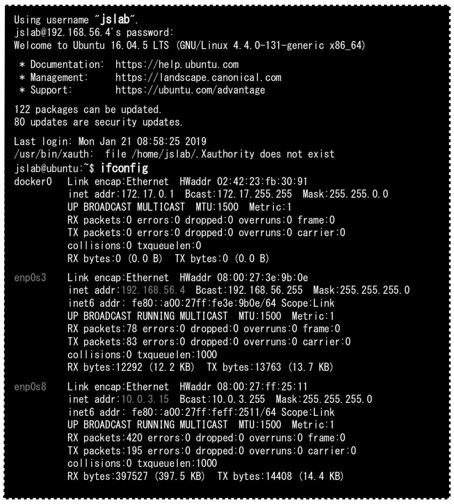
II. 리눅스(LINUX) 설치

❖ SSH 접속 IP 주소 확인

- ifconfig (예: Docker 설치 후 화면)



```
Using username "jslab".
jslab@192.168.56.4's password:
Welcome to Ubuntu 16.04.5 LTS (GNU/Linux 4.4.0-131-generic x86_64)

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

122 packages can be updated.
80 updates are security updates.

Last login: Mon Jan 21 08:58:25 2019
/usr/bin/xauth:  file /home/jslab/.Xauthority does not exist
jslab@ubuntu:~$ ifconfig
docker0   Link encap:Ethernet  HWaddr 02:42:23:fb:30:91
          inet addr:172.17.0.1  Bcast:172.17.255.255  Mask:255.255.0.0
          UP BROADCAST MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

enp0s3    Link encap:Ethernet  HWaddr 08:00:27:3e:9b:0e
          inet addr:192.168.56.4  Bcast:192.168.56.255  Mask:255.255.255.0
          inet6 addr: fe80::a00:27ff:fe3e:9b0e/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:78 errors:0 dropped:0 overruns:0 frame:0
          TX packets:83 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:12292 (12.2 KB)  TX bytes:13763 (13.7 KB)

enp0s8    Link encap:Ethernet  HWaddr 08:00:27:ff:25:11
          inet addr:10.0.3.15  Bcast:10.0.3.255  Mask:255.255.255.0
          inet6 addr: fe80::a00:27ff:feff:2511/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:420 errors:0 dropped:0 overruns:0 frame:0
          TX packets:195 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:397527 (397.5 KB)  TX bytes:14408 (14.4 KB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:160 errors:0 dropped:0 overruns:0 frame:0
          TX packets:160 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:11840 (11.8 KB)  TX bytes:11840 (11.8 KB)

virbr0    Link encap:Ethernet  HWaddr 52:54:00:84:5c:08
          inet addr:192.168.122.1  Bcast:192.168.122.255  Mask:255.255.255.0
          UP BROADCAST MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)
```

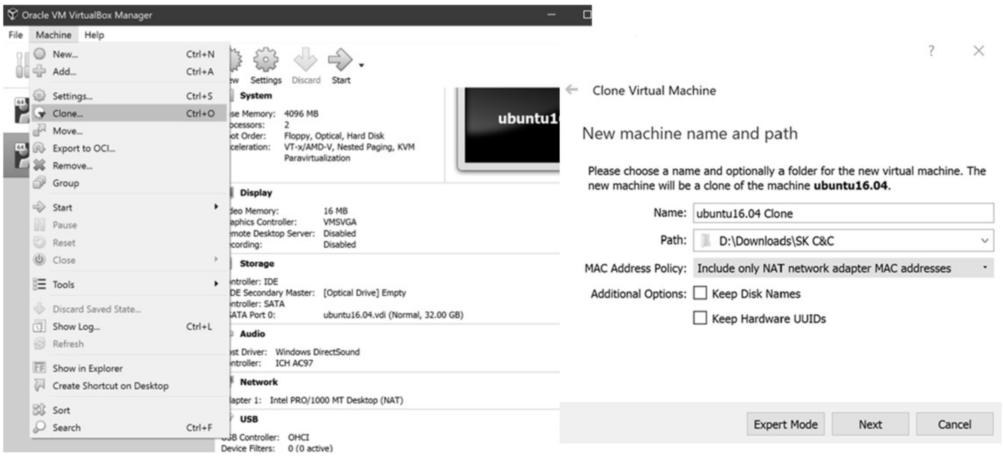


```
Using username "jslab".
jslab@192.168.56.4's password:
Welcome to Ubuntu 16.04.5 LTS (GNU/Linux 4.4.0-131-generic x86_64)

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

122 packages can be updated.
80 updates are security updates.

Last login: Mon Jan 21 08:58:25 2019
/usr/bin/xauth:  file /home/jslab/.Xauthority does not exist
jslab@ubuntu:~$ ifconfig
docker0   Link encap:Ethernet  HWaddr 02:42:23:fb:30:91
          inet addr:172.17.0.1  Bcast:172.17.255.255  Mask:255.255.0.0
          UP BROADCAST MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

enp0s3    Link encap:Ethernet  HWaddr 08:00:27:3e:9b:0e
          inet addr:192.168.56.4  Bcast:192.168.56.255  Mask:255.255.255.0
          inet6 addr: fe80::a00:27ff:fe3e:9b0e/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:78 errors:0 dropped:0 overruns:0 frame:0
          TX packets:83 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:12292 (12.2 KB)  TX bytes:13763 (13.7 KB)

enp0s8    Link encap:Ethernet  HWaddr 08:00:27:ff:25:11
          inet addr:10.0.3.15  Bcast:10.0.3.255  Mask:255.255.255.0
          inet6 addr: fe80::a00:27ff:feff:2511/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:420 errors:0 dropped:0 overruns:0 frame:0
          TX packets:195 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:397527 (397.5 KB)  TX bytes:14408 (14.4 KB)
```

II. 리눅스(LINUX) 설치

❖ Clone (선택)

- Cloud Native 실습 클러스터링시 노드 추가에 사용
- Host Name, IP 주소 등의 정책 (선택)



```
System
se Memory:      4096 MB
ocessors:       2
ot Order:       Floppy, Optical, Hard Disk
celeration:     VT-x/AMD-V, Nested Paging, KVM
                Paravirtualization

Display
deo Memory:             16 MB
aphics Controller:      VMSVGA
mote Desktop Server:    Disabled
cording:                Disabled

Storage
ntroller: IDE
DE Secondary Master:    [Optical Drive] Empty
ntroller: SATA
ATA Port 0:             ubuntu16.04.vdi (Normal, 32.00 GB)

Audio
st Driver:   Windows DirectSound
ntroller:    ICH AC97

Network
apter 1:   Intel PRO/1000 MT Desktop (NAT)

USB
SB Controller:   OHCI
Device Filters:  0 (0 active)
```

Clone Virtual Machine

New machine name and path

Please choose a name and optionally a folder for the new virtual machine. The new machine will be a clone of the machine **ubuntu16.04**.

Name: ubuntu16.04 Clone

Path: D:\Downloads\SK C&C

MAC Address Policy: Include only NAT network adapter MAC addresses

Additional Options: □ Keep Disk Names

□ Keep Hardware UUIDs

II. 리눅스(LINUX) 설치

❖ Clone (선택)

- Cloud Native 실습 클러스터링시 노드 추가에 사용
- Host Name, IP 주소 등의 정책 (선택)
- 클라우드 네이티브 자원 Naming Convention 필요

Naming convention (예)

번호	IP 주소	Hostname (예1)	Hostname (예2)
1	192.168.1.70	rancher	rancher
2	192.168.1.71	master71	master71
3	192.168.1.72	worker72	master72
4	192.168.1.73	worker73	master73
x	192.168.1.7x	worker7x	worker7x

II. 리눅스(LINUX) 설치

❖ 운영 환경 시 필요한 설정 16.04 (예)

- SSH Well-known Port 변경 -

```
sudo vi /etc/ssh/sshd_config

# What ports, IPs and protocols we listen for
Port 33322
```

- 계정 암호 변경 -

```
To change the root password:
sudo passwd
To change your user password:
passwd
To change other users password:
sudo passwd USERNAME
```

- Root 계정 생성 -

```
sudo -I
passwd
sudo passwd root
```

- Root 계정 @ Remote -

```
/etc/ssh/sshd_config
PermitRootLogin yes
```

- Remote for sshd @ Putty -

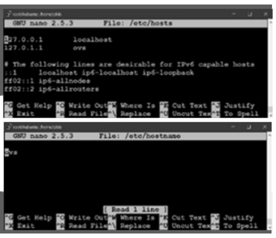
```
192.168.1.xxx @ Putty for VyOS
ssh jslab@192.168.0.yy
```

- 고정 IP 주소 설정-

```
sudo vi /etc/network/interfaces

# Iface ens160 inet dhcp                              'esc' i for
auto ens160                                           Insert mode
iface ens160 inet static
        address 192.168.0.xx
        netmask 255.255.255.0
        gateway 192.168.0.1
        dns-nameservers 8.8.8.8

'esc' :x ('nano'인 경우 cntl+x or cntl+o → enter → cntl+x)
sudo /etc/init.d/networking restart (or reboot)
```

- 호스트 이름 변경 -

```
/etc/hostname
/etc/hosts
sudo nano /etc/hostname
sudo nano /etc/hosts
** reboot 권장 **
```



```
  GNU nano 2.5.3        File: /etc/hosts

127.0.0.1       localhost
127.0.1.1       ovs

# The following lines are desirable for IPv6 capable hosts
::1     localhost ip6-localhost ip6-loopback
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters

^G Get Help  ^O Write Out ^W Where Is  ^K Cut Text  ^J Justify
^X Exit      ^R Read File ^\ Replace   ^U Uncut Text ^T To Spell
```

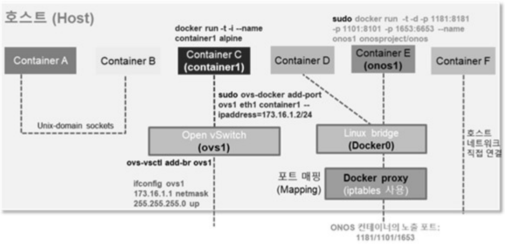
```
  GNU nano 2.5.3        File: /etc/hostname

ovs

                    [ Read 1 line ]
^G Get Help  ^O Write Out ^W Where Is  ^K Cut Text  ^J Justify
^X Exit      ^R Read File ^\ Replace   ^U Uncut Text ^T To Spell
```

- Root 활성화 -

```
sudo su - root
(return with ctrl-d)
```

III. OVS/도커 (Docker) 설치

- 가상스위치 설치
- 가상스위치의 컨테이너 연결
- SDN 제어기 연결



```
docker run -t -i --name
container1 alpine
```

```
sudo docker run -t -d -p 1181:8181
-p 1101:8101 -p 1653:6653 --name
onos1 onosproject/onos
```

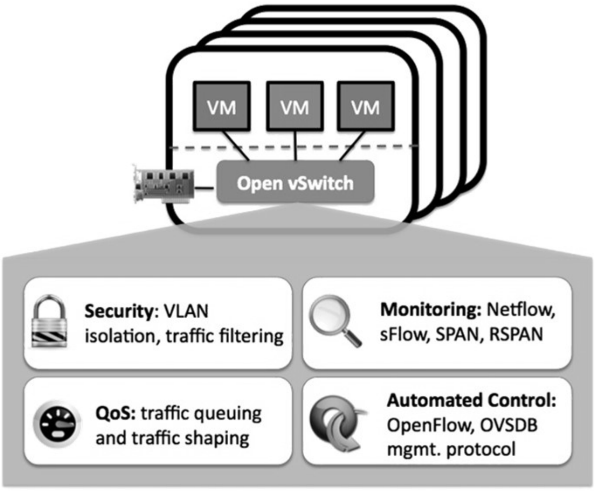
```
sudo ovs-docker add-port
ovs1 eth1 container1 --
ipaddress=173.16.1.2/24
```

```
ovs-vsctl add-br ovs1
```

```
ifconfig ovs1
173.16.1.1 netmask
255.255.255.0 up
```

III. OVS/도커 (DOCKER) 설치

- ❖ Open vSwitch (OVS)

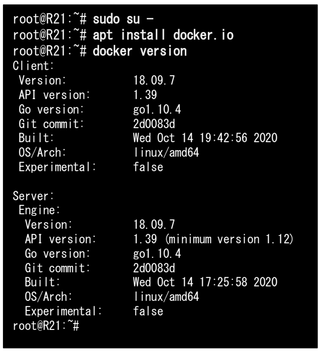

VM
VM
VM
Open vSwitch
Security: VLAN isolation, traffic filtering
Monitoring: Netflow, sFlow, SPAN, RSPAN
QoS: traffic queuing and traffic shaping
Automated Control: OpenFlow, OVSDB mgmt. protocol

Source: https://www.openvswitch.org/

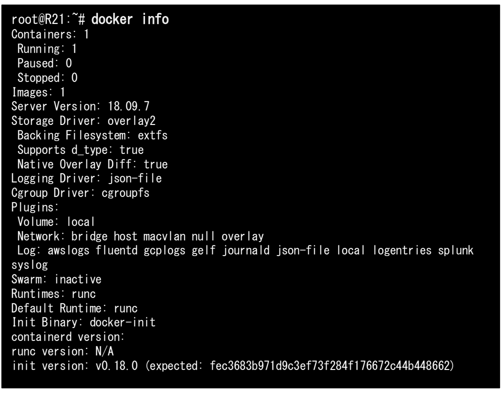
III. OVS/도커 (DOCKER) 설치

- ❖ Docker 설치

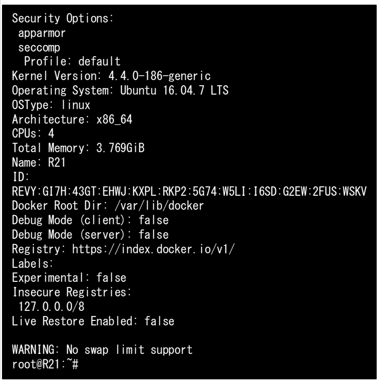
① **sudo su** # 암호 필요 ‘jslab123’
② **apt install docker.io** # docker 설치 sudo apt install docker.io
③ **docker version**
④ **docker info**



```
root@R21:~# sudo su -
root@R21:~# apt install docker.io
root@R21:~# docker version
Client:
 Version:           18.09.7
 API version:       1.39
 Go version:        go1.10.4
 Git commit:        2d0083d
 Built:             Wed Oct 14 19:42:56 2020
 OS/Arch:           linux/amd64
 Experimental:      false

Server:
 Engine:
  Version:          18.09.7
  API version:      1.39 (minimum version 1.12)
  Go version:       go1.10.4
  Git commit:       2d0083d
  Built:            Wed Oct 14 17:25:58 2020
  OS/Arch:          linux/amd64
  Experimental:     false
root@R21:~#
```



```
root@R21:~# docker info
Containers: 1
 Running: 1
 Paused: 0
 Stopped: 0
Images: 1
Server Version: 18.09.7
Storage Driver: overlay2
 Backing Filesystem: extfs
 Supports d_type: true
 Native Overlay Diff: true
Logging Driver: json-file
Cgroup Driver: cgroupfs
Plugins:
 Volume: local
 Network: bridge host macvlan null overlay
 Log: awslogs fluentd gcplogs gelf journald json-file local logentries splunk
syslog
Swarm: inactive
Runtimes: runc
Default Runtime: runc
Init Binary: docker-init
containerd version:
runc version: N/A
init version: v0.18.0 (expected: fec3683b971d9c3ef73f284f176672c44b448662)
```



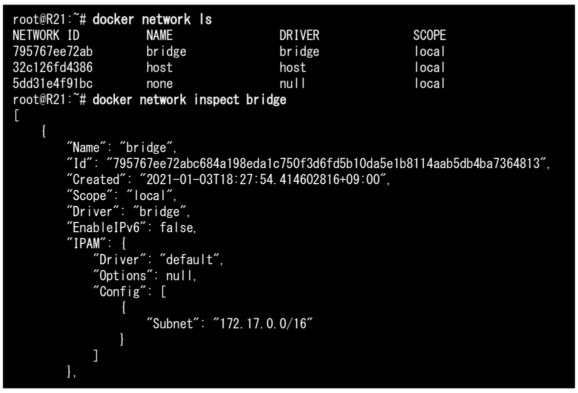
```
Security Options:
 apparmor
 seccomp
  Profile: default
Kernel Version: 4.4.0-186-generic
Operating System: Ubuntu 16.04.7 LTS
OSType: linux
Architecture: x86_64
CPUs: 4
Total Memory: 3.769GiB
Name: R21
ID:
REVY:GI7H:43GT:EHWJ:KXPL:RKP2:5G74:W5LI:I6SD:G2EW:2FUS:WSKV
Docker Root Dir: /var/lib/docker
Debug Mode (client): false
Debug Mode (server): false
Registry: https://index.docker.io/v1/
Labels:
Experimental: false
Insecure Registries:
 127.0.0.0/8
Live Restore Enabled: false

WARNING: No swap limit support
root@R21:~#
```

III. OVS/도커 (DOCKER) 설치

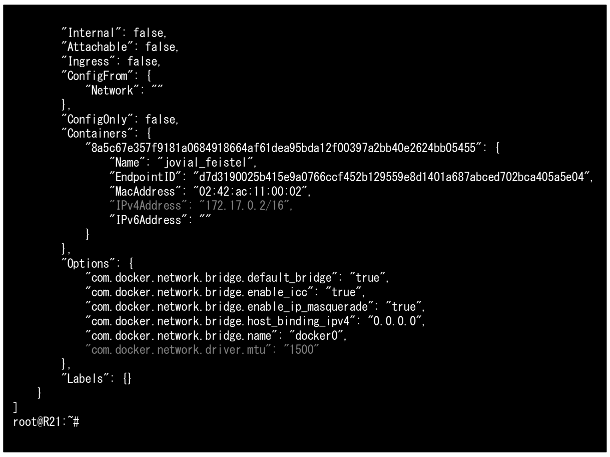
❖ Docker 네트워크 확인

① docker network ls

② docker network inspect bridge



```
root@R21:~# docker network ls
NETWORK ID          NAME                DRIVER              SCOPE
795767ee72ab        bridge              bridge              local
32c126fd4386        host                host                local
5dd31e4f91bc        none                null                local
root@R21:~# docker network inspect bridge
[
    {
        "Name": "bridge",
        "Id": "795767ee72abc684a198eda1c750f3d6fd5b10da5e1b8114aab5db4ba7364813",
        "Created": "2021-01-03T18:27:54.414602816+09:00",
        "Scope": "local",
        "Driver": "bridge",
        "EnableIPv6": false,
        "IPAM": {
            "Driver": "default",
            "Options": null,
            "Config": [
                {
                    "Subnet": "172.17.0.0/16"
                }
            ]
        },
```



```
        "Internal": false,
        "Attachable": false,
        "Ingress": false,
        "ConfigFrom": {
            "Network": ""
        },
        "ConfigOnly": false,
        "Containers": {
            "8a5c67e357f9181a0684918664af61dea95bda12f00397a2bb40e2624bb05455": {
                "Name": "jovial_feistel",
                "EndpointID": "d7d3190025b415e9a0766ccf452b129559e8d1401a687abced702bca405a5e04",
                "MacAddress": "02:42:ac:11:00:02",
                "IPv4Address": "172.17.0.2/16",
                "IPv6Address": ""
            }
        },
        "Options": {
            "com.docker.network.bridge.default_bridge": "true",
            "com.docker.network.bridge.enable_icc": "true",
            "com.docker.network.bridge.enable_ip_masquerade": "true",
            "com.docker.network.bridge.host_binding_ipv4": "0.0.0.0",
            "com.docker.network.bridge.name": "docker0",
            "com.docker.network.driver.mtu": "1500"
        },
        "Labels": {}
    }
]
root@R21:~#
```

III. OVS/도커 (DOCKER) 설치

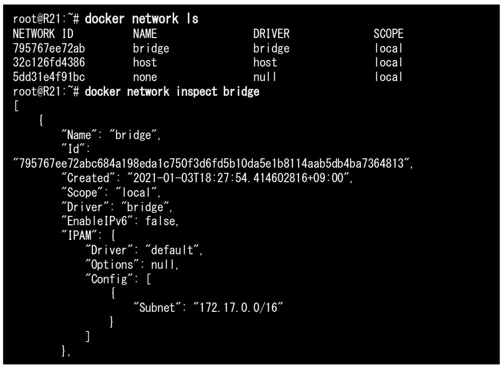
❖ Docker/OVS-Docker 설치

① **sudo su** # 암호 필요 'jslab123'

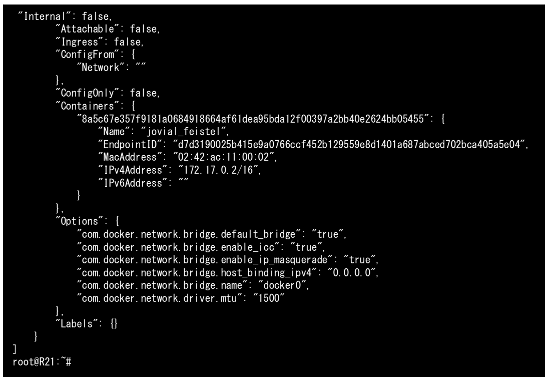
② **apt install docker.io** # docker 설치 sudo apt install docker.io

③ **cd /usr/bin** # Install ovs-docker utility.

④ **sudo wget https://raw.githubusercontent.com/openvswitch/ovs/master/utilities/ovs-docker**



```
root@R21:~# docker network ls
NETWORK ID          NAME                DRIVER              SCOPE
795767ee72ab        bridge              bridge              local
32c126fd4386        host                host                local
5dd31e4f91bc        none                null                local
root@R21:~# docker network inspect bridge
[
    {
        "Name": "bridge",
        "Id":
"795767ee72abc684a198eda1c750f3d6fd5b10da5e1b8114aab5db4ba7364813",
        "Created": "2021-01-03T18:27:54.414602816+09:00",
        "Scope": "local",
        "Driver": "bridge",
        "EnableIPv6": false,
        "IPAM": {
            "Driver": "default",
            "Options": null,
            "Config": [
                {
                    "Subnet": "172.17.0.0/16"
                }
            ]
        },
```

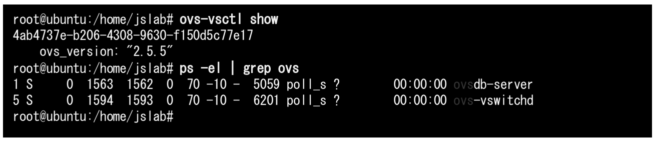


```
"Internal": false,
        "Attachable": false,
        "Ingress": false,
        "ConfigFrom": {
            "Network": ""
        },
        "ConfigOnly": false,
        "Containers": {
            "8a5c67e357f9181a0684918664af61dea95bda12f00397a2bb40e2624bb05455": {
                "Name": "jovial_feistel",
                "EndpointID": "d7d3190025b415e9a0766ccf452b129559e8d1401a687abced702bca405a5e04",
                "MacAddress": "02:42:ac:11:00:02",
                "IPv4Address": "172.17.0.2/16",
                "IPv6Address": ""
            }
        },
        "Options": {
            "com.docker.network.bridge.default_bridge": "true",
            "com.docker.network.bridge.enable_icc": "true",
            "com.docker.network.bridge.enable_ip_masquerade": "true",
            "com.docker.network.bridge.host_binding_ipv4": "0.0.0.0",
            "com.docker.network.bridge.name": "docker0",
            "com.docker.network.driver.mtu": "1500"
        },
        "Labels": {}
    }
]
root@R21:~#
```

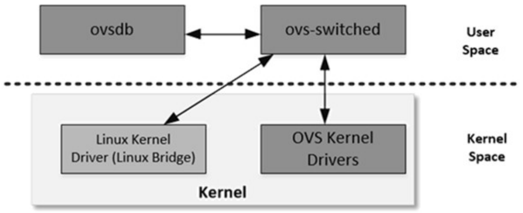
III. OVS/도커 (DOCKER) 설치

❖ **OVS 설치**

① **sudo apt install -y openvswitch-switch**
② **sudo su** # 암호 필요 jslab123
③ **ovs-vsctl show** # sudo ovs-vsctl show
④ **ps -el | grep ovs**



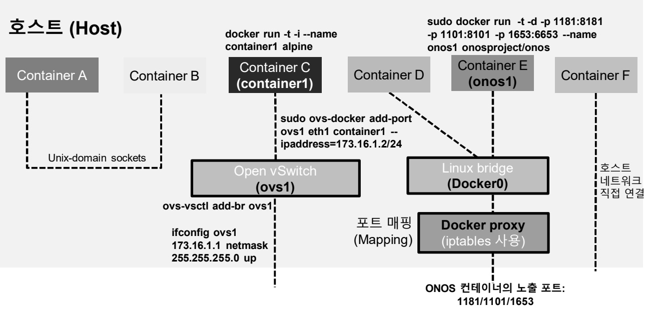
```
root@ubuntu:/home/jslab# ovs-vsctl show
4ab4737e-b206-4308-9630-f150d5c77e17
    ovs_version: "2.5.5"
root@ubuntu:/home/jslab# ps -el | grep ovs
1 S     0  1563  1562  0  70 -10 -  5059 poll_s ?        00:00:00 ovsdb-server
5 S     0  1594  1593  0  70 -10 -  6201 poll_s ?        00:00:00 ovs-vswitchd
root@ubuntu:/home/jslab#
```



III. OVS/도커 (DOCKER) 설치

❖ **Docker network option과 구성**

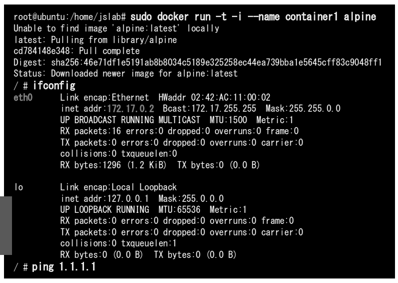
① **`ovs-vsctl add-br ovs1`** # OVS 스위치 생성
② **`ovs-vsctl show`**
③ **`sudo ovs-docker add-port ovs1 eth1 container1 --ipaddress=173.16.1.2/24`** # OVS1 ←→ 컨테이너 접속
④ **`ifconfig ovs1 173.16.1.1 netmask 255.255.255.0 up`** # ovs1 스위치에 호스트 외부 접속 인터페이스 생성
⑤ **## onos 컨테이너 생성시 노출포트 지정 생성** (8181, 8101, 6653)
✓ **`sudo docker run  -t -d -p 1181:8181 -p 1101:8101 -p 1653:6653 --name onos1 onosproject/onos`**


호스트 (Host)
docker run -t -i --name container1 alpine
sudo docker run -t -d -p 1181:8181 -p 1101:8101 -p 1653:6653 --name onos1 onosproject/onos
Container A
Container B
Container C (container1)
Container D
Container E (onos1)
Container F
sudo ovs-docker add-port ovs1 eth1 container1 --ipaddress=173.16.1.2/24
Unix-domain sockets
Open vSwitch (ovs1)
Linux bridge (Docker0)
호스트 네트워크 직접 연결
ovs-vsctl add-br ovs1
ifconfig ovs1 173.16.1.1 netmask 255.255.255.0 up
포트 매핑 (Mapping)
Docker proxy (iptables 사용)
ONOS 컨테이너의 노출 포트: 1181/1101/1653

III. OVS/도커 (DOCKER) 설치

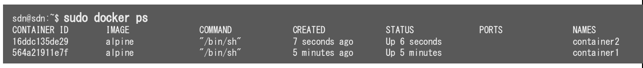
❖ OVS bridge for docker networking

```
① docker run -t -i --name container1 alpine
② / # ifconfig   # at container1 or ‘ip a’
③ sudo docker run -t -i -d --name container2 alpine  # New Term
④ sudo docker ps                                     # Check container ID
⑤ sudo docker exec container2 ifconfig
⑥ sudo ovs-docker add-port ovs1 eth1 container2 --ipaddress=173.16.1.3/24
⑦ sudo docker exec container2 ifconfig
⑧ sudo ovs-docker add-port ovs1 eth1 container1 --ipaddress=173.16.1.2/24
⑨ sudo docker exec container1 ifconfig
⑩ sudo docker exec container2 ping 1.1.1.1
⑪ ovs-vsctl show
```



```
root@ubuntu:/home/jslab# sudo docker run -t -i --name container1 alpine
Unable to find image 'alpine:latest' locally
latest: Pulling from library/alpine
cd784148e348: Pull complete
Digest: sha256:46e71df1e5191ab8b8034c5189e325258ec44ea739bba1e5645cff83c9048ff1
Status: Downloaded newer image for alpine:latest
/ # ifconfig
eth0      Link encap:Ethernet  HWaddr 02:42:AC:11:00:02
          inet addr:172.17.0.2  Bcast:172.17.255.255  Mask:255.255.0.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:16 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:1296 (1.2 KiB)  TX bytes:0 (0.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)
/ # ping 1.1.1.1
```

ovs-docker 버그 있음

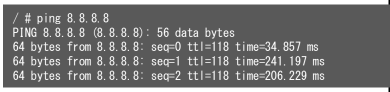


```
sdn@sdn:~$ sudo docker ps
CONTAINER ID   IMAGE    COMMAND      CREATED          STATUS          PORTS   NAMES
16ddc135de29   alpine   "/bin/sh"    7 seconds ago    Up 6 seconds            container2
564a21911e7f   alpine   "/bin/sh"    5 minutes ago    Up 5 minutes            container1
```

III. OVS/도커 (DOCKER) 설치

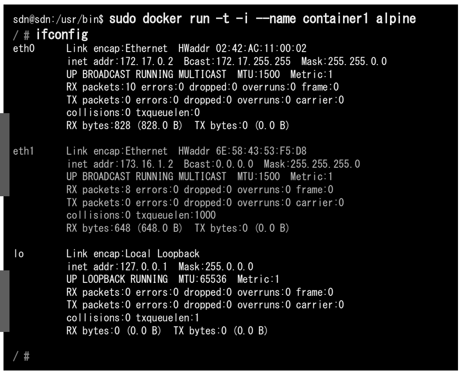
❖ Using OVS bridge for docker networking

```
① sudo ovs-docker add-port ovs1 eth1 container1 --ipaddress=173.16.1.2/24
② sudo ovs-docker add-port ovs1 eth1 container2 --ipaddress=173.16.1.3/24
③ sudo docker exec container2 ifconfig              # check for Internet
④ sudo docker exec container2 ping 173.16.1.2
```



```
/ # ping 8.8.8.8
PING 8.8.8.8 (8.8.8.8): 56 data bytes
64 bytes from 8.8.8.8: seq=0 ttl=118 time=34.857 ms
64 bytes from 8.8.8.8: seq=1 ttl=118 time=241.197 ms
64 bytes from 8.8.8.8: seq=2 ttl=118 time=206.229 ms
```

1.포트 삭제: sudo ovs-docker del-port ovs2 eth1 container2 --ipaddress=173.16.1.3/24
2.It will be back after docker container
3.미사용 컨테이너 삭제: sudo docker system prune
4.http://containertutorials.com/network/ovs_docker.html

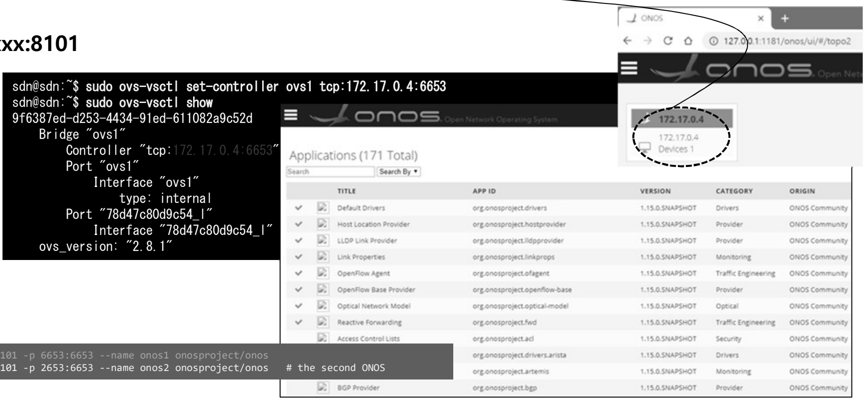


```
sdn@sdn:/usr/bin$ sudo docker run -t -i --name container1 alpine
/ # ifconfig
eth0      Link encap:Ethernet  HWaddr 02:42:AC:11:00:02
          inet addr:172.17.0.2  Bcast:172.17.255.255  Mask:255.255.0.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:10 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:828 (828.0 B)  TX bytes:0 (0.0 B)

eth1      Link encap:Ethernet  HWaddr 6E:58:43:53:F5:D8
          inet addr:173.16.1.2  Bcast:0.0.0.0  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:8 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:648 (648.0 B)  TX bytes:0 (0.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

/ #
```

III. OVS/도커 (DOCKER) 설치

❖ Open vSwitch 의 제어기 연결 (SDN 제어기 설치 후 선택)

① **sudo docker run -t -d -p 8181:8181 -p 8101:8101 -p 6653:6653 --name onos1 onosproject/onos**
② **http://192.168.26.132:8181/onos/ui**   # ID: **onos** / Password: **rocks**
③ **sudo ovs-vsctl set-controller ovs1 tcp:172.17.0.4:6653**
④ **sudo ovs-vsctl show**
⑤ **ssh james@192.168.99.xxx:8101**
⑥ **Check ONOS App**



```
sdn@sdn:~$ sudo ovs-vsctl set-controller ovs1 tcp:172.17.0.4:6653
sdn@sdn:~$ sudo ovs-vsctl show
9f6387ed-d253-4434-91ed-611082a9c52d
    Bridge "ovs1"
        Controller "tcp:172.17.0.4:6653"
        Port "ovs1"
            Interface "ovs1"
                type: internal
        Port "78d47c80d9c54_l"
            Interface "78d47c80d9c54_l"
    ovs_version: "2.8.1"
```

ONOS
127.0.0.1:1181/onos/ui/#/topo2
onos Open Network Operating System
172.17.0.4
172.17.0.4
Devices 1

Applications (171 Total)

	TITLE	APP ID	VERSION	CATEGORY	ORIGIN
✓	Default Drivers	org.onosproject.drivers	1.15.0.SNAPSHOT	Drivers	ONOS Community
✓	Host Location Provider	org.onosproject.hostprovider	1.15.0.SNAPSHOT	Provider	ONOS Community
✓	LLDP Link Provider	org.onosproject.lldpprovider	1.15.0.SNAPSHOT	Provider	ONOS Community
✓	Link Properties	org.onosproject.linkprops	1.15.0.SNAPSHOT	Monitoring	ONOS Community
✓	OpenFlow Agent	org.onosproject.ofagent	1.15.0.SNAPSHOT	Traffic Engineering	ONOS Community
✓	OpenFlow Base Provider	org.onosproject.openflow-base	1.15.0.SNAPSHOT	Provider	ONOS Community
✓	Optical Network Model	org.onosproject.optical-model	1.15.0.SNAPSHOT	Optical	ONOS Community
✓	Reactive Forwarding	org.onosproject.fwd	1.15.0.SNAPSHOT	Traffic Engineering	ONOS Community
	Access Control Lists	org.onosproject.acl	1.15.0.SNAPSHOT	Security	ONOS Community
		org.onosproject.drivers.arista	1.15.0.SNAPSHOT	Drivers	ONOS Community
		org.onosproject.artemis	1.15.0.SNAPSHOT	Monitoring	ONOS Community
	BGP Provider	org.onosproject.bgp	1.15.0.SNAPSHOT	Provider	ONOS Community

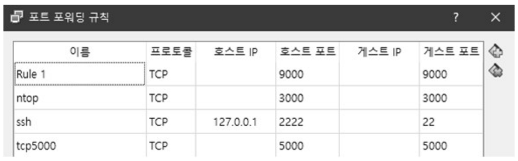
```
1.sudo docker run  -t -d -p 8181:8181 -p 8101:8101 -p 6653:6653 --name onos1 onosproject/onos
2.sudo docker run  -t -d -p 2181:8181 -p 2101:8101 -p 2653:6653 --name onos2 onosproject/onos   # the second ONOS
```

III. OVS/도커 (DOCKER) 설치

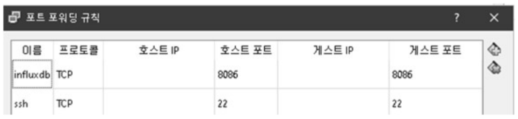
❖ VirtualBox의 NAT 설정 (선택)

- **VirtualBox 포트포워딩 설정 (VirtualBox NAT 사용시) **호스트전용아답터 사용시 필요 없음**
  - o onos 컨테이너 생성시 노출포트 지정 생성 (8181 → 1181, 8101 → 1101, 6653 → 1653)
  - o sudo docker run -t -d -p 1181:8181 -p 1101:8101 -p 1653:6653 --name onos1 onosproject/onos

Web	TCP		1181		1181
CLI (SSH)	TCP		1101		1101
OVS	TCP		1653		1653



이름	프로토콜	호스트 IP	호스트 포트	게스트 IP	게스트 포트
Rule 1	TCP		9000		9000
ntop	TCP		3000		3000
ssh	TCP	127.0.0.1	2222		22
tcp5000	TCP		5000		5000

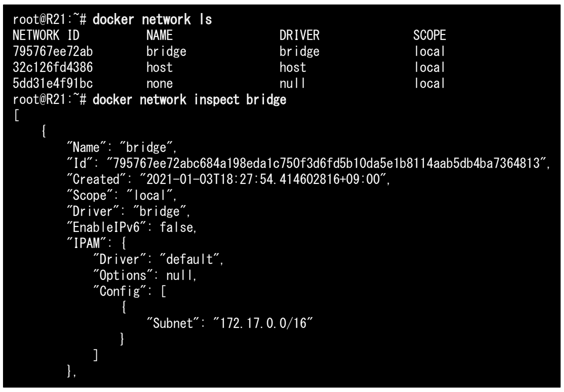


이름	프로토콜	호스트 IP	호스트 포트	게스트 IP	게스트 포트
influxdb	TCP		8086		8086
ssh	TCP		22		22

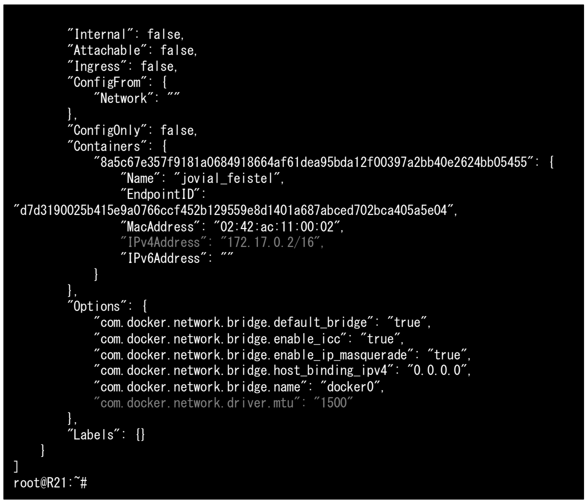
III. OVS/도커 (DOCKER) 설치

❖ Docker 네트워크 확인

① docker network ls
② docker network inspect bridge



```
root@R21:~# docker network ls
NETWORK ID          NAME                DRIVER              SCOPE
795767ee72ab        bridge              bridge              local
32c126fd4386        host                host                local
5dd31e4f91bc        none                null                local
root@R21:~# docker network inspect bridge
[
    {
        "Name": "bridge",
        "Id": "795767ee72abc684a198eda1c750f3d6fd5b10da5e1b8114aab5db4ba7364813",
        "Created": "2021-01-03T18:27:54.414602816+09:00",
        "Scope": "local",
        "Driver": "bridge",
        "EnableIPv6": false,
        "IPAM": {
            "Driver": "default",
            "Options": null,
            "Config": [
                {
                    "Subnet": "172.17.0.0/16"
                }
            ]
        },
```



```
        "Internal": false,
        "Attachable": false,
        "Ingress": false,
        "ConfigFrom": {
            "Network": ""
        },
        "ConfigOnly": false,
        "Containers": {
            "8a5c67e357f9181a0684918664af61dea95bda12f00397a2bb40e2624bb05455": {
                "Name": "jovial_feistel",
                "EndpointID":
"d7d3190025b415e9a0766ccf452b129559e8d1401a687abced702bca405a5e04",
                "MacAddress": "02:42:ac:11:00:02",
                "IPv4Address": "172.17.0.2/16",
                "IPv6Address": ""
            }
        },
        "Options": {
            "com.docker.network.bridge.default_bridge": "true",
            "com.docker.network.bridge.enable_icc": "true",
            "com.docker.network.bridge.enable_ip_masquerade": "true",
            "com.docker.network.bridge.host_binding_ipv4": "0.0.0.0",
            "com.docker.network.bridge.name": "docker0",
            "com.docker.network.driver.mtu": "1500"
        },
        "Labels": {}
    }
]
root@R21:~#
```

JS Lab

III. OVS/도커 (DOCKER) 설치

❖ Review

- BIOS 가상화 세팅 확인
- 윈도우 제공 압축 소프트웨어 대체 소프트웨어 Commander 시도
- 오픈소스 다운로드 동시접속자 증가시 설치 에러 발생 가능
- Player에서 구동하는 VM의 터미널 직접 사용 비추(IP 주소 확인 정도만), SSH 접속 권장
- Container는 Serverless나 FaaS의 기반 서비스 (필요시 수행하고 비활성화)
- 제조사는 기업고객을 위해 OVS가 설치된 제품을 제공
- ESXi 스토리지 추가
- CNF(예): 5G Edge Load Balancer 'LoxiLB'

JS Lab

IV. Docker Networking

- 도커 네트워킹

IV. DOCKER NETWORKING

❖ Docker Networking CLI

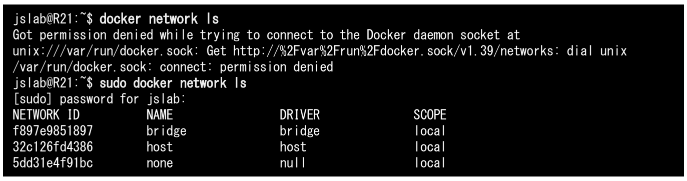
- **docker network ls**
  - **Host Networking:** The container shares the same IP address and network namespace as that of the host. Services running inside of this container have the same network capabilities as services running directly on the host.
  - **Bridge Networking:** The container runs in a private network internal to the host. Communication is open to other containers in the same network. Communication with services outside of the host goes through network address translation (NAT) before exiting the host. (This is the default mode of networking when the --net option isn't specified)
  - **Custom bridge network:** This is the same as Bridge Networking but uses a bridge explicitly created for this (and other) containers. An example of how to use this would be a container that runs on an exclusive "database" bridge network. Another container can have an interface on the default bridge and the database bridge, enabling it to communicate with both networks.
  - **Container-defined Networking:** A container can share the address and network configuration of another container. This type enables process isolation between containers, where each container runs one service but where services can still communicate with one another on the localhost address.
  - **No networking:** This option disables all networking for the container.

Host Networking

Bridge Networking

Custom bridge network

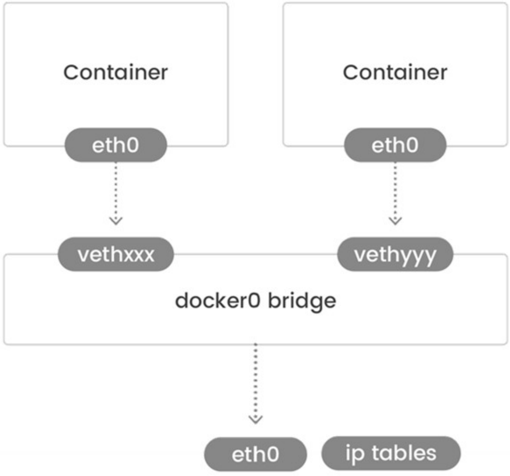
Container-defined Networking



```
jslab@R21:~$ docker network ls
Got permission denied while trying to connect to the Docker daemon socket at
unix:///var/run/docker.sock: Get http://%2Fvar%2Frun%2Fdocker.sock/v1.39/networks: dial unix
/var/run/docker.sock: connect: permission denied
jslab@R21:~$ sudo docker network ls
[sudo] password for jslab:
NETWORK ID          NAME                DRIVER              SCOPE
f897e9851897        bridge              bridge              local
32c126fd4386        host                host                local
5dd31e4f91bc        none                null                local
```

IV. DOCKER NETWORKING

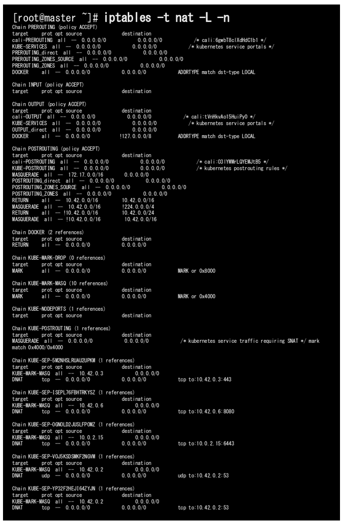
❖ **Docker Bridge Networking**



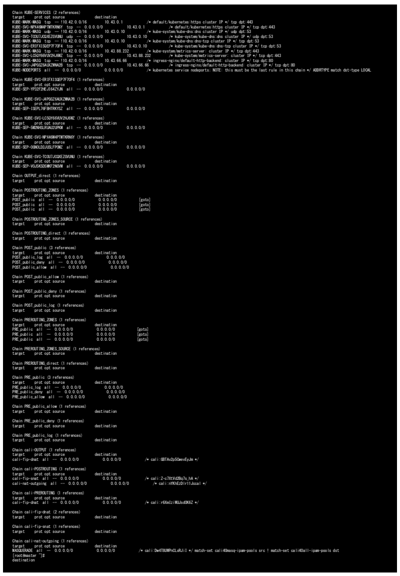
IV. DOCKER NETWORKING

❖ **Docker Networking CLI**

- **docker network ls**
  - ① **docker network**
  - ② **docker network ls**
  - ③ **docker network inspect bridge**
  - ④ **docker ps**
  - ⑤ **docker network inspect bridge**
  - ⑥ **docker network inspect host**
  - ⑦ **iptables -t nat -L -n**



```
[root@master ~]# iptables -t nat -L -n
Chain PREROUTING (policy ACCEPT)
target     prot opt source               destination
cali-PREROUTING  all  --  0.0.0.0/0            0.0.0.0/0            /* cali:6gwbT8clXdHdC1b1 */
KUBE-SERVICES  all  --  0.0.0.0/0            0.0.0.0/0            /* kubernetes service portals */
PREROUTING_direct  all  --  0.0.0.0/0            0.0.0.0/0
PREROUTING_ZONES_SOURCE  all  --  0.0.0.0/0            0.0.0.0/0
PREROUTING_ZONES  all  --  0.0.0.0/0            0.0.0.0/0
DOCKER     all  --  0.0.0.0/0            0.0.0.0/0            ADDRTYPE match dst-type LOCAL

Chain INPUT (policy ACCEPT)
target     prot opt source               destination

Chain OUTPUT (policy ACCEPT)
target     prot opt source               destination
cali-OUTPUT  all  --  0.0.0.0/0            0.0.0.0/0            /* cali:tVnHkvAo15HuiPy0 */
KUBE-SERVICES  all  --  0.0.0.0/0            0.0.0.0/0            /* kubernetes service portals */
OUTPUT_direct  all  --  0.0.0.0/0            0.0.0.0/0
DOCKER     all  --  0.0.0.0/0           !127.0.0.0/8          ADDRTYPE match dst-type LOCAL

Chain POSTROUTING (policy ACCEPT)
target     prot opt source               destination
cali-POSTROUTING  all  --  0.0.0.0/0            0.0.0.0/0            /* cali:O3lYWMrLQYEMJtB5 */
KUBE-POSTROUTING  all  --  0.0.0.0/0            0.0.0.0/0            /* kubernetes postrouting rules */
MASQUERADE  all  --  172.17.0.0/16        0.0.0.0/0
POSTROUTING_direct  all  --  0.0.0.0/0            0.0.0.0/0
POSTROUTING_ZONES_SOURCE  all  --  0.0.0.0/0            0.0.0.0/0
POSTROUTING_ZONES  all  --  0.0.0.0/0            0.0.0.0/0
RETURN     all  --  10.42.0.0/16         10.42.0.0/16
MASQUERADE  all  --  10.42.0.0/16        !224.0.0.0/4
RETURN     all  -- !10.42.0.0/16         10.42.0.0/24
MASQUERADE  all  -- !10.42.0.0/16         10.42.0.0/16

Chain DOCKER (2 references)
target     prot opt source               destination
RETURN     all  --  0.0.0.0/0            0.0.0.0/0

Chain KUBE-MARK-DROP (0 references)
target     prot opt source               destination
MARK       all  --  0.0.0.0/0            0.0.0.0/0            MARK or 0x8000

Chain KUBE-MARK-MASQ (10 references)
target     prot opt source               destination
MARK       all  --  0.0.0.0/0            0.0.0.0/0            MARK or 0x4000

Chain KUBE-NODEPORTS (1 references)
target     prot opt source               destination

Chain KUBE-POSTROUTING (1 references)
target     prot opt source               destination
MASQUERADE  all  --  0.0.0.0/0            0.0.0.0/0            /* kubernetes service traffic requiring SNAT */ mark
match 0x4000/0x4000

Chain KUBE-SEP-5M2NHSLRUAU2UPKM (1 references)
target     prot opt source               destination
KUBE-MARK-MASQ  all  --  10.42.0.3            0.0.0.0/0
DNAT       tcp  --  0.0.0.0/0            0.0.0.0/0            tcp to:10.42.0.3:443

Chain KUBE-SEP-ISEPL76FBHTRKYSZ (1 references)
target     prot opt source               destination
KUBE-MARK-MASQ  all  --  10.42.0.6            0.0.0.0/0
DNAT       tcp  --  0.0.0.0/0            0.0.0.0/0            tcp to:10.42.0.6:8080

Chain KUBE-SEP-OGNOLD2JUSLFPOMZ (1 references)
target     prot opt source               destination
KUBE-MARK-MASQ  all  --  10.0.2.15            0.0.0.0/0
DNAT       tcp  --  0.0.0.0/0            0.0.0.0/0            tcp to:10.0.2.15:6443

Chain KUBE-SEP-VOJ5KSDSMKF2NGVM (1 references)
target     prot opt source               destination
KUBE-MARK-MASQ  all  --  10.42.0.2            0.0.0.0/0
DNAT       udp  --  0.0.0.0/0            0.0.0.0/0            udp to:10.42.0.2:53

Chain KUBE-SEP-YP32F2HEJI64ZYJN (1 references)
target     prot opt source               destination
KUBE-MARK-MASQ  all  --  10.42.0.2            0.0.0.0/0
DNAT       tcp  --  0.0.0.0/0            0.0.0.0/0            tcp to:10.42.0.2:53
```



```
Chain KUBE-SERVICES (2 references)
target     prot opt source               destination
KUBE-MARK-MASQ  tcp  -- !10.42.0.0/16         10.43.0.1            /* default/kubernetes:https cluster IP */ tcp dpt:443
KUBE-SVC-NPX46M4PTMTKRN6Y  tcp  --  0.0.0.0/0            10.43.0.1            /* default/kubernetes:https cluster IP */ tcp dpt:443
KUBE-MARK-MASQ  udp  -- !10.42.0.0/16         10.43.0.10           /* kube-system/kube-dns:dns cluster IP */ udp dpt:53
KUBE-SVC-TCOU7JCQXEZGVUNU  udp  --  0.0.0.0/0            10.43.0.10           /* kube-system/kube-dns:dns cluster IP */ udp dpt:53
KUBE-MARK-MASQ  tcp  -- !10.42.0.0/16         10.43.0.10           /* kube-system/kube-dns:dns-tcp cluster IP */ tcp dpt:53
KUBE-SVC-ERIFXISQEP7F7OF4  tcp  --  0.0.0.0/0            10.43.0.10           /* kube-system/kube-dns:dns-tcp cluster IP */ tcp dpt:53
KUBE-MARK-MASQ  tcp  -- !10.42.0.0/16         10.43.88.232         /* kube-system/metrics-server: cluster IP */ tcp dpt:443
KUBE-SVC-LC5QY66VUV2HJ6WZ  tcp  --  0.0.0.0/0            10.43.88.232         /* kube-system/metrics-server: cluster IP */ tcp dpt:443
KUBE-MARK-MASQ  tcp  -- !10.42.0.0/16         10.43.66.66          /* ingress-nginx/default-http-backend: cluster IP */ tcp dpt:80
KUBE-SVC-J4PGGZ6AUXZWNA2B  tcp  --  0.0.0.0/0            10.43.66.66          /* ingress-nginx/default-http-backend: cluster IP */ tcp dpt:80
KUBE-NODEPORTS  all  --  0.0.0.0/0            0.0.0.0/0            /* kubernetes service nodeports; NOTE: this must be the last rule in this chain */ ADDRTYPE match dst-type LOCAL

Chain KUBE-SVC-ERIFXISQEP7F7OF4 (1 references)
target     prot opt source               destination
KUBE-SEP-YP32F2HEJI64ZYJN  all  --  0.0.0.0/0            0.0.0.0/0

Chain KUBE-SVC-J4PGGZ6AUXZWNA2B (1 references)
target     prot opt source               destination
KUBE-SEP-ISEPL76FBHTRKYSZ  all  --  0.0.0.0/0            0.0.0.0/0

Chain KUBE-SVC-LC5QY66VUV2HJ6WZ (1 references)
target     prot opt source               destination
KUBE-SEP-5M2NHSLRUAU2UPKM  all  --  0.0.0.0/0            0.0.0.0/0

Chain KUBE-SVC-NPX46M4PTMTKRN6Y (1 references)
target     prot opt source               destination
KUBE-SEP-OGNOLD2JUSLFPOMZ  all  --  0.0.0.0/0            0.0.0.0/0

Chain KUBE-SVC-TCOU7JCQXEZGVUNU (1 references)
target     prot opt source               destination
KUBE-SEP-VOJ5KSDSMKF2NGVM  all  --  0.0.0.0/0            0.0.0.0/0

Chain OUTPUT_direct (1 references)
target     prot opt source               destination

Chain POSTROUTING_ZONES (1 references)
target     prot opt source               destination
POST_public  all  --  0.0.0.0/0            0.0.0.0/0           [goto]
POST_public  all  --  0.0.0.0/0            0.0.0.0/0           [goto]
POST_public  all  --  0.0.0.0/0            0.0.0.0/0           [goto]

Chain POSTROUTING_ZONES_SOURCE (1 references)
target     prot opt source               destination

Chain POSTROUTING_direct (1 references)
target     prot opt source               destination

Chain POST_public (3 references)
target     prot opt source               destination
POST_public_log  all  --  0.0.0.0/0            0.0.0.0/0
POST_public_deny  all  --  0.0.0.0/0            0.0.0.0/0
POST_public_allow  all  --  0.0.0.0/0            0.0.0.0/0

Chain POST_public_allow (1 references)
target     prot opt source               destination

Chain POST_public_deny (1 references)
target     prot opt source               destination

Chain POST_public_log (1 references)
target     prot opt source               destination

Chain PREROUTING_ZONES (1 references)
target     prot opt source               destination
PRE_public  all  --  0.0.0.0/0            0.0.0.0/0           [goto]
PRE_public  all  --  0.0.0.0/0            0.0.0.0/0           [goto]
PRE_public  all  --  0.0.0.0/0            0.0.0.0/0           [goto]

Chain PREROUTING_ZONES_SOURCE (1 references)
target     prot opt source               destination

Chain PREROUTING_direct (1 references)
target     prot opt source               destination

Chain PRE_public (3 references)
target     prot opt source               destination
PRE_public_log  all  --  0.0.0.0/0            0.0.0.0/0
PRE_public_deny  all  --  0.0.0.0/0            0.0.0.0/0
PRE_public_allow  all  --  0.0.0.0/0            0.0.0.0/0

Chain PRE_public_allow (1 references)
target     prot opt source               destination

Chain PRE_public_deny (1 references)
target     prot opt source               destination

Chain PRE_public_log (1 references)
target     prot opt source               destination

Chain cali-OUTPUT (1 references)
target     prot opt source               destination
cali-fip-dnat  all  --  0.0.0.0/0            0.0.0.0/0            /* cali:GBTAv2p5OwevEyJm */

Chain cali-POSTROUTING (1 references)
target     prot opt source               destination
cali-fip-snat  all  --  0.0.0.0/0            0.0.0.0/0            /* cali:Z-c7XtVd2Bq7s_hA */
cali-nat-outgoing  all  --  0.0.0.0/0            0.0.0.0/0            /* cali:nYKhEzDlr11Jccal */

Chain cali-PREROUTING (1 references)
target     prot opt source               destination
cali-fip-dnat  all  --  0.0.0.0/0            0.0.0.0/0            /* cali:r6XmIziWUJsdOK6Z */

Chain cali-fip-dnat (2 references)
target     prot opt source               destination

Chain cali-fip-snat (1 references)
target     prot opt source               destination

Chain cali-nat-outgoing (1 references)
target     prot opt source               destination
MASQUERADE  all  --  0.0.0.0/0            0.0.0.0/0            /* cali:Dw4T8UWPnCLxRJiI */ match-set cali40masq-ipam-pools src ! match-set cali40all-ipam-pools dst
[root@master ~]#
destination
```

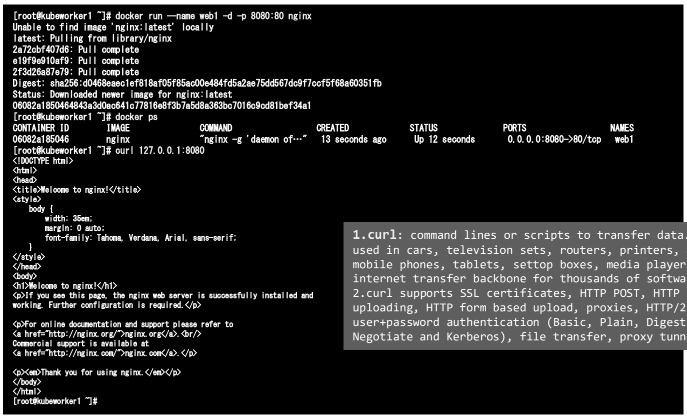
IV. DOCKER NETWORKING

❖ Docker Networking

① sudo docker run --name web1 -d -p 8080:80 nginx

② sudo docker ps

③ sudo curl 127.0.0.1:8080



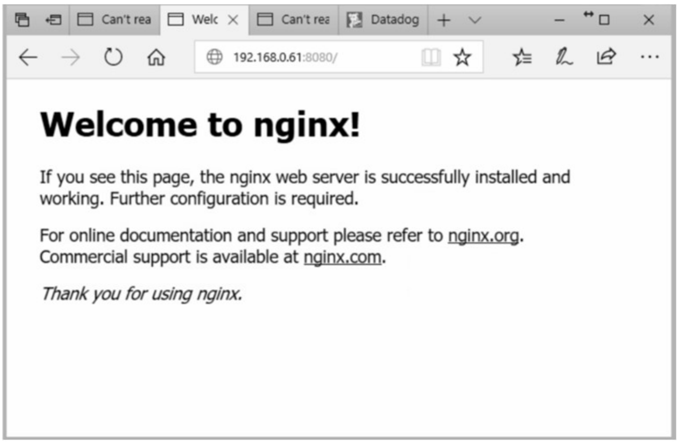
```
[root@kubeworker1 ~]# docker run —name web1 -d -p 8080:80 nginx
Unable to find image 'nginx:latest' locally
latest: Pulling from library/nginx
2a72cbf407d6: Pull complete
e19f9e910af9: Pull complete
2f3d26a87e79: Pull complete
Digest: sha256:d0468eaec1ef818af05f85ac00e484fd5a2ae75dd567dc9f7ccf5f68a60351fb
Status: Downloaded newer image for nginx:latest
06082a1850464843a3d0ac641c77816e8f3b7a5d8a363bc7016c9cd81bef34a1
[root@kubeworker1 ~]# docker ps
CONTAINER ID        IMAGE               COMMAND                  CREATED             STATUS              PORTS                  NAMES
06082a185046        nginx               "nginx -g 'daemon of…"   13 seconds ago      Up 12 seconds       0.0.0.0:8080->80/tcp   web1
[root@kubeworker1 ~]# curl 127.0.0.1:8080
<!DOCTYPE html>
<html>
<head>
<title>Welcome to nginx!</title>
<style>
    body {
        width: 35em;
        margin: 0 auto;
        font-family: Tahoma, Verdana, Arial, sans-serif;
    }
</style>
</head>
<body>
<h1>Welcome to nginx!</h1>
<p>If you see this page, the nginx web server is successfully installed and
working. Further configuration is required.</p>

<p>For online documentation and support please refer to
<a href="http://nginx.org/">nginx.org</a>.<br/>
Commercial support is available at
<a href="http://nginx.com/">nginx.com</a>.</p>

<p><em>Thank you for using nginx.</em></p>
</body>
</html>
[root@kubeworker1 ~]#
```

1.curl: command lines or scripts to transfer data. It is also used in cars, television sets, routers, printers, audio equipment, mobile phones, tablets, settop boxes, media players and is the internet transfer backbone for thousands of software applications.
2.curl supports SSL certificates, HTTP POST, HTTP PUT, FTP uploading, HTTP form based upload, proxies, HTTP/2, cookies, user+password authentication (Basic, Plain, Digest, CRAM-MD5, NTLM, Negotiate and Kerberos), file transfer, proxy tunneling and more.

IV. DOCKER NETWORKING

❖ 외부 연결을 위한 NAT 구성

① http://192.168.100.xxx:8080



Welcome to nginx!

If you see this page, the nginx web server is successfully installed and working. Further configuration is required.

For online documentation and support please refer to nginx.org.
Commercial support is available at nginx.com.

Thank you for using nginx.

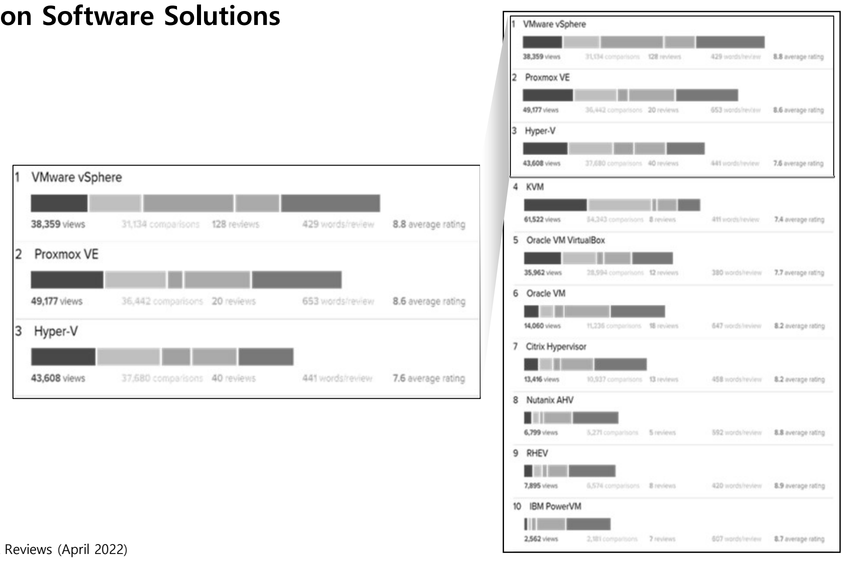
V. HCI

- Proxmox 개요
- Proxmox 설치
- Operations

V. HCI

❖ Top Server Virtualization Software Solutions

1. VMware vSphere
2. Proxmox VE
3. Hyper-V
4. KVM
5. Oracle VM VirtualBox
6. Oracle VM
7. Citrix Hypervisor
8. Nutanix AHV
9. RHEV
10. IBM PowerVM



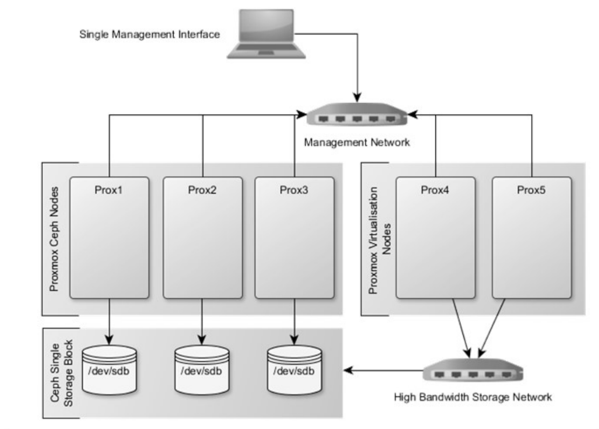
1	VMware vSphere	38,359 views	31,134 comparisons	128 reviews	429 words/review	8.8 average rating
2	Proxmox VE	49,177 views	36,442 comparisons	20 reviews	653 words/review	8.6 average rating
3	Hyper-V	43,608 views	37,680 comparisons	40 reviews	441 words/review	7.6 average rating
4	KVM	61,522 views	54,243 comparisons	8 reviews	411 words/review	7.4 average rating
5	Oracle VM VirtualBox	35,962 views	28,994 comparisons	12 reviews	380 words/review	7.7 average rating
6	Oracle VM	14,060 views	11,236 comparisons	18 reviews	647 words/review	8.2 average rating
7	Citrix Hypervisor	13,416 views	10,937 comparisons	13 reviews	458 words/review	8.2 average rating
8	Nutanix AHV	6,799 views	5,271 comparisons	5 reviews	592 words/review	8.8 average rating
9	RHEV	7,895 views	6,574 comparisons	8 reviews	420 words/review	8.9 average rating
10	IBM PowerVM	2,562 views	2,181 comparisons	7 reviews	607 words/review	8.7 average rating

PeerSpot

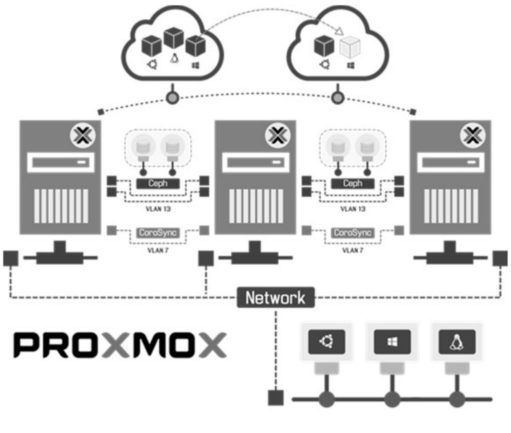
Source: Server Virtualization Software Buyer's Guide & Reviews (April 2022)

V. HCI

❖ **Proxmox**


Single Management Interface
Management Network
Proxmox Ceph Nodes
Prox1
Prox2
Prox3
Proxmox Virtualisation Nodes
Prox4
Prox5
Ceph Single Storage Block
/dev/sdb
/dev/sdb
/dev/sdb
High Bandwidth Storage Network

JamesCoyle.net

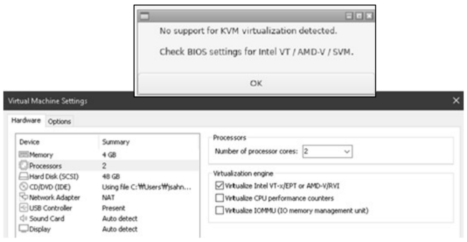


Laboratorio PROXMOX + Cluster + Ceph

V. HCI

❖ **Proxmox Installation**

- **vCPU x 2**
- **vRAM 4 GB 이하 (RAM 16GB시)**
- **HDD 48 GB**
- **Network NAT (동일 서브넷 필요)**
- **Virtualize**



No support for KVM virtualization detected.

Check BIOS settings for Intel VT / AMD-V / SVM.

OK

Virtual Machine Settings

Hardware | Options

Device	Summary
Memory	4 GB
Processors	2
Hard Disk (SCSI)	48 GB
CD/DVD (IDE)	Using file C:₩Users₩jsahn...
Network Adapter	NAT
USB Controller	Present
Sound Card	Auto detect
Display	Auto detect

Processors

Number of processor cores: 2

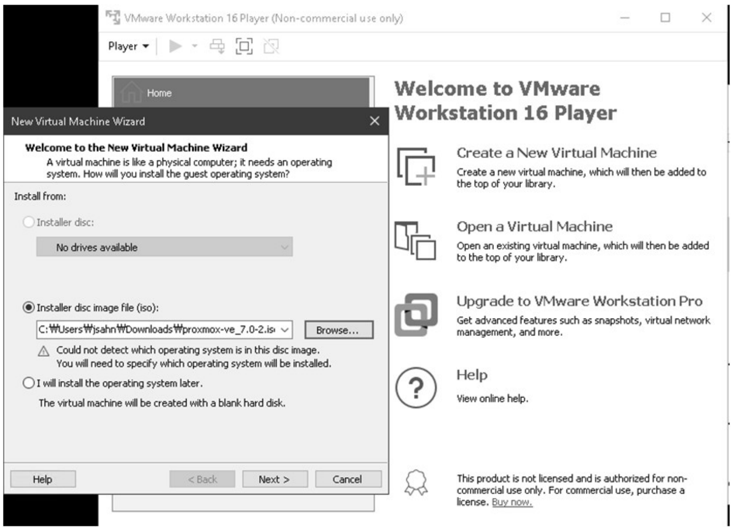
Virtualization engine

☑ Virtualize Intel VT-x/EPT or AMD-V/RVI

□ Virtualize CPU performance counters

□ Virtualize IOMMU (IO memory management unit)

Source: https://www.proxmox.com/en/downloads/category/iso-images-pve



VMware Workstation 16 Player (Non-commercial use only)

New Virtual Machine Wizard

Welcome to the New Virtual Machine Wizard

A virtual machine is like a physical computer; it needs an operating system. How will you install the guest operating system?

Install from:

○ Installer disc:

No drives available

● Installer disc image file (iso):

C:₩Users₩jsahn₩Downloads₩proxmox-ve_7.0-2.is

Browse...

⚠ Could not detect which operating system is in this disc image. You will need to specify which operating system will be installed.

○ I will install the operating system later.

The virtual machine will be created with a blank hard disk.

Help | < Back | Next > | Cancel

Welcome to VMware Workstation 16 Player

Create a New Virtual Machine

Create a new virtual machine, which will then be added to the top of your library.

Open a Virtual Machine

Open an existing virtual machine, which will then be added to the top of your library.

Upgrade to VMware Workstation Pro

Get advanced features such as snapshots, virtual network management, and more.

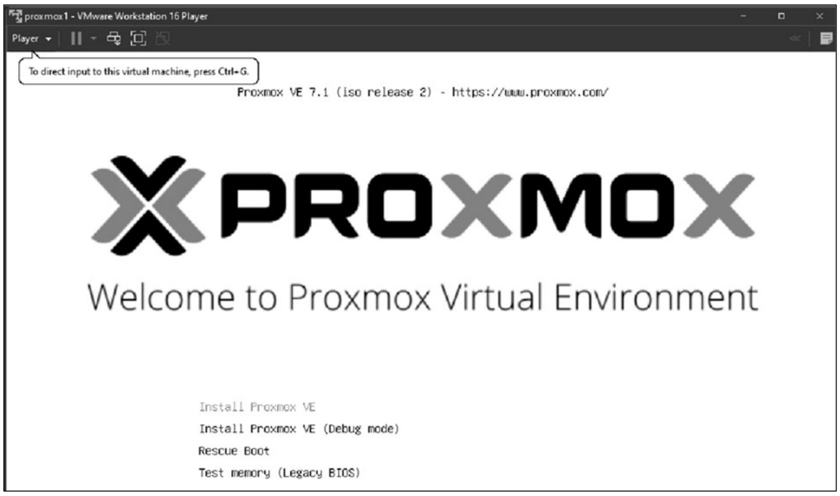
Help

View online help.

This product is not licensed and is authorized for non-commercial use only. For commercial use, purchase a license. Buy now.

V. HCI

- **Proxmox Installation**



To direct input to this virtual machine, press Ctrl+G.

```
Proxmox VE 7.1 (iso release 2) - https://www.proxmox.com/
```

PROXMOX

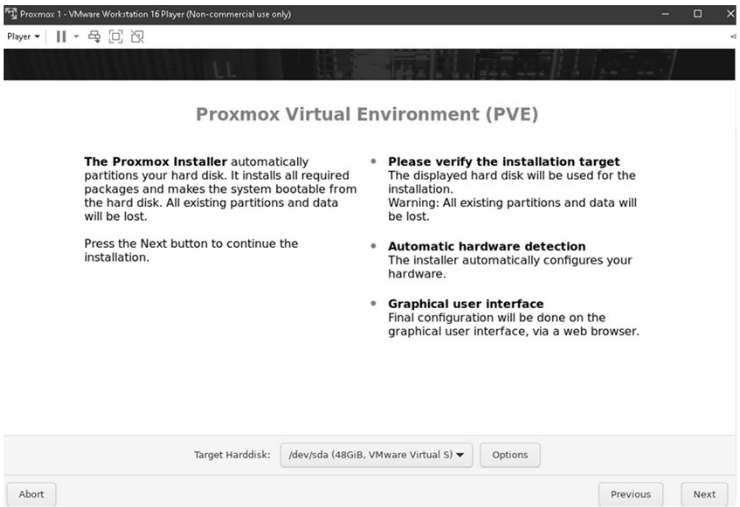
Welcome to Proxmox Virtual Environment

```
Install Proxmox VE
Install Proxmox VE (Debug mode)
Rescue Boot
Test memory (Legacy BIOS)
```

Source: https://www.proxmox.com/en/downloads/category/iso-images-pve

V. HCI

- **Proxmox Installation**



Proxmox 1 - VMware Workstation 16 Player (Non-commercial use only)
Player

Proxmox Virtual Environment (PVE)

The Proxmox Installer automatically partitions your hard disk. It installs all required packages and makes the system bootable from the hard disk. All existing partitions and data will be lost.

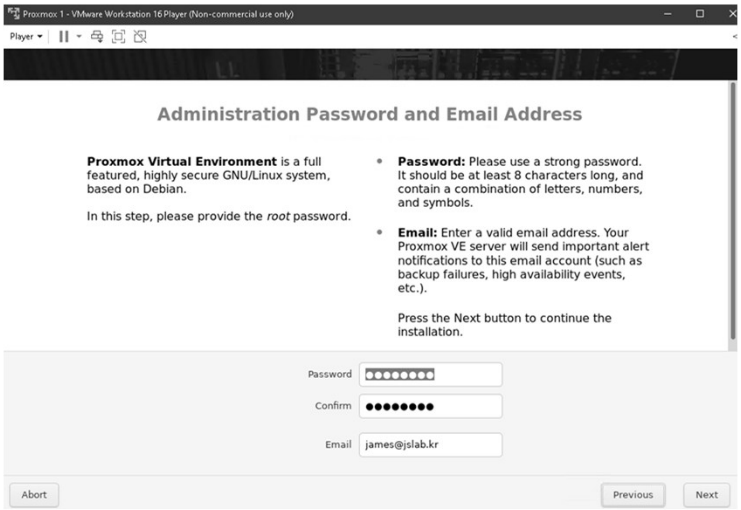
Press the Next button to continue the installation.

- **Please verify the installation target**
  The displayed hard disk will be used for the installation.
  Warning: All existing partitions and data will be lost.
- **Automatic hardware detection**
  The installer automatically configures your hardware.
- **Graphical user interface**
  Final configuration will be done on the graphical user interface, via a web browser.

Target Harddisk: /dev/sda (48GiB, VMware Virtual S) ▾ Options

V. HCI

❖ **Proxmox Installation**



Proxmox 1 - VMware Workstation 16 Player (Non-commercial use only)
Player ▾

Administration Password and Email Address

Proxmox Virtual Environment is a full featured, highly secure GNU/Linux system, based on Debian.

In this step, please provide the *root* password.

- **Password:** Please use a strong password. It should be at least 8 characters long, and contain a combination of letters, numbers, and symbols.
- **Email:** Enter a valid email address. Your Proxmox VE server will send important alert notifications to this email account (such as backup failures, high availability events, etc.).

Press the Next button to continue the installation.

Password: ●●●●●●●●

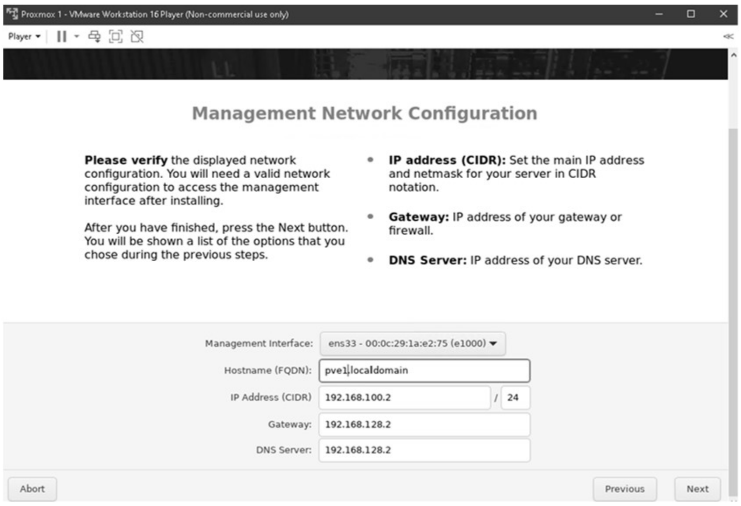
Confirm: ●●●●●●●●

Email: james@jslab.kr

V. HCI

❖ **Proxmox Installation**

- **pve1.training-network**
- **pve1, pve2, pve3**
- **동일 서브넷 IP: xx, yy, zz**



Proxmox 1 - VMware Workstation 16 Player (Non-commercial use only)
Player ▾

Management Network Configuration

Please verify the displayed network configuration. You will need a valid network configuration to access the management interface after installing.

After you have finished, press the Next button. You will be shown a list of the options that you chose during the previous steps.

- **IP address (CIDR):** Set the main IP address and netmask for your server in CIDR notation.
- **Gateway:** IP address of your gateway or firewall.
- **DNS Server:** IP address of your DNS server.

Management Interface: ens33 - 00:0c:29:1a:e2:75 (e1000) ▾

Hostname (FQDN): pve1.localdomain

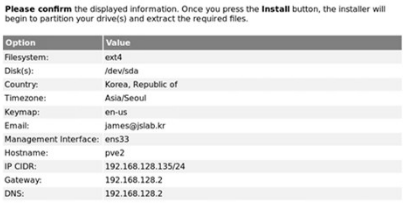
IP Address (CIDR): 192.168.100.2 / 24

Gateway: 192.168.128.2

DNS Server: 192.168.128.2

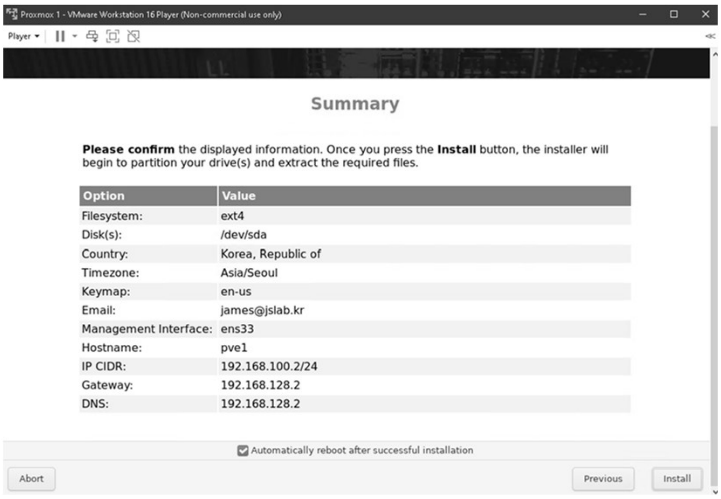
V. HCI

❖ **Proxmox Installation - Summary**



Please confirm the displayed information. Once you press the **Install** button, the installer will begin to partition your drive(s) and extract the required files.

Option	Value
Filesystem:	ext4
Disk(s):	/dev/sda
Country:	Korea, Republic of
Timezone:	Asia/Seoul
Keymap:	en-us
Email:	james@jslab.kr
Management Interface:	ens33
Hostname:	pve2
IP CIDR:	192.168.128.135/24
Gateway:	192.168.128.2
DNS:	192.168.128.2



Proxmox 1 - VMware Workstation 16 Player (Non-commercial use only)
Player

Summary

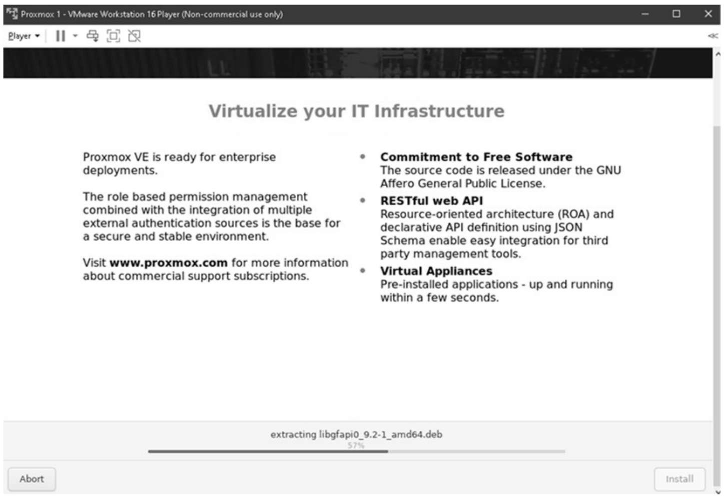
Please confirm the displayed information. Once you press the **Install** button, the installer will begin to partition your drive(s) and extract the required files.

Option	Value
Filesystem:	ext4
Disk(s):	/dev/sda
Country:	Korea, Republic of
Timezone:	Asia/Seoul
Keymap:	en-us
Email:	james@jslab.kr
Management Interface:	ens33
Hostname:	pve1
IP CIDR:	192.168.100.2/24
Gateway:	192.168.128.2
DNS:	192.168.128.2

☑ Automatically reboot after successful installation

V. HCI

❖ **Proxmox Installation**



Proxmox 1 - VMware Workstation 16 Player (Non-commercial use only)
Player

Virtualize your IT Infrastructure

Proxmox VE is ready for enterprise deployments.

The role based permission management combined with the integration of multiple external authentication sources is the base for a secure and stable environment.

Visit **www.proxmox.com** for more information about commercial support subscriptions.

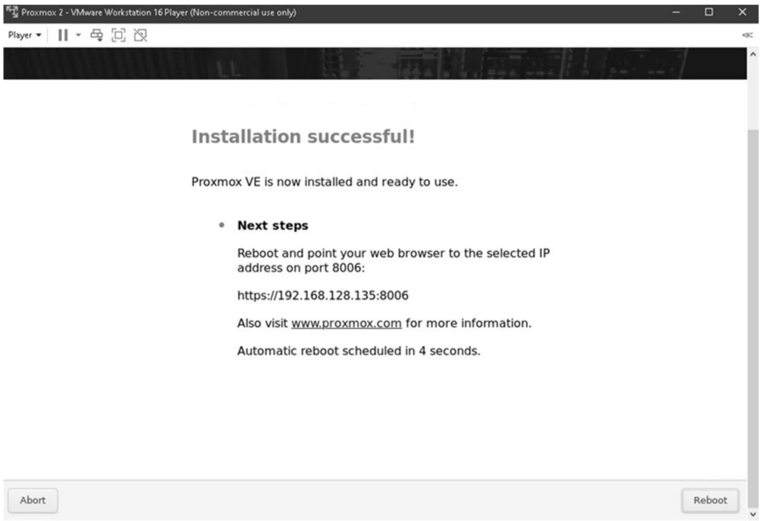
- **Commitment to Free Software**
  The source code is released under the GNU Affero General Public License.
- **RESTful web API**
  Resource-oriented architecture (ROA) and declarative API definition using JSON Schema enable easy integration for third party management tools.
- **Virtual Appliances**
  Pre-installed applications - up and running within a few seconds.

extracting libgfapi0_9.2-1_amd64.deb

57%

V. HCI

❖ **Installation Successful**



Proxmox 2 - VMware Workstation 16 Player (Non-commercial use only)
Player

Installation successful!

Proxmox VE is now installed and ready to use.

- **Next steps**

  Reboot and point your web browser to the selected IP address on port 8006:

  https://192.168.128.135:8006

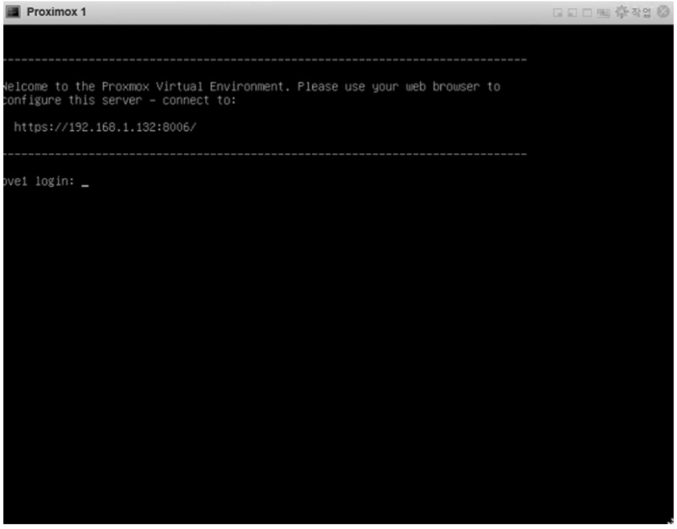
  Also visit www.proxmox.com for more information.

  Automatic reboot scheduled in 4 seconds.

V. HCI

❖ **Installation – Console**

- **ID/Password: root/jslab123**



```
------------------------------------------------------------------------------

elcome to the Proxmox Virtual Environment. Please use your web browser to
onfigure this server - connect to:

 https://192.168.1.132:8006/

------------------------------------------------------------------------------

ve1 login: _
```

V. HCI

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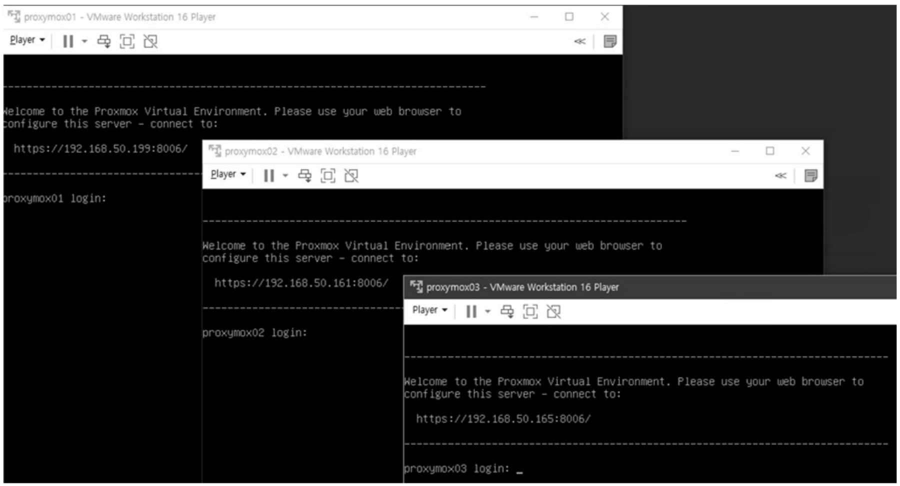
❖ **Cluster Nodes**



proxymox01 - VMware Workstation 16 Player
Player

```
--------------------------------------------------------------------------------

Welcome to the Proxmox Virtual Environment. Please use your web browser to
configure this server - connect to:

  https://192.168.50.199:8006/

--------------------------------------------------------------------------------

proxymox01 login:
```

proxymox02 - VMware Workstation 16 Player
Player

```
--------------------------------------------------------------------------------

Welcome to the Proxmox Virtual Environment. Please use your web browser to
configure this server - connect to:

  https://192.168.50.161:8006/

--------------------------------------------------------------------------------

proxymox02 login:
```

proxymox03 - VMware Workstation 16 Player
Player

```
--------------------------------------------------------------------------------

Welcome to the Proxmox Virtual Environment. Please use your web browser to
configure this server - connect to:

  https://192.168.50.165:8006/

--------------------------------------------------------------------------------

proxymox03 login: _
```

◆ ◆ ◆ ◆ **JS Lab**

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V. HCI

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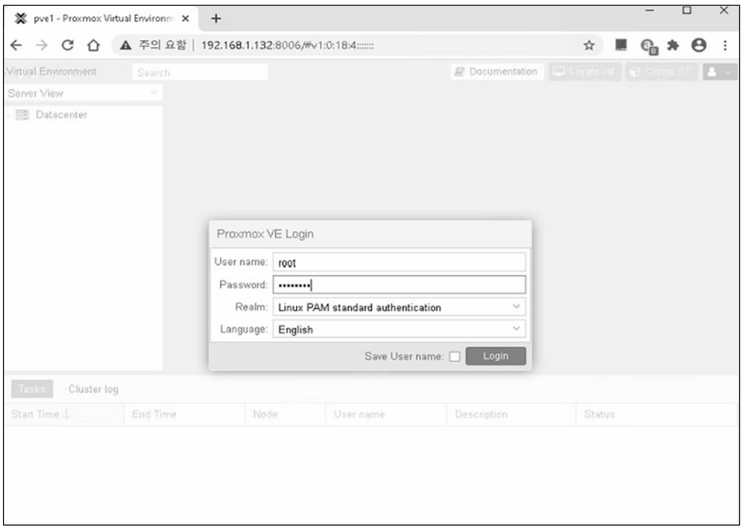
❖ **Web Login**

- <u>**https://192.168.50.195:8006**</u>
- **ID/Password: root/jslab123**



Proxmox VE Login

User name: root

Password: ••••••••

Realm: Linux PAM standard authentication

Language: English

Save User name: □ Login

◆ ◆ ◆ ◆ **JS Lab**

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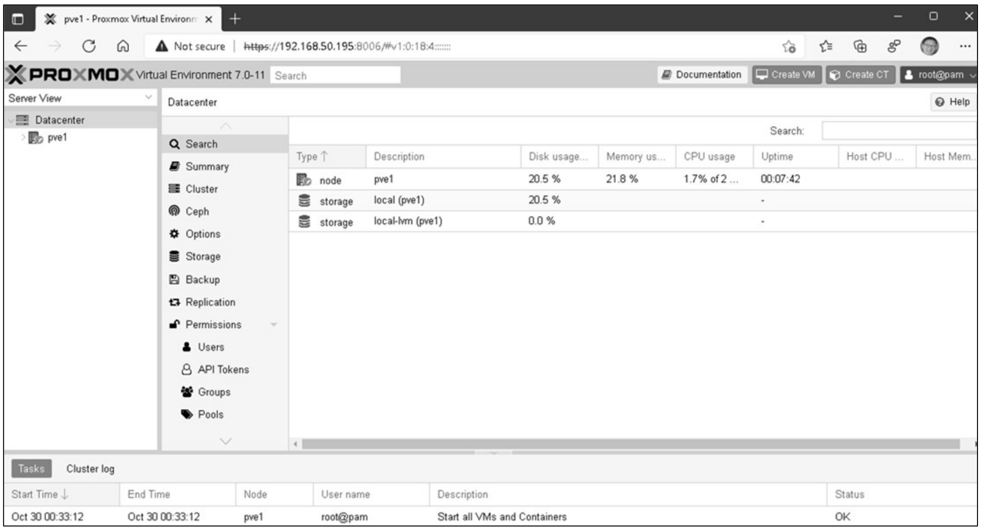
V. HCI

❖ **Datacenter**



pve1 - Proxmox Virtual Environm

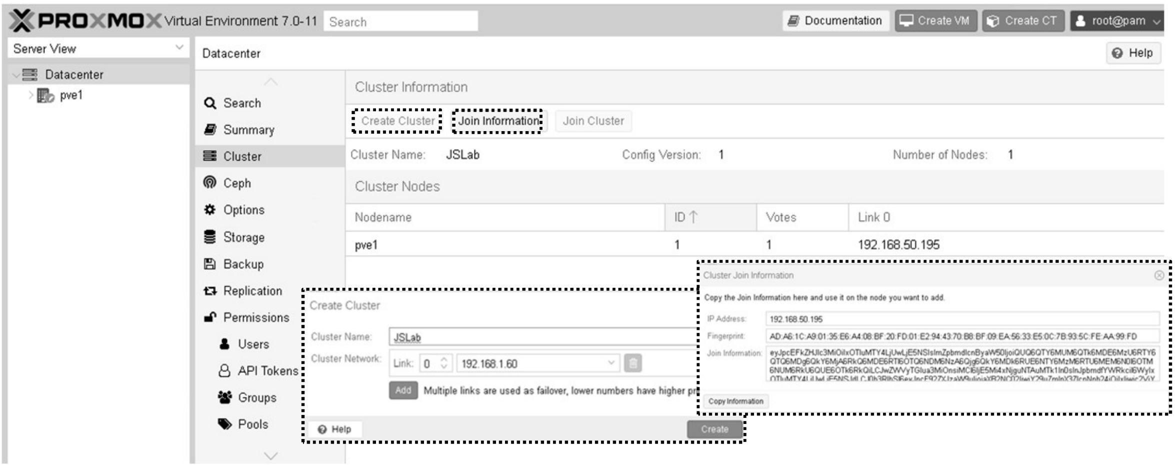
Not secure | ~~https~~://192.168.50.195:8006/#v1:0:18:4::::::

Type ↑	Description	Disk usage...	Memory us...	CPU usage	Uptime	Host CPU ...	Host Mem...
node	pve1	20.5 %	21.8 %	1.7% of 2 ...	00:07:42		
storage	local (pve1)	20.5 %			-		
storage	local-lvm (pve1)	0.0 %			-		

Start Time ↓	End Time	Node	User name	Description	Status
Oct 30 00:33:12	Oct 30 00:33:12	pve1	root@pam	Start all VMs and Containers	OK

V. HCI

❖ **Datacenter**



Cluster Name: JSLab Config Version: 1 Number of Nodes: 1

Cluster Nodes

Nodename	ID ↑	Votes	Link 0
pve1	1	1	192.168.50.195

Create Cluster

Cluster Name: JSLab

Cluster Network: Link: 0 192.168.1.60

Add Multiple links are used as failover, lower numbers have higher pr

Cluster Join Information

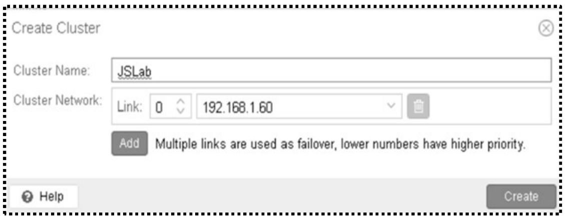
Copy the Join Information here and use it on the node you want to add.

IP Address: 192.168.50.195

Fingerprint: AD:A6:1C:A9:01:35:E6:A4:08:BF:20:FD:01:E2:94:43:70:B8:BF:09:EA:56:33:E5:0C:7B:93:5C:FE:AA:99:FD

Join Information: eyJpcEFkZHJlc3MiOilxOTluMTY4LjUwLjE5NSIsImZpbmdlcnByaW50IjoiQUQ6QTY6MUM6QTk6MDE6MzU6RTY6
QTQ6MDg6QkY6MjA6RkQ6MDE6RTI6OTQ6NDM6NzA6Qjg6QkY6MDk6RUE6NTY6MzM6RTU6MEM6N0I6OTM
6NUM6RkU6QUE6OTk6RkQiLCJwZWVyTGlua3MiOnsiMCI6IjE5Mi4xNjguNTAuMTk1In0sInJpbmdfYWRkcil6Wylx

❖ **Cluster**

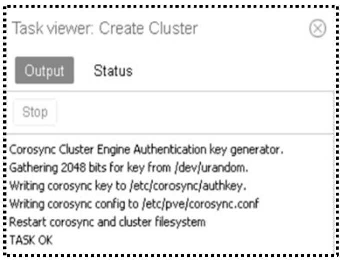


Create Cluster

Cluster Name: JSLab

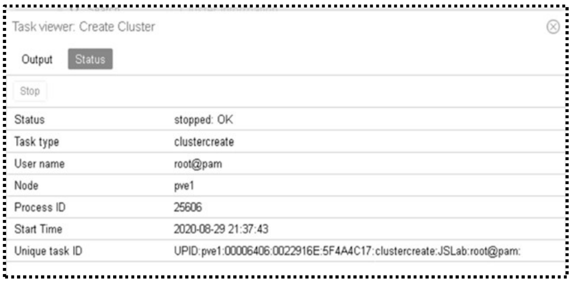
Cluster Network: Link: 0 192.168.1.60

Add Multiple links are used as failover, lower numbers have higher priority.



Task viewer: Create Cluster

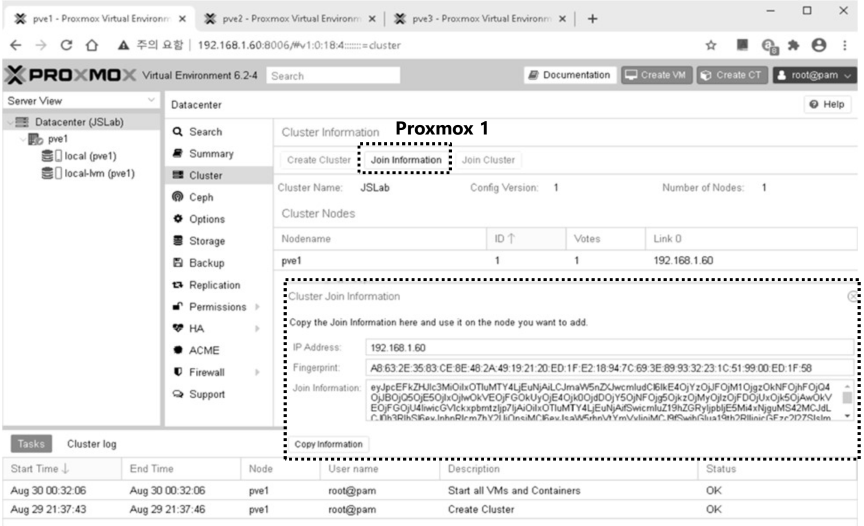
```
Corosync Cluster Engine Authentication key generator.
Gathering 2048 bits for key from /dev/urandom.
Writing corosync key to /etc/corosync/authkey.
Writing corosync config to /etc/pve/corosync.conf
Restart corosync and cluster filesystem
TASK OK
```



Task viewer: Create Cluster

Status	stopped: OK
Task type	clustercreate
User name	root@pam
Node	pve1
Process ID	25606
Start Time	2020-08-29 21:37:43
Unique task ID	UPID:pve1:00006406:0022916E:5F4A4C17:clustercreate:JSLab:root@pam:

❖ **Cluster**



Proxmox 1

Cluster Name: JSLab Config Version: 1 Number of Nodes: 1

Cluster Nodes

Nodename	ID ↑	Votes	Link 0
pve1	1	1	192.168.1.60

Cluster Join Information

Copy the Join Information here and use it on the node you want to add.

IP Address: 192.168.1.60

Fingerprint: A8:63:2E:35:83:CE:8E:48:2A:49:19:21:20:ED:1F:E2:18:94:7C:69:3E:89:93:32:23:1C:51:99:00:ED:1F:58

Join Information:

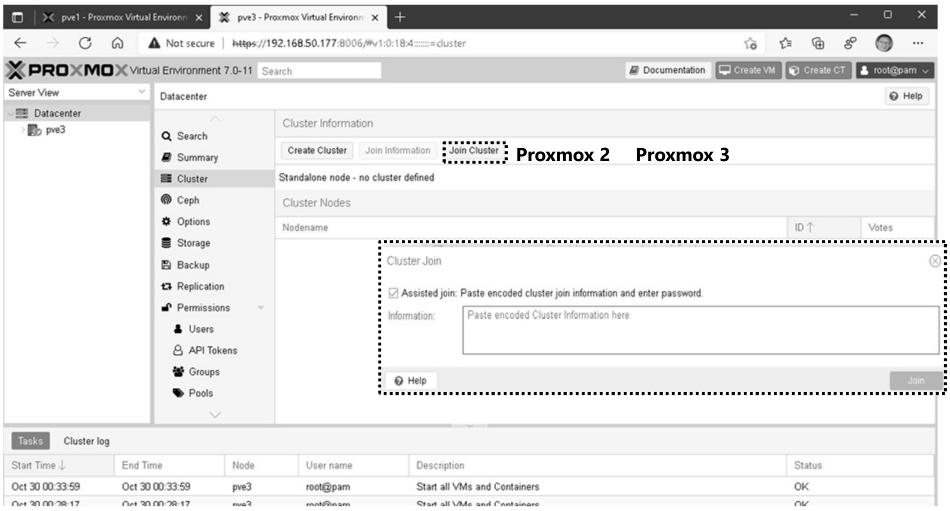
```
eyJpcEFkZHJlc3MiOilxOTluMTY4LjEuNjAiLCJmaW5nZXJwcmludCI6IkE4OjYzOjJFOjM1OjgzOkNFOjhFOjQ4
OjJBOjQ5OjE5OjlxOjlwOkVEOjFGOkUyOjE4Ojk0OjdDOjY5OjNFOjg5OjkzOjMyOjlzOjFDOjUxOjk5OjAwOkV
EOjFGOjU4liwicGVlckxpbmtzljp7IjAiOilxOTluMTY4LjEuNjAifSwicmluZ19hZGRyljpbljE5Mi4xNjguMS42MCJdL
```

Copy Information

Start Time ↓	End Time	Node	User name	Description	Status
Aug 30 00:32:06	Aug 30 00:32:06	pve1	root@pam	Start all VMs and Containers	OK
Aug 29 21:37:43	Aug 29 21:37:46	pve1	root@pam	Create Cluster	OK

V. HCI

❖ Cluster Join



Proxmox 2 Proxmox 3

https://192.168.50.177:8006/#v1:0:18:4::::::=cluster

PROXMOX Virtual Environment 7.0-11

Datacenter

Cluster Information

Create Cluster | Join Information | Join Cluster

Standalone node - no cluster defined

Cluster Nodes

Nodename	ID ↑	Votes

Cluster Join

☑ Assisted join: Paste encoded cluster join information and enter password.

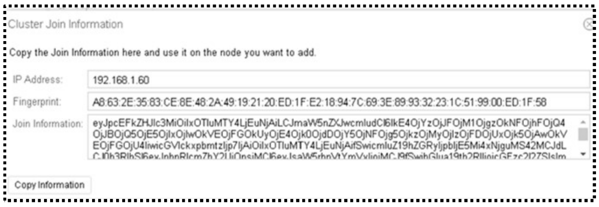
Information: Paste encoded Cluster Information here

Start Time ↓	End Time	Node	User name	Description	Status
Oct 30 00:33:59	Oct 30 00:33:59	pve3	root@pam	Start all VMs and Containers	OK
Oct 30 00:28:17	Oct 30 00:28:17	pve3	root@pam	Start all VMs and Containers	OK

V. HCI

❖ Cluster Join (Key + Password)

Proxmox 1



Cluster Join Information

Copy the Join Information here and use it on the node you want to add.

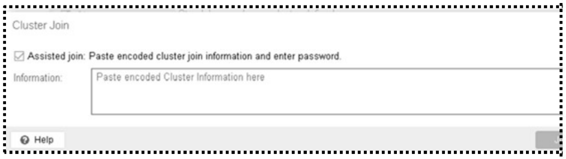
IP Address: 192.168.1.60

Fingerprint: A8:63:2E:35:83:CE:8E:48:2A:49:19:21:20:ED:1F:E2:18:94:7C:69:3E:89:93:32:23:1C:51:99:00:ED:1F:58

Join Information:

```
eyJpcEFkZHJlc3MiOilxOTluMTY4LjEuNjAiLCJmaW5nZXJwcmludCI6IkE4OjYzOjJFOjM1OjgzOkNFOjhFOjQ4
OjJBOjQ5OjE5OjIxOjIwOkVEOjFGOkUyOjE4Ojk0OjdDOjY5OjNFOjg5OjkzOjMyOjIzOjFDOjUxOjk5OjAwOkV
EOjFGOjU4IiwicGVlckxpbmtzIjp7IjAiOilxOTluMTY4LjEuNjAifSwicmluZ19hZGRyIjpbIjE5Mi4xNjguMS42MCJdL
```

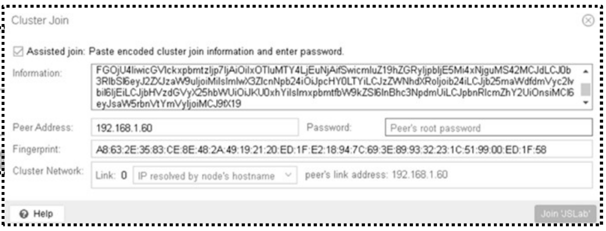
Proxmox 2 Proxmox 3



Cluster Join

☑ Assisted join: Paste encoded cluster join information and enter password.

Information: Paste encoded Cluster Information here



Cluster Join

☑ Assisted join: Paste encoded cluster join information and enter password.

Information:

```
FGOjU4IiwicGVlckxpbmtzIjp7IjAiOilxOTluMTY4LjEuNjAifSwicmluZ19hZGRyIjpbIjE5Mi4xNjguMS42MCJdLCJ0b
3RlbSI6eyJ2ZXJzaW9uIjoiMiIsImlwX3ZlcnNpb24iOiJpcHY0LTYiLCJzZWNhdXRoIjoib24iLCJjb25maWdfdmVyc2lv
biI6IjEiLCJjbHVzdGVyX25hbWUiOiJKU0xhYiIsImxpbmtfbW9kZSI6InBhc3NpdmUiLCJpbnRlcmZhY2UiOnsiMCI6
eyJsaW5rbnVtYmVyIjoiMCJ9fX19
```

Peer Address: 192.168.1.60

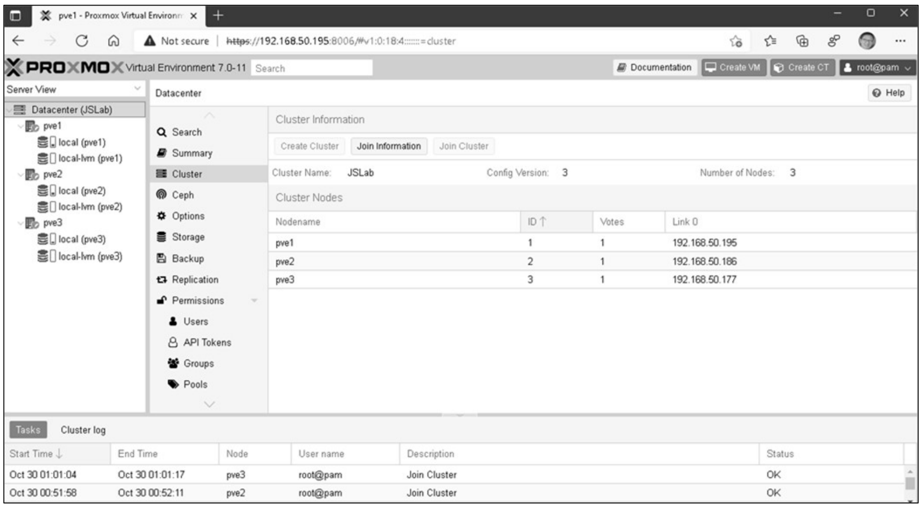
Password: Peer's root password

Fingerprint: A8:63:2E:35:83:CE:8E:48:2A:49:19:21:20:ED:1F:E2:18:94:7C:69:3E:89:93:32:23:1C:51:99:00:ED:1F:58

Cluster Network: Link: 0 IP resolved by node's hostname peer's link address: 192.168.1.60

V. HCI

❖ Join Information



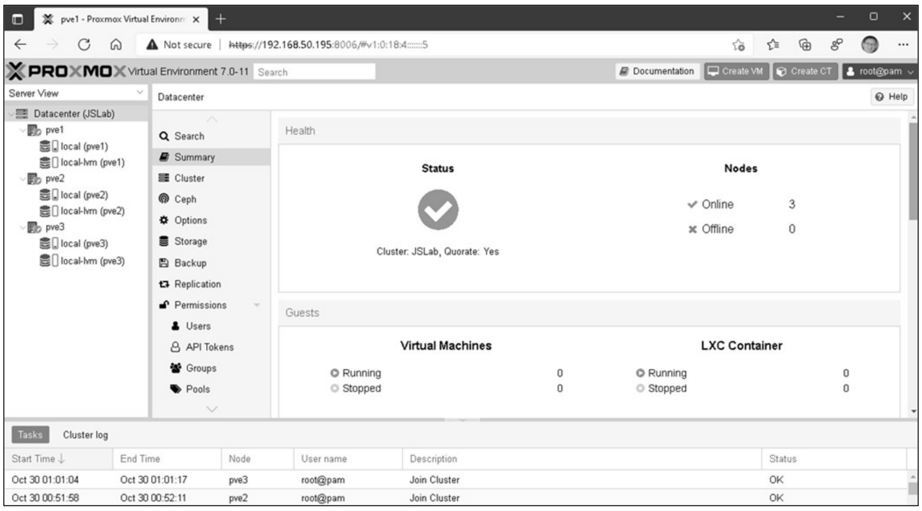
Cluster Name: JSLab Config Version: 3 Number of Nodes: 3

Nodename	ID ↑	Votes	Link 0
pve1	1	1	192.168.50.195
pve2	2	1	192.168.50.186
pve3	3	1	192.168.50.177

Start Time ↓	End Time	Node	User name	Description	Status
Oct 30 01:01:04	Oct 30 01:01:17	pve3	root@pam	Join Cluster	OK
Oct 30 00:51:58	Oct 30 00:52:11	pve2	root@pam	Join Cluster	OK

V. HCI

❖ Summary



Cluster: JSLab, Quorate: Yes

✓ Online 3
✗ Offline 0

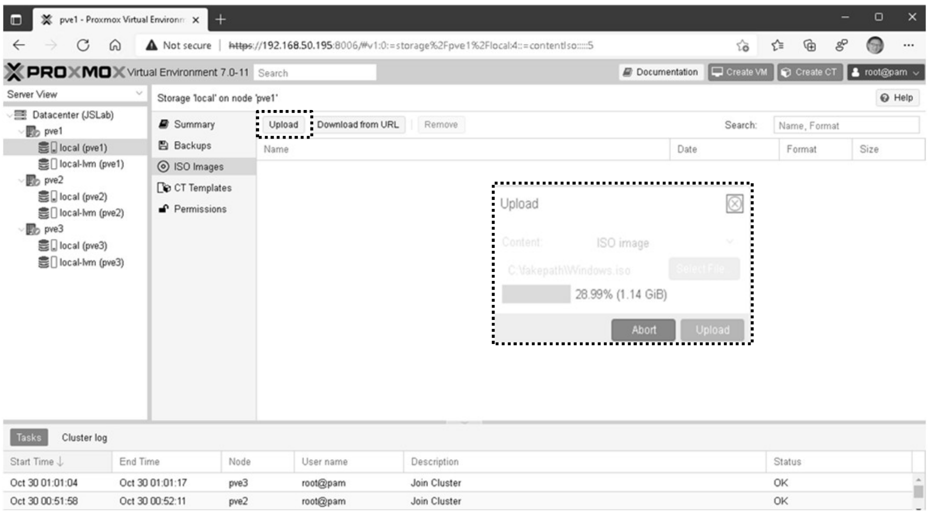
Virtual Machines
○ Running 0
○ Stopped 0

LXC Container
○ Running 0
○ Stopped 0

Start Time ↓	End Time	Node	User name	Description	Status
Oct 30 01:01:04	Oct 30 01:01:17	pve3	root@pam	Join Cluster	OK
Oct 30 00:51:58	Oct 30 00:52:11	pve2	root@pam	Join Cluster	OK

V. HCI

❖ **ISO Upload**



Upload

Content: ISO image

C:\fakepath\Windows.iso

Select File

28.99% (1.14 GiB)

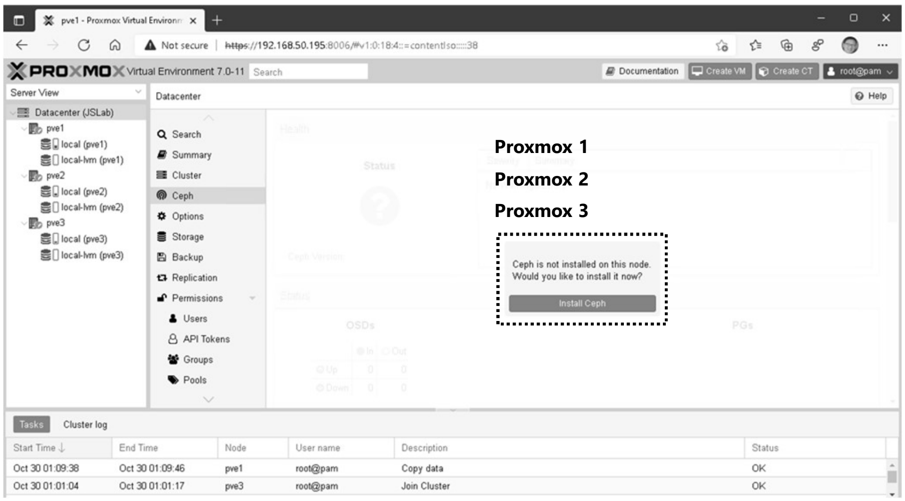
Abort Upload

Start Time ↓	End Time	Node	User name	Description	Status
Oct 30 01:01:04	Oct 30 01:01:17	pve3	root@pam	Join Cluster	OK
Oct 30 00:51:58	Oct 30 00:52:11	pve2	root@pam	Join Cluster	OK

JS Lab

V. HCI

❖ **Install Ceph (type: test)**



Proxmox 1

Proxmox 2

Proxmox 3

Ceph is not installed on this node.
Would you like to install it now?

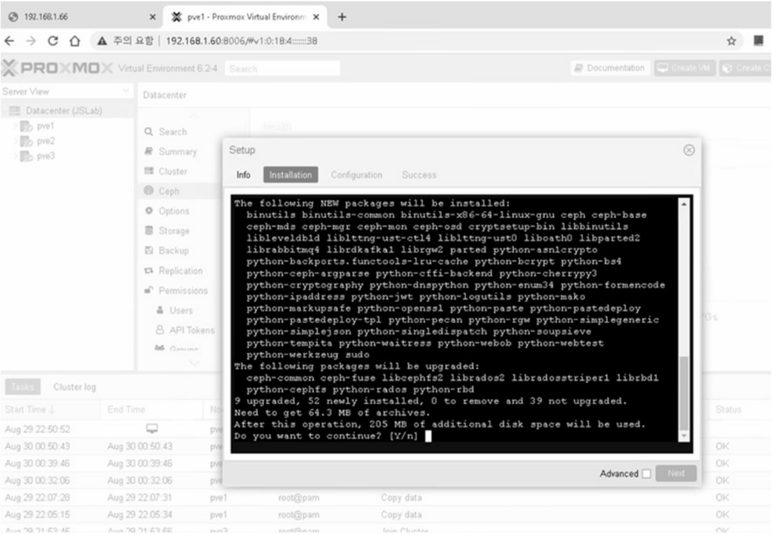
Install Ceph

Start Time ↓	End Time	Node	User name	Description	Status
Oct 30 01:09:38	Oct 30 01:09:46	pve1	root@pam	Copy data	OK
Oct 30 01:01:04	Oct 30 01:01:17	pve3	root@pam	Join Cluster	OK

JS Lab

V. HCI

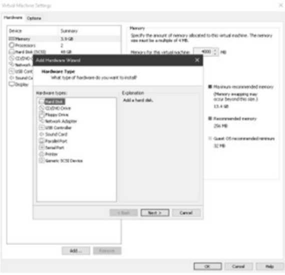
- Y for Setup

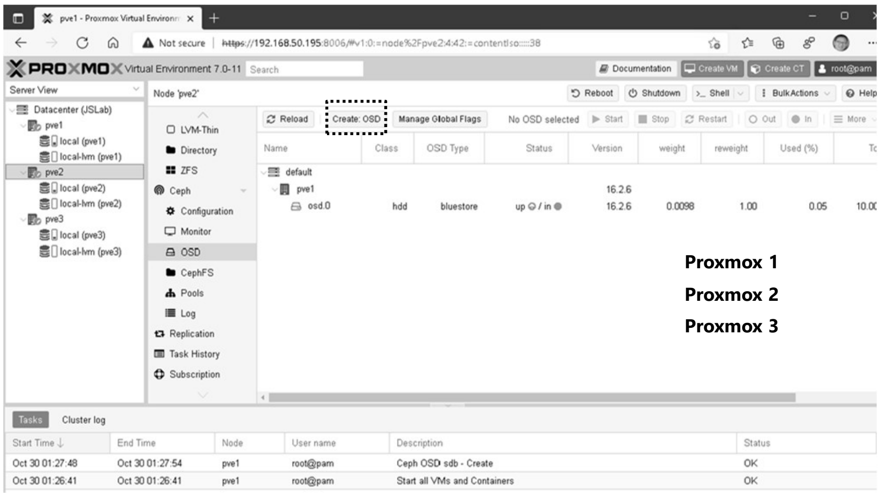


```
The following NEW packages will be installed:
  binutils binutils-common binutils-x86-64-linux-gnu ceph ceph-base
  ceph-mds ceph-mgr ceph-mon ceph-osd cryptsetup-bin libbinutils
  libleveldb1d liblttng-ust-ctl4 liblttng-ust0 liboath0 libparted2
  librabbitmq4 librdkafka1 librgw2 parted python-asn1crypto
  python-backports.functools-lru-cache python-bcrypt python-bs4
  python-ceph-argparse python-cffi-backend python-cherrypy3
  python-cryptography python-dnspython python-enum34 python-formencode
  python-ipaddress python-jwt python-logutils python-mako
  python-markupsafe python-openssl python-paste python-pastedeploy
  python-pastedeploy-tpl python-pecan python-rgw python-simplegeneric
  python-simplejson python-singledispatch python-soupsieve
  python-tempita python-waitress python-webob python-webtest
  python-werkzeug sudo
The following packages will be upgraded:
  ceph-common ceph-fuse libcephfs2 librados2 libradosstriper1 librbd1
  python-cephfs python-rados python-rbd
9 upgraded, 52 newly installed, 0 to remove and 39 not upgraded.
Need to get 64.3 MB of archives.
After this operation, 205 MB of additional disk space will be used.
Do you want to continue? [Y/n]
```

V. HCI

- Create OSD @ Ceph
  - Add HDD & Reboot





Name	Class	OSD Type	Status	Version	weight	reweight	Used (%)	To
default								
pve1				16.2.6				
osd.0	hdd	bluestore	up ● / in ●	16.2.6	0.0098	1.00	0.05	10.0

Proxmox 1

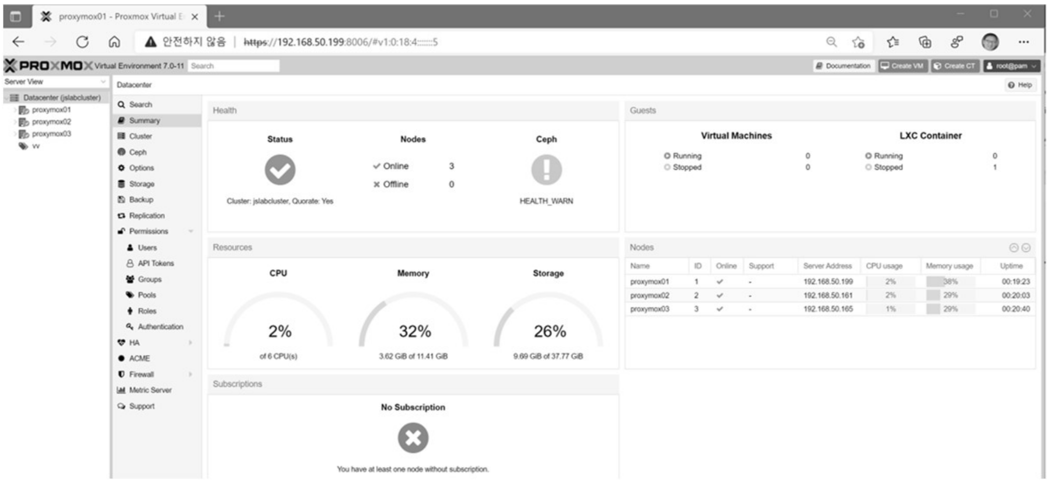
Proxmox 2

Proxmox 3

Start Time	End Time	Node	User name	Description	Status
Oct 30 01:27:48	Oct 30 01:27:54	pve1	root@pam	Ceph OSD sdb - Create	OK
Oct 30 01:26:41	Oct 30 01:26:41	pve1	root@pam	Start all VMs and Containers	OK

V. HCI

- ❖ https://***.***.***.*** root/jslab



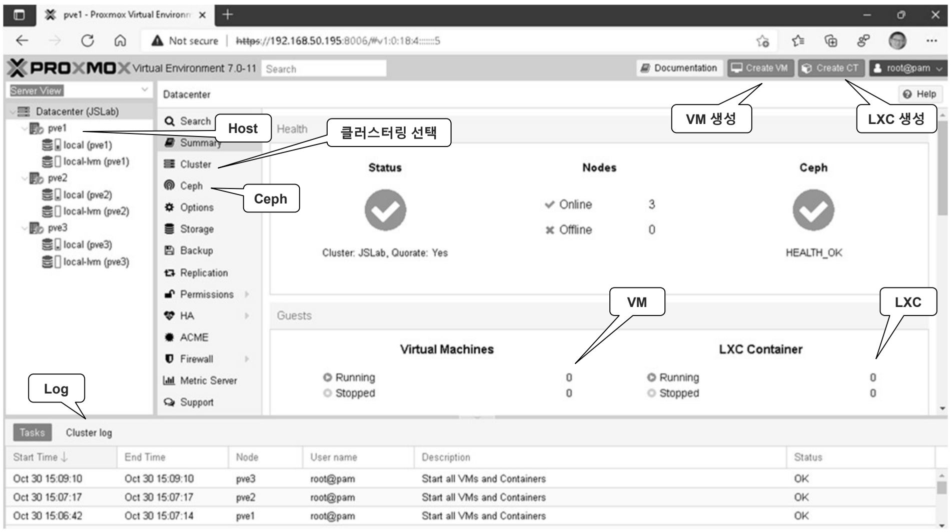
Virtual Machines		LXC Container	
Running	0	Running	0
Stopped	0	Stopped	1

Nodes

Name	ID	Online	Support	Server Address	CPU usage	Memory usage	Uptime
proxymox01	1	✓	-	192.168.50.199	2%	38%	00:19:23
proxymox02	2	✓	-	192.168.50.161	2%	29%	00:20:03
proxymox03	3	✓	-	192.168.50.165	1%	29%	00:20:40

V. HCI

- ❖ Summary
- ❖ Cluster
- ❖ Ceph
- ❖ Options
- ❖ Storage
- ❖ Backup
- ❖ Replication
- ❖ Permissions
- ❖ HA
- ❖ ACME
- ❖ Firewall
- ❖ Metric Server
- ❖ Support



Host

클러스터링 선택

Ceph

VM 생성

LXC 생성

VM

LXC

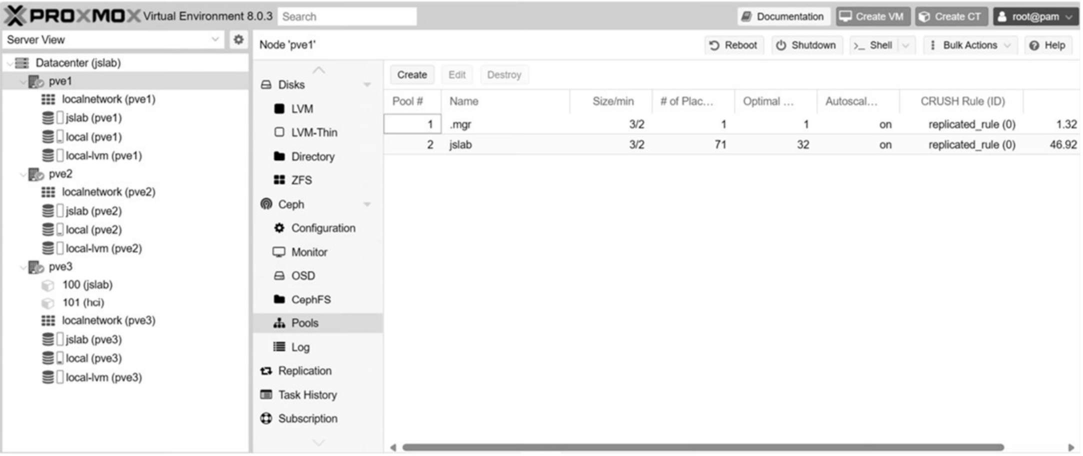
Log

Virtual Machines		LXC Container	
Running	0	Running	0
Stopped	0	Stopped	0

Start Time ↓	End Time	Node	User name	Description	Status
Oct 30 15:09:10	Oct 30 15:09:10	pve3	root@pam	Start all VMs and Containers	OK
Oct 30 15:07:17	Oct 30 15:07:17	pve2	root@pam	Start all VMs and Containers	OK
Oct 30 15:06:42	Oct 30 15:07:14	pve1	root@pam	Start all VMs and Containers	OK

V. HCI

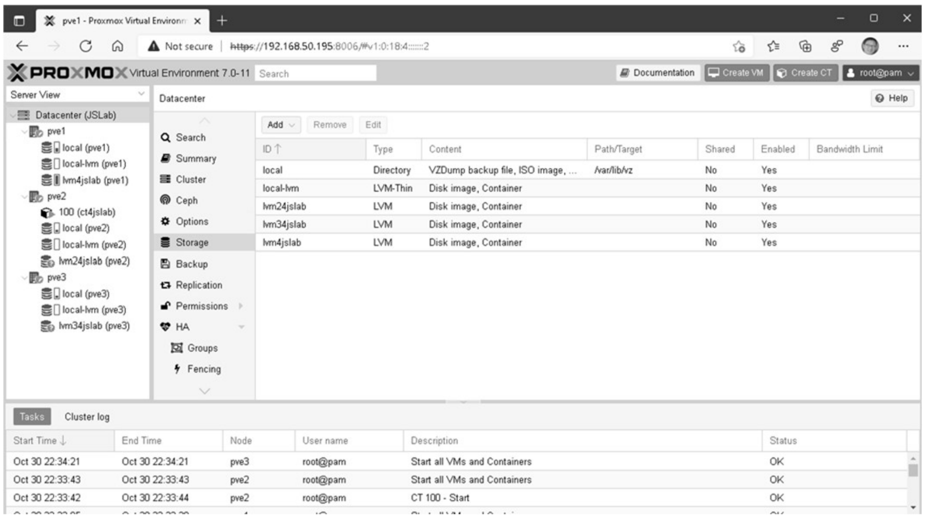
❖ Ceph - Pool



Pool #	Name	Size/min	# of Plac...	Optimal ...	Autoscal...	CRUSH Rule (ID)	
1	.mgr	3/2	1	1	on	replicated_rule (0)	1.32
2	jslab	3/2	71	32	on	replicated_rule (0)	46.92

V. HCI

❖ Storage

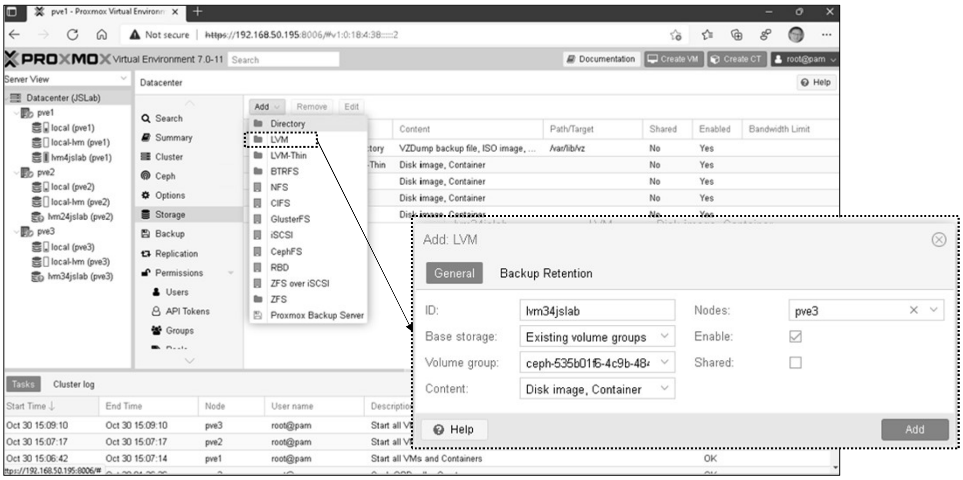


ID ↑	Type	Content	Path/Target	Shared	Enabled	Bandwidth Limit
local	Directory	VZDump backup file, ISO image, ...	/var/lib/vz	No	Yes	
local-lvm	LVM-Thin	Disk image, Container		No	Yes	
lvm24jslab	LVM	Disk image, Container		No	Yes	
lvm34jslab	LVM	Disk image, Container		No	Yes	
lvm4jslab	LVM	Disk image, Container		No	Yes	

Start Time ↓	End Time	Node	User name	Description	Status
Oct 30 22:34:21	Oct 30 22:34:21	pve3	root@pam	Start all VMs and Containers	OK
Oct 30 22:33:43	Oct 30 22:33:43	pve2	root@pam	Start all VMs and Containers	OK
Oct 30 22:33:42	Oct 30 22:33:44	pve2	root@pam	CT 100 - Start	OK

V. HCI

❖ Add Storage for LVM (Ceph) or RBD (Ceph)



Content	Path/Target	Shared	Enabled	Bandwidth Limit
VZDump backup file, ISO image, ...	/var/lib/vz	No	Yes	
Disk image, Container		No	Yes	
Disk image, Container		No	Yes	
Disk image, Container		No	Yes	

Add: LVM

General | Backup Retention

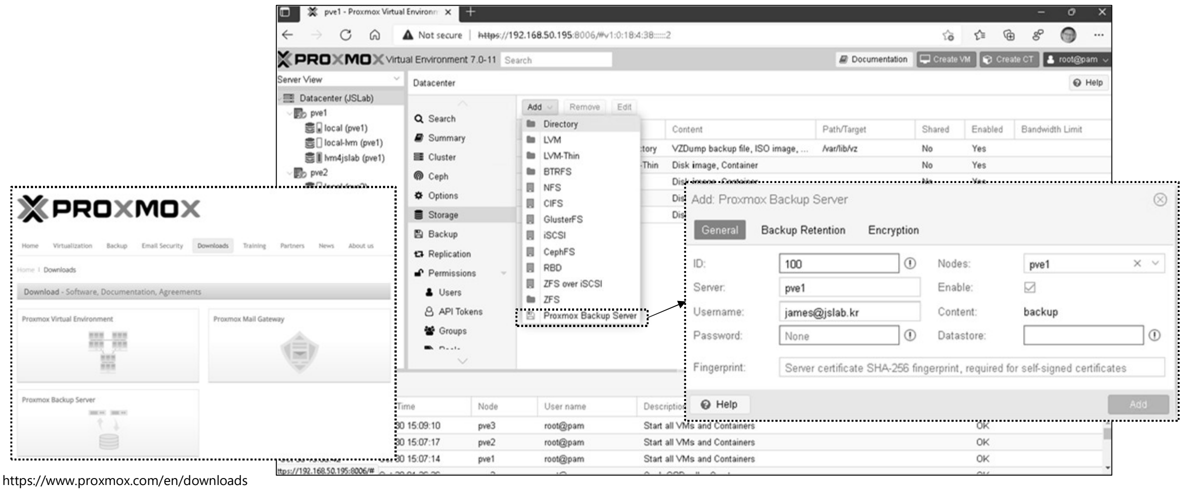
ID:	lvm34jslab	Nodes:	pve3
Base storage:	Existing volume groups	Enable:	☑
Volume group:	ceph-535b01f6-4c9b-48‹	Shared:	☐
Content:	Disk image, Container		

Help | Add

Start Time ↓	End Time	Node	User name	Description
Oct 30 15:09:10	Oct 30 15:09:10	pve3	root@pam	Start all V
Oct 30 15:07:17	Oct 30 15:07:17	pve2	root@pam	Start all V
Oct 30 15:06:42	Oct 30 15:07:14	pve1	root@pam	Start all VMs and Containers

V. HCI

❖ Add Storage for Backup (** 별도 백업서버 설치 가능)



Content	Path/Target	Shared	Enabled	Bandwidth Limit
VZDump backup file, ISO image, ...	/var/lib/vz	No	Yes	
Disk image, Container		No	Yes	

Add: Proxmox Backup Server

General | Backup Retention | Encryption

ID:	100	Nodes:	pve1
Server:	pve1	Enable:	☑
Username:	james@jslab.kr	Content:	backup
Password:	None	Datastore:	
Fingerprint:	Server certificate SHA-256 fingerprint, required for self-signed certificates		

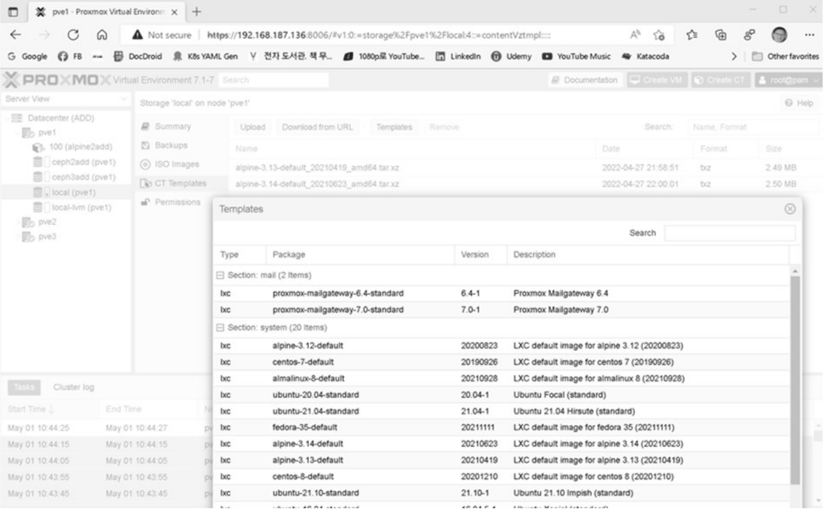
Help | Add

Time	Node	User name	Description	
30 15:09:10	pve3	root@pam	Start all VMs and Containers	OK
30 15:07:17	pve2	root@pam	Start all VMs and Containers	OK
30 15:07:14	pve1	root@pam	Start all VMs and Containers	OK

https://www.proxmox.com/en/downloads

V. HCI

❖ **리눅스 컨테이너 Template 다운로드**



Storage 'local' on node 'pve1'

Name	Date	Format	Size
alpine-3.13-default_20210419_amd64.tar.xz	2022-04-27 21:58:51	txz	2.49 MB
alpine-3.14-default_20210623_amd64.tar.xz	2022-04-27 22:00:01	txz	2.50 MB

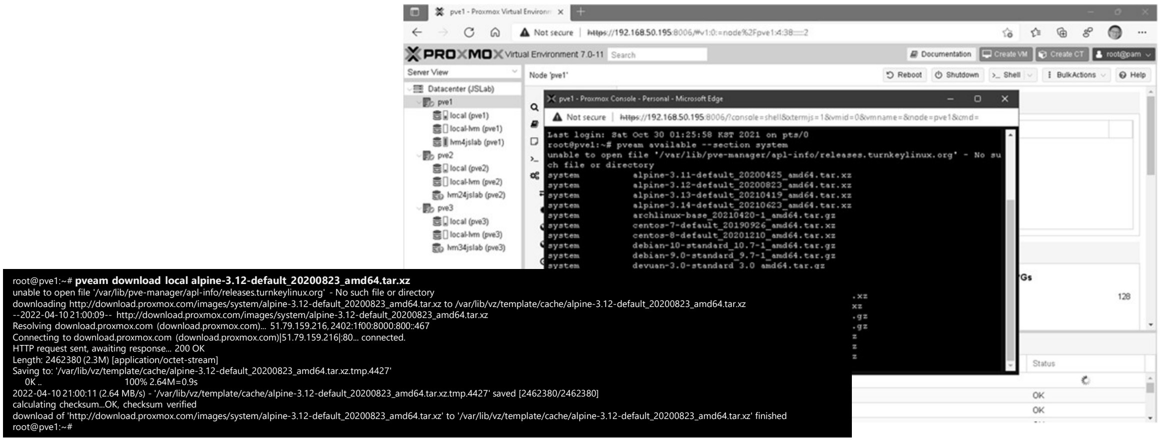
Templates

Type	Package	Version	Description
Section: mail (2 Items)			
lxc	proxmox-mailgateway-6.4-standard	6.4-1	Proxmox Mailgateway 6.4
lxc	proxmox-mailgateway-7.0-standard	7.0-1	Proxmox Mailgateway 7.0
Section: system (20 Items)			
lxc	alpine-3.12-default	20200823	LXC default image for alpine 3.12 (20200823)
lxc	centos-7-default	20190926	LXC default image for centos 7 (20190926)
lxc	almalinux-8-default	20210928	LXC default image for almalinux 8 (20210928)
lxc	ubuntu-20.04-standard	20.04-1	Ubuntu Focal (standard)
lxc	ubuntu-21.04-standard	21.04-1	Ubuntu 21.04 Hirsute (standard)
lxc	fedora-35-default	20211111	LXC default image for fedora 35 (20211111)
lxc	alpine-3.14-default	20210623	LXC default image for alpine 3.14 (20210623)
lxc	alpine-3.13-default	20210419	LXC default image for alpine 3.13 (20210419)
lxc	centos-8-default	20201210	LXC default image for centos 8 (20201210)
lxc	ubuntu-21.10-standard	21.10-1	Ubuntu 21.10 Impish (standard)

V. HCI

❖ **리눅스 컨테이너 Template 다운로드 (선택)**

- **pveam available --section system** @ >_Shell
- **pveam download local alpine-3.12-default_20200823_amd64.tar.xz**

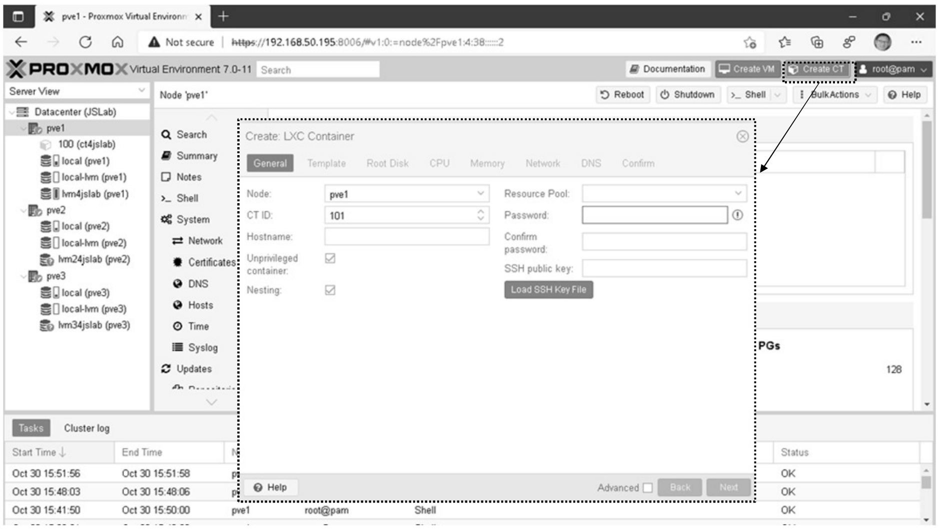


```
Last login: Sat Oct 30 01:25:58 KST 2021 on pts/0
root@pve1:~# pveam available --section system
unable to open file '/var/lib/pve-manager/apl-info/releases.turnkeylinux.org' - No su
ch file or directory
system          alpine-3.11-default_20200425_amd64.tar.xz
system          alpine-3.12-default_20200823_amd64.tar.xz
system          alpine-3.13-default_20210419_amd64.tar.xz
system          alpine-3.14-default_20210623_amd64.tar.xz
system          archlinux-base_20210420-1_amd64.tar.gz
system          centos-7-default_20190926_amd64.tar.xz
system          centos-8-default_20201210_amd64.tar.xz
system          debian-10-standard_10.7-1_amd64.tar.gz
system          debian-9.0-standard_9.7-1_amd64.tar.gz
system          devuan-3.0-standard 3.0 amd64.tar.gz
```

```
root@pve1:~# pveam download local alpine-3.12-default_20200823_amd64.tar.xz
unable to open file '/var/lib/pve-manager/apl-info/releases.turnkeylinux.org'  - No such file or directory
downloading http://download.proxmox.com/images/system/alpine-3.12-default_20200823_amd64.tar.xz to /var/lib/vz/template/cache/alpine-3.12-default_20200823_amd64.tar.xz
--2022-04-10 21:00:09--  http://download.proxmox.com/images/system/alpine-3.12-default_20200823_amd64.tar.xz
Resolving download.proxmox.com (download.proxmox.com)... 51.79.159.216, 2402:1f00:8000:800::467
Connecting to download.proxmox.com (download.proxmox.com)|51.79.159.216|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 2462380 (2.3M) [application/octet-stream]
Saving to: '/var/lib/vz/template/cache/alpine-3.12-default_20200823_amd64.tar.xz.tmp.4427'
     0K ..                                    100% 2.64M=0.9s
2022-04-10 21:00:11 (2.64 MB/s) - '/var/lib/vz/template/cache/alpine-3.12-default_20200823_amd64.tar.xz.tmp.4427' saved [2462380/2462380]
calculating checksum...OK, checksum verified
download of 'http://download.proxmox.com/images/system/alpine-3.12-default_20200823_amd64.tar.xz' to '/var/lib/vz/template/cache/alpine-3.12-default_20200823_amd64.tar.xz' finished
root@pve1:~#
```

V. HCI

❖ Create LXC



Create: LXC Container

General | Template | Root Disk | CPU | Memory | Network | DNS | Confirm

Node: pve1
CT ID: 101
Hostname:
Unprivileged container: ☑
Nesting: ☑
Resource Pool:
Password:
Confirm password:
SSH public key:
Load SSH Key File

Help   Advanced □   Back   Next

Start Time ↓	End Time	N			Status
Oct 30 15:51:56	Oct 30 15:51:58	p			OK
Oct 30 15:48:03	Oct 30 15:48:06	p			OK
Oct 30 15:41:50	Oct 30 15:50:00	pve1	root@pam	Shell	OK

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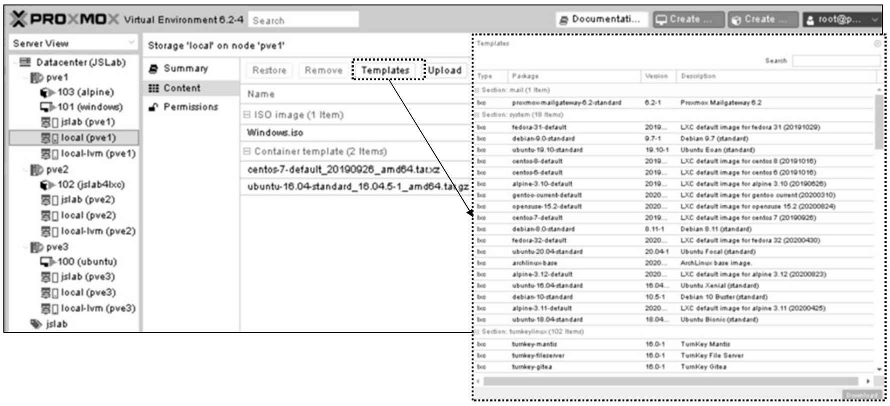
V. HCI

❖ Templates for LXC



Name
⊟ ISO image (1 Item)
Windows.iso
⊟ Container template (2 Items)
centos-7-default_20190926_amd64.tar.xz
ubuntu-16.04-standard_16.04.5-1_amd64.tar.gz

Templates

Search

Type	Package	Version	Description
⊟ Section: mail (1 Item)			
lxc	proxmox-mailgateway-6.2-standard	6.2-1	Proxmox Mailgateway 6.2
⊟ Section: system (18 Items)			
lxc	fedora-31-default	2019...	LXC default image for fedora 31 (20191029)
lxc	debian-9.0-standard	9.7-1	Debian 9.7 (standard)
lxc	ubuntu-19.10-standard	19.10-1	Ubuntu Eoan (standard)
lxc	centos-8-default	2019...	LXC default image for centos 8 (20191016)
lxc	centos-6-default	2019...	LXC default image for centos 6 (20191016)
lxc	alpine-3.10-default	2019...	LXC default image for alpine 3.10 (20190626)
lxc	gentoo-current-default	2020...	LXC default image for gentoo current (20200310)
lxc	opensuse-15.2-default	2020...	LXC default image for opensuse 15.2 (20200824)
lxc	centos-7-default	2019...	LXC default image for centos 7 (20190926)
lxc	debian-8.0-standard	8.11-1	Debian 8.11 (standard)
lxc	fedora-32-default	2020...	LXC default image for fedora 32 (20200430)
lxc	ubuntu-20.04-standard	20.04-1	Ubuntu Focal (standard)
lxc	archlinux-base	2020...	ArchLinux base image.
lxc	alpine-3.12-default	2020...	LXC default image for alpine 3.12 (20200823)
lxc	ubuntu-16.04-standard	16.04...	Ubuntu Xenial (standard)
lxc	debian-10-standard	10.5-1	Debian 10 Buster (standard)
lxc	alpine-3.11-default	2020...	LXC default image for alpine 3.11 (20200425)
lxc	ubuntu-18.04-standard	18.04...	Ubuntu Bionic (standard)
⊟ Section: turnkeylinux (102 Items)			
lxc	turnkey-mantis	16.0-1	TurnKey Mantis
lxc	turnkey-fileserver	16.0-1	TurnKey File Server
lxc	turnkey-gitea	16.0-1	TurnKey Gitea

Source: https://pve.proxmox.com/wiki/Linux_Container

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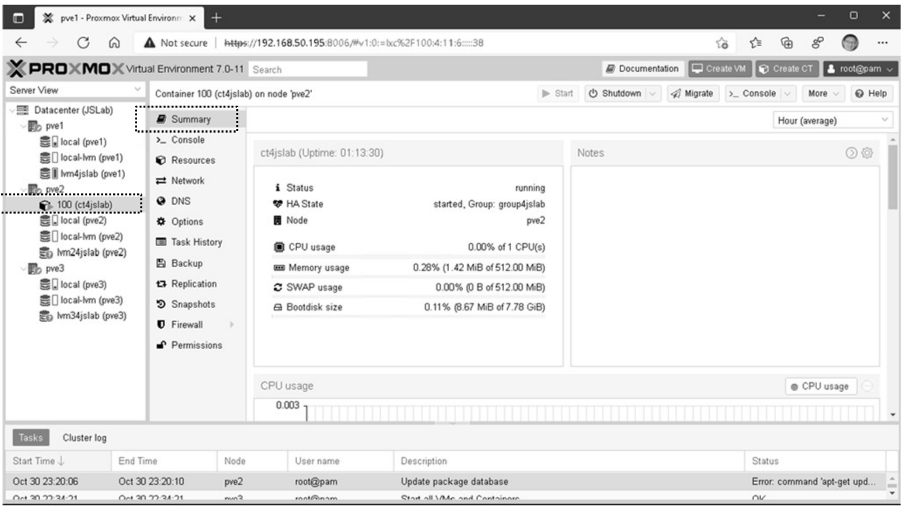
V. HCI

- ❖ **LXC Summary**



Container 100 (ct4jslab) on node 'pve2'

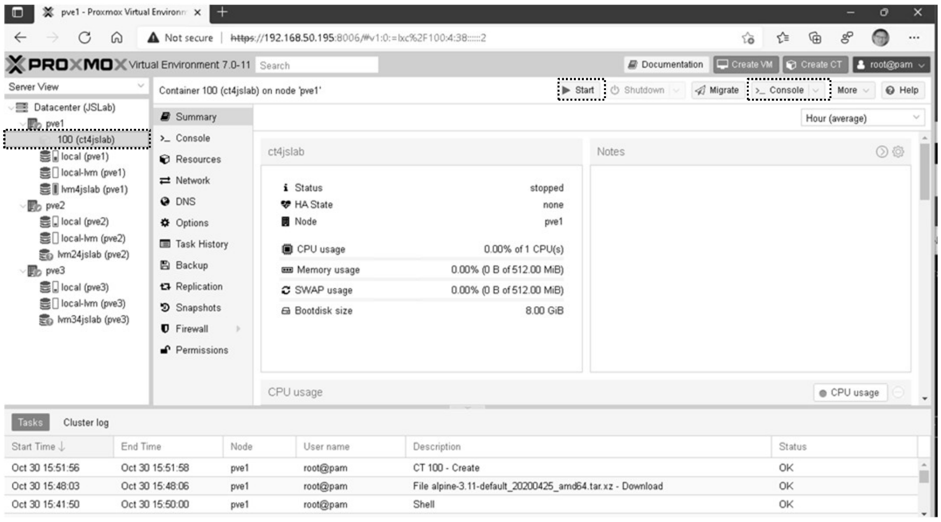
ct4jslab (Uptime: 01:13:30)

Status	running
HA State	started, Group: group4jslab
Node	pve2
CPU usage	0.00% of 1 CPU(s)
Memory usage	0.28% (1.42 MiB of 512.00 MiB)
SWAP usage	0.00% (0 B of 512.00 MiB)
Bootdisk size	0.11% (8.67 MiB of 7.78 GiB)

Start Time ↓	End Time	Node	User name	Description	Status
Oct 30 23:20:06	Oct 30 23:20:10	pve2	root@pam	Update package database	Error: command 'apt-get upd...
Oct 30 22:34:21	Oct 30 22:34:21	pve3	root@pam	Start all VMs and Containers	OK

V. HCI

- ❖ **LXC Start**
- ❖ **Console**
- ❖ **Migrate**



Container 100 (ct4jslab) on node 'pve1'

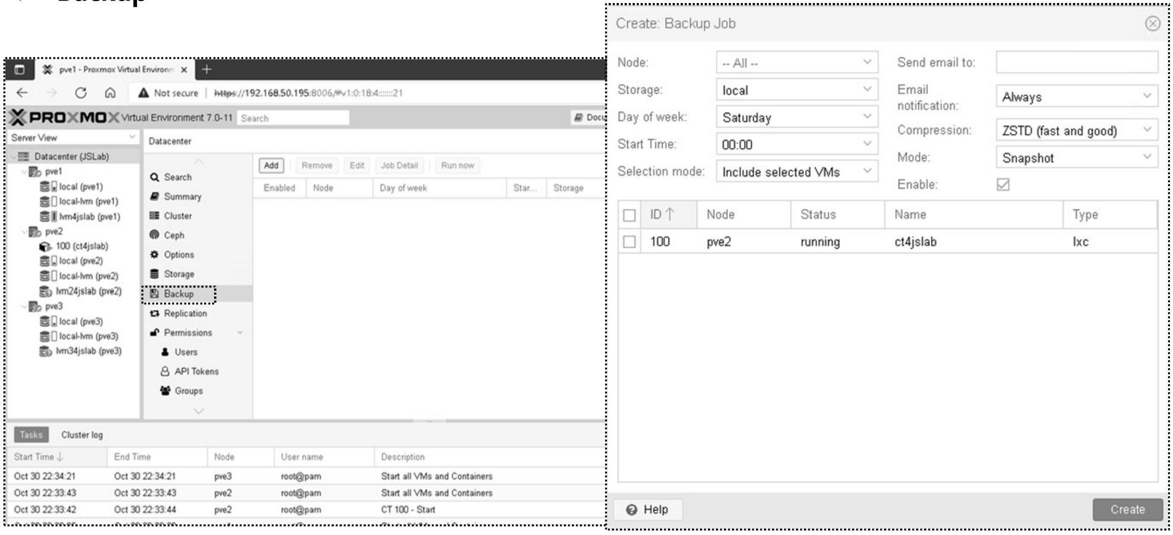
ct4jslab

Status	stopped
HA State	none
Node	pve1
CPU usage	0.00% of 1 CPU(s)
Memory usage	0.00% (0 B of 512.00 MiB)
SWAP usage	0.00% (0 B of 512.00 MiB)
Bootdisk size	8.00 GiB

Start Time ↓	End Time	Node	User name	Description	Status
Oct 30 15:51:56	Oct 30 15:51:58	pve1	root@pam	CT 100 - Create	OK
Oct 30 15:48:03	Oct 30 15:48:06	pve1	root@pam	File alpine-3.11-default_20200425_amd64.tar.xz - Download	OK
Oct 30 15:41:50	Oct 30 15:50:00	pve1	root@pam	Shell	OK

V. HCI

❖ Backup



Start Time ↓	End Time	Node	User name	Description
Oct 30 22:34:21	Oct 30 22:34:21	pve3	root@pam	Start all VMs and Containers
Oct 30 22:33:43	Oct 30 22:33:43	pve2	root@pam	Start all VMs and Containers
Oct 30 22:33:42	Oct 30 22:33:44	pve2	root@pam	CT 100 - Start

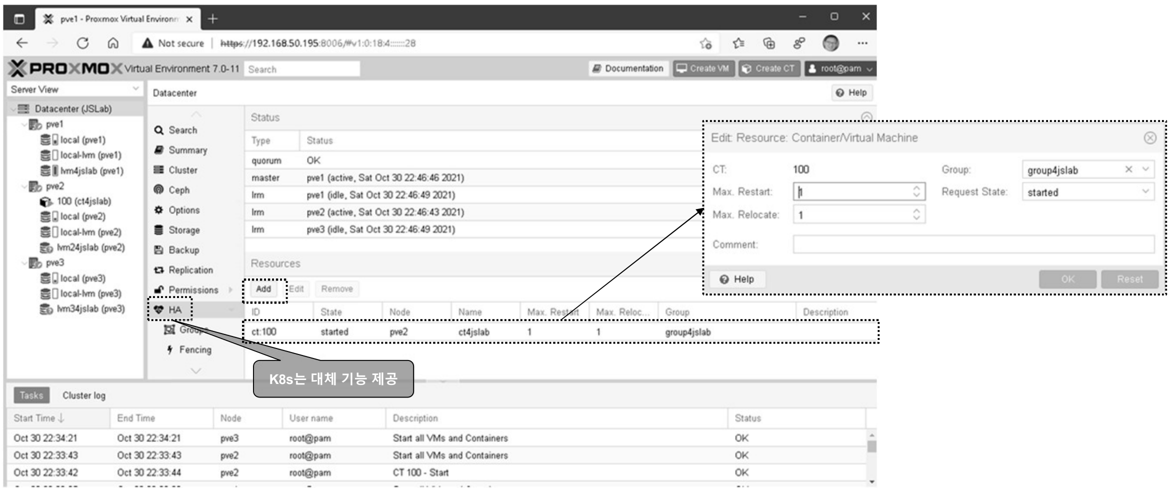
Create: Backup Job

Node: -- All --
Storage: local
Day of week: Saturday
Start Time: 00:00
Selection mode: Include selected VMs
Send email to:
Email notification: Always
Compression: ZSTD (fast and good)
Mode: Snapshot
Enable: ☑

□	ID ↑	Node	Status	Name	Type
□	100	pve2	running	ct4jslab	lxc

V. HCI

❖ HA



Status

Type	Status
quorum	OK
master	pve1 (active, Sat Oct 30 22:46:46 2021)
lrm	pve1 (idle, Sat Oct 30 22:46:49 2021)
lrm	pve2 (active, Sat Oct 30 22:46:43 2021)
lrm	pve3 (idle, Sat Oct 30 22:46:49 2021)

ID	State	Node	Name	Max. Restart	Max. Reloc...	Group	Description
ct:100	started	pve2	ct4jslab	1	1	group4jslab	

Edit: Resource: Container/Virtual Machine

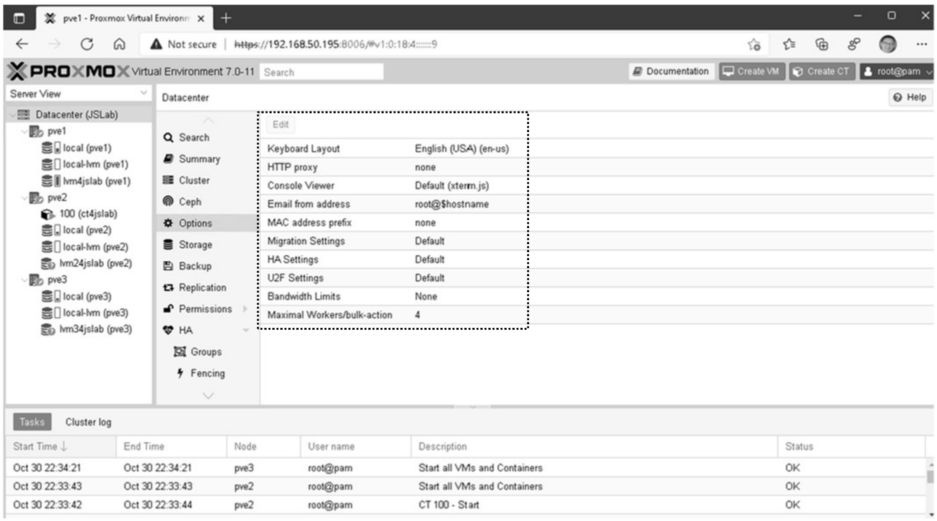
CT: 100
Max. Restart: 1
Max. Relocate: 1
Comment:
Group: group4jslab
Request State: started

K8s는 대체 기능 제공

Start Time ↓	End Time	Node	User name	Description	Status
Oct 30 22:34:21	Oct 30 22:34:21	pve3	root@pam	Start all VMs and Containers	OK
Oct 30 22:33:43	Oct 30 22:33:43	pve2	root@pam	Start all VMs and Containers	OK
Oct 30 22:33:42	Oct 30 22:33:44	pve2	root@pam	CT 100 - Start	OK

V. HCI

- ❖ **Options**



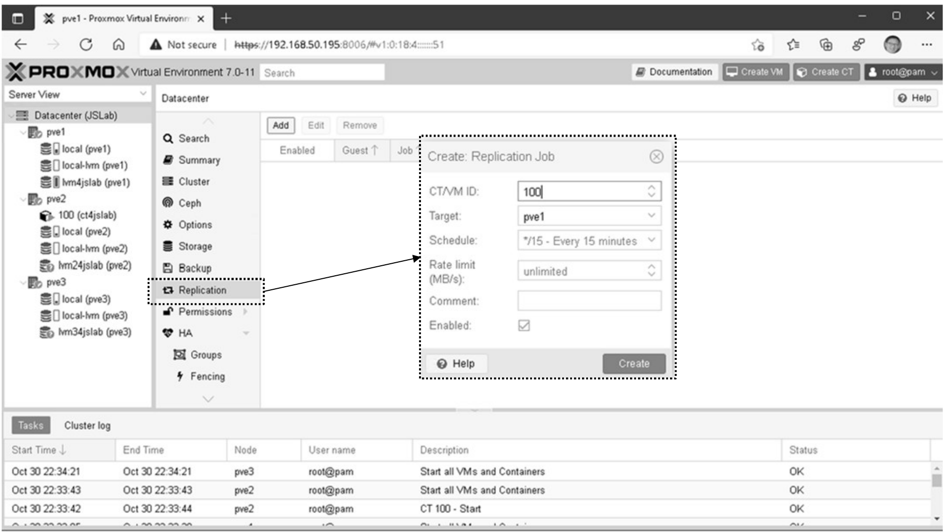
Keyboard Layout	English (USA) (en-us)
HTTP proxy	none
Console Viewer	Default (xterm.js)
Email from address	root@$hostname
MAC address prefix	none
Migration Settings	Default
HA Settings	Default
U2F Settings	Default
Bandwidth Limits	None
Maximal Workers/bulk-action	4

Start Time ↓	End Time	Node	User name	Description	Status
Oct 30 22:34:21	Oct 30 22:34:21	pve3	root@pam	Start all VMs and Containers	OK
Oct 30 22:33:43	Oct 30 22:33:43	pve2	root@pam	Start all VMs and Containers	OK
Oct 30 22:33:42	Oct 30 22:33:44	pve2	root@pam	CT 100 - Start	OK

◆ ◆ ◆ ◆ **JS Lab**

V. HCI

- ❖ **Replication**



Create: Replication Job

- CT/VM ID: 100
- Target: pve1
- Schedule: */15 - Every 15 minutes
- Rate limit (MB/s): unlimited
- Comment:
- Enabled: ☑

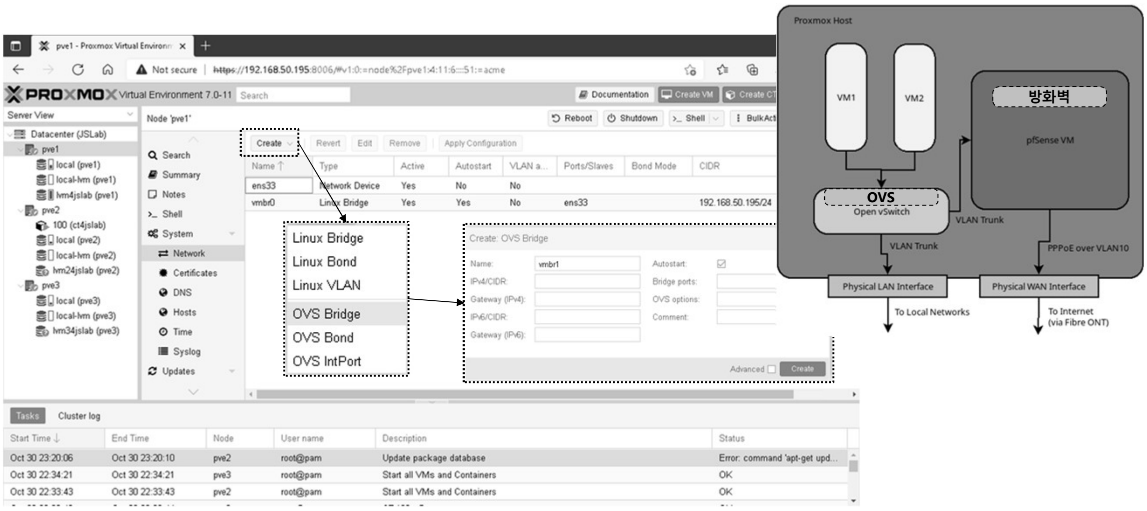
Help | Create

Start Time ↓	End Time	Node	User name	Description	Status
Oct 30 22:34:21	Oct 30 22:34:21	pve3	root@pam	Start all VMs and Containers	OK
Oct 30 22:33:43	Oct 30 22:33:43	pve2	root@pam	Start all VMs and Containers	OK
Oct 30 22:33:42	Oct 30 22:33:44	pve2	root@pam	CT 100 - Start	OK

◆ ◆ ◆ ◆ **JS Lab**

V. HCI

❖ **Host (System/Network)**



Name ↑	Type	Active	Autostart	VLAN a...	Ports/Slaves	Bond Mode	CIDR
ens33	Network Device	Yes	No	No			
vmbr0	Linux Bridge	Yes	Yes	No	ens33		192.168.50.195/24

Create: OVS Bridge

Name:	vmbr1	Autostart:	☑
IPv4/CIDR:		Bridge ports:	
Gateway (IPv4):		OVS options:	
IPv6/CIDR:		Comment:	
Gateway (IPv6):			

Advanced □

Start Time ↓	End Time	Node	User name	Description	Status
Oct 30 23:20:06	Oct 30 23:20:10	pve2	root@pam	Update package database	Error: command 'apt-get upd...
Oct 30 22:34:21	Oct 30 22:34:21	pve3	root@pam	Start all VMs and Containers	OK
Oct 30 22:33:43	Oct 30 22:33:43	pve2	root@pam	Start all VMs and Containers	OK

VI. SDN Controller (ONOS)

- **ONOS Operations**
- **Leaf-Spine**
- **Intent**

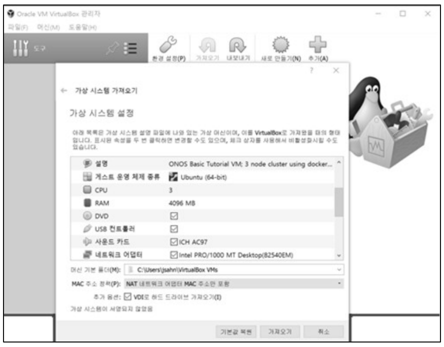
✓ **Zip 파일 'D'에 다시 다운로드 @ mSD**
✓ **'C'에서 압축 풀기** @ NVMe
✓ **Run ONOS VM**
✓ **sudo mn -c** (for mininet clear)
✓ **VM Rebooting (다른 PC는 Rebooting 만으로 해결)**

VI. SDN CONTROLLER (ONOS)

❖ **Create Virtual Machine** (VirtualBox)

- **VirtualBox 설치 (https://www.virtualbox.org/wiki/Downloads)**
- **OVA 파일 사용 (onos-1.15.0.ova)**
- **OVA 파일 더블클릭 (Double-click on ONOS OVA file).**
- **VirtualBox 실행 (open virtual box with an import dialog).**
- **CPU/RAM 할당 (Allocate 2-3 CPUs and 4-8GB of RAM for the VM).**

Name	Version	Date
Woodpecker	2.6.0	Jul 16, 2021
Uguisu	2.4.0	Jun 5,2020
Toucan	2.3.0	Jan 27,2020
Sparrow	2.2.0	Aug 30,2019
	2.2.1	Feb 20, 2020
	2.2.2	Mar 25, 2020
	2.2.3	Jul 3, 2020
Raven	2.1.0	Apr 30, 2019
Quail	2.0.0	Jan 18, 2019
Peacock	1.15.0	Nov 29, 2018
Owl	1.14.0	Sep 4, 2018
Nightingale	1.13.10	Feb 20, 2020
	1.13.3	Sep 5, 2018
	1.13.2	July 11, 2018
	1.13.1	May 2, 2018
Magpie	1.12.0	Dec 11, 2017
Loon	1.11.2	March 28, 2018
	1.11.1	Sep 15, 2017
	1.11.0	Sep 8, 2017
Kingfisher	1.10.4	Aug 25, 2017
	1.10.3	Aug 2, 2017
	1.10.2	Jun 22, 2017
	1.10.0	Jun 5, 2017
Junco	1.9.2	Jun 22, 2017
	1.9.0	Feb 28, 2017
Ibis	1.8.9	Jun 22, 2017
	1.8.7	May 15, 2017
	1.8.6	May 9, 2017
	1.8.5	May 8, 2017
	1.8.4	Mar. 9, 2017
	1.8.3	Mar. 8, 2017
	1.8.2	Jan 12, 2017
	1.8.0	Dec. 9, 2016
Hummingbird	1.7.1	Oct. 25, 2016
	1.7.0	Sept. 23, 2016
Goldeneye	1.6.0	Jun. 24, 2016
Falcon	1.5.1	Apr. 20, 2016
	1.5.0	Mar. 10, 2016
Emu	1.4.0	Dec. 16, 2015
Drake	1.3.0	Sept. 18, 2015
Cardinal	1.2.2	Sept. 1, 2015
	1.2.1	June 25, 2015
	1.2.0	June 5, 2015
Blackbird	1.1.0	Mar. 17, 2015
Avocet	1.0.1	Jan. 22, 2015
	1.0.0	Dec. 5, 2014



← 가상 시스템 가져오기

가상 시스템 설정

아래 목록은 가상 시스템 설명 파일에 나와 있는 가상 머신이며, 이를 VirtualBox로 가져왔을 때의 형태입니다. 표시된 속성을 두 번 클릭하면 변경할 수도 있으며, 체크 상자를 사용해서 비활성화시킬 수도 있습니다.

설명	ONOS Basic Tutorial VM; 3 node cluster using docker...
게스트 운영 체제 종류	Ubuntu (64-bit)
CPU	3
RAM	4096 MB
DVD	☑
USB 컨트롤러	☑
사운드 카드	☑ ICH AC97
네트워크 어댑터	☑ Intel PRO/1000 MT Desktop(82540EM)

머신 기본 폴더(M): C:\Users\jsahn\VirtualBox VMs

MAC 주소 정책(P): NAT 네트워크 어댑터 MAC 주소만 포함

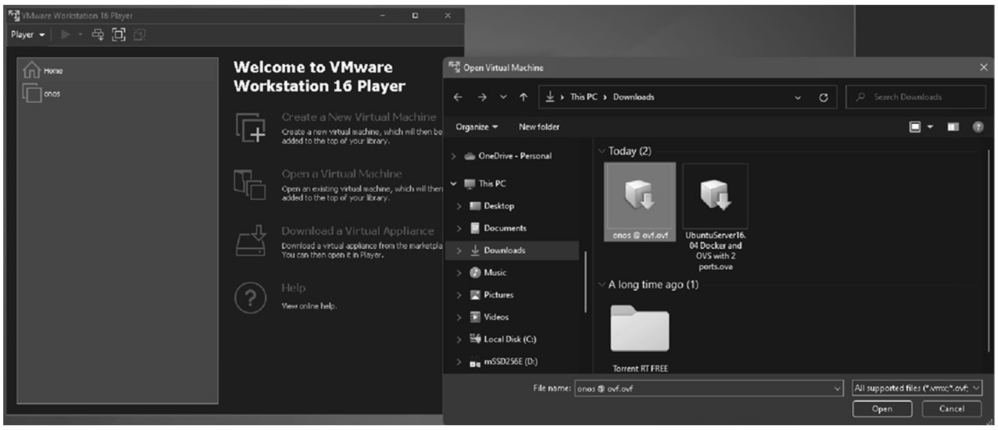
추가 옵션: ☑ VDI로 하드 드라이브 가져오기(I)

가상 시스템이 서명되지 않았음

VI. SDN CONTROLLER (ONOS)

❖ **Open a Virtual Machine** (VMware Workstation Player로 가능함)

- **ONOS 버전: ONOS version 1.15.0 (Peacock)**


VMware Workstation 16 Player
Player
Home
onos
Welcome to VMware Workstation 16 Player
Create a New Virtual Machine
Create a new virtual machine, which will then be added to the top of your library.
Open a Virtual Machine
Open an existing virtual machine, which will then be added to the top of your library.
Download a Virtual Appliance
Download a virtual appliance from the marketplace. You can then open it in Player.
Help
View online help.
Open Virtual Machine
This PC › Downloads
Search Downloads
Organize
New folder
OneDrive - Personal
This PC
Desktop
Documents
Downloads
Music
Pictures
Videos
Local Disk (C:)
mSSD256E (D:)
Today (2)
onos @ ovf.ovf
UbuntuServer16.04 Docker and OVS with 2 ports.ova
A long time ago (1)
Torrent RT FREE
Open
Cancel

File name: onos @ ovf.ovf

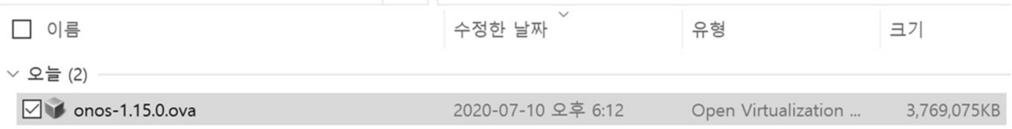
All supported files (*.vmx;*.ovf;

Source: https://drive.google.com/file/d/1StbFU8sOBA6jdaEZRzdplcFa8qZ-Ge4D/view?usp=sharing

VI. SDN CONTROLLER (ONOS)

❖ **SDN 컨트롤러 ONOS 사용** (VirtualBox 사용)

- **ONOS 버전: ONOS version 1.15.0 (Peacock)**
- **권장 RAM 용량: at least 8GB of RAM**
- **권장 디스크 용량: at least 20GB of free hard disk space**
- **CPU 코어 2개 이상: A faster processor or solid-state drive will speed up**
- **모니터 스크린: larger screen will help to manage multiple terminal windows.**
- **사용 가능 OS: Windows, Mac OS X, or Linux**



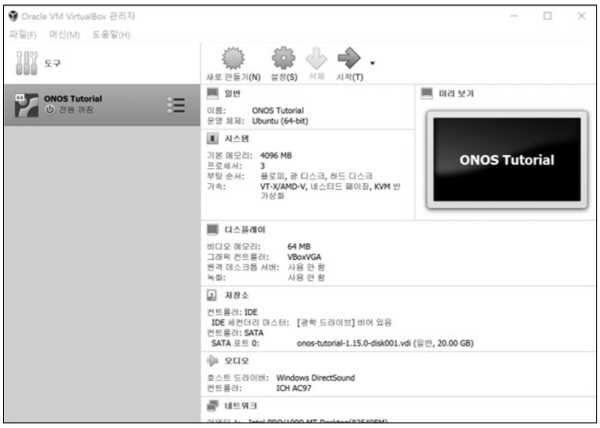
□ 이름	수정한 날짜	유형	크기
∨ 오늘 (2)			
☑ onos-1.15.0.ova	2020-07-10 오후 6:12	Open Virtualization ...	3,769,075KB

Source: https://drive.google.com/file/d/1StbFU8sOBA6jdaEZRzdplcFa8qZ-Ge4D/view?usp=sharing

VI. SDN CONTROLLER (ONOS)

❖ **Create Virtual Machine** (선택 VirtualBox)

- **Check setting**
- **오류 메시지 발생시 네트워크 설정변경**


Oracle VM VirtualBox 관리자
파일(F) 머신(M) 도움말(H)
도구
새로 만들기(N) 설정(S) 삭제 시작(T)
ONOS Tutorial
전원 꺼짐
미리 보기
ONOS Tutorial

일반
이름: ONOS Tutorial
운영 체제: Ubuntu (64-bit)

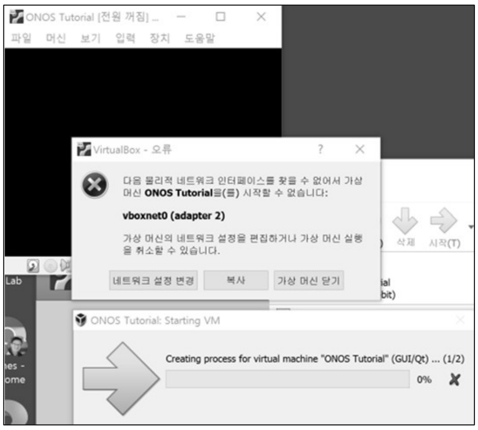
시스템
기본 메모리: 4096 MB
프로세서: 3
부팅 순서: 플로피, 광 디스크, 하드 디스크
가속: VT-X/AMD-V, 네스티드 페이징, KVM 반가상화

디스플레이
비디오 메모리: 64 MB
그래픽 컨트롤러: VBoxVGA
원격 데스크톱 서버: 사용 안 함
녹화: 사용 안 함

저장소
컨트롤러: IDE
IDE 세컨더리 마스터: [광학 드라이브] 비어 있음
컨트롤러: SATA
SATA 포트 0: onos-tutorial-1.15.0-disk001.vdi (일반, 20.00 GB)

오디오
호스트 드라이버: Windows DirectSound
컨트롤러: ICH AC97

네트워크


ONOS Tutorial [전원 꺼짐] ...
파일 머신 보기 입력 장치 도움말
VirtualBox - 오류
네트워크 설정 변경
복사
가상 머신 닫기
삭제 시작(T)
ONOS Tutorial: Starting VM
0%

다음 물리적 네트워크 인터페이스를 찾을 수 없어서 가상 머신 **ONOS Tutorial**을(를) 시작할 수 없습니다:

vboxnet0 (adapter 2)

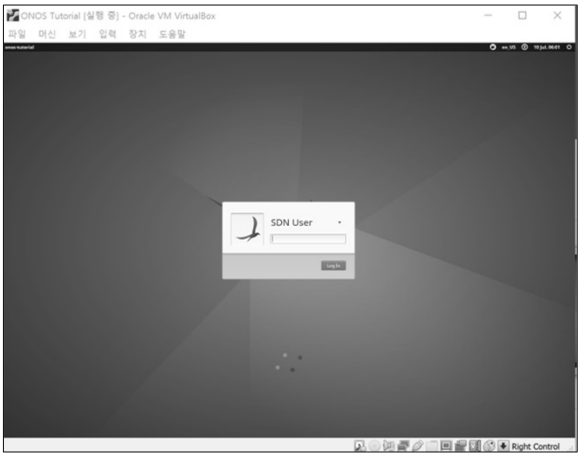
가상 머신의 네트워크 설정을 편집하거나 가상 머신 실행을 취소할 수 있습니다.

Creating process for virtual machine "ONOS Tutorial" (GUI/Qt) ... (1/2)

VI. SDN CONTROLLER (ONOS)

❖ **VM 로그인**

- **Click on import. When the import is finished start the VM and**
- **로그인: SDN User (sdn) with password rocks**

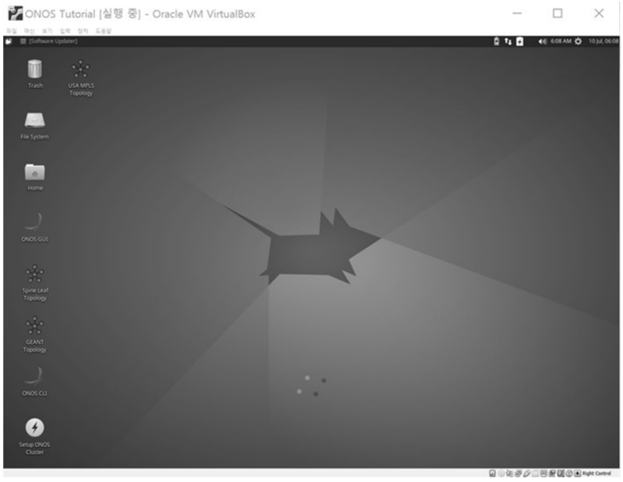

ONOS Tutorial [실행 중] - Oracle VM VirtualBox
파일 머신 보기 입력 장치 도움말
SDN User
Log In
Right Control

Source: https://wiki.onosproject.org/display/ONOS/Basic+ONOS+Tutorial

VI. SDN CONTROLLER (ONOS)

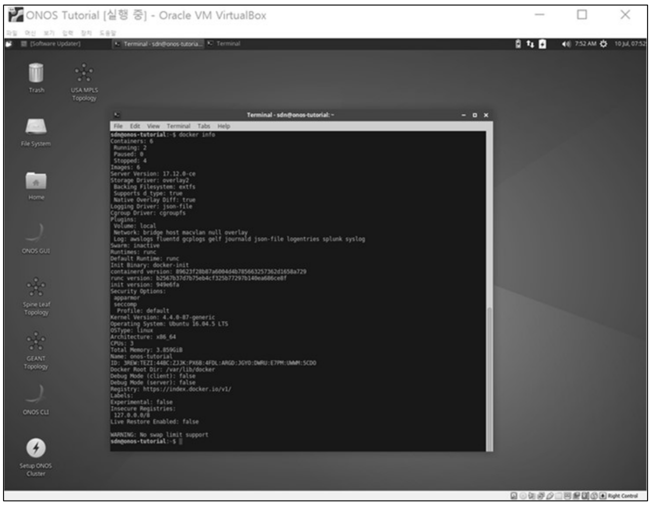
❖ **아이콘 확인**

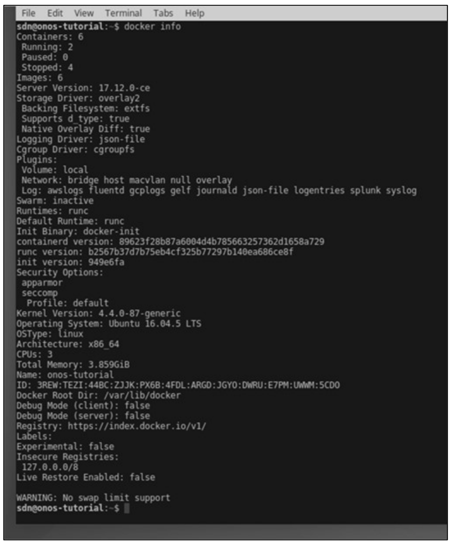
- **Check Topology (mininet: Spine Leaf, GEANT, USA MPLS)**
- **Check GUI and CLI**



VI. SDN CONTROLLER (ONOS)

❖ **Docker 확인**



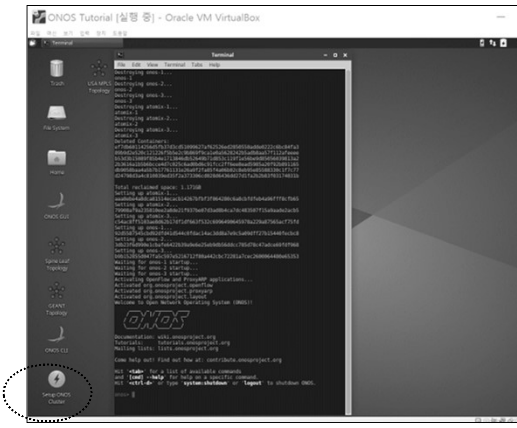


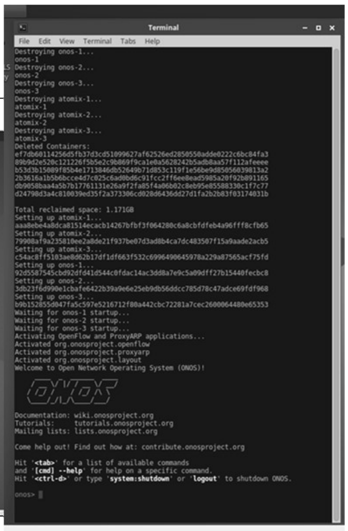
```
sdn@onos-tutorial:~$ docker info
Containers: 6
 Running: 2
 Paused: 0
 Stopped: 4
Images: 6
Server Version: 17.12.0-ce
Storage Driver: overlay2
 Backing Filesystem: extfs
 Supports d_type: true
 Native Overlay Diff: true
Logging Driver: json-file
Cgroup Driver: cgroupfs
Plugins:
 Volume: local
 Network: bridge host macvlan null overlay
 Log: awslogs fluentd gcplogs gelf journald json-file logentries splunk syslog
Swarm: inactive
Runtimes: runc
Default Runtime: runc
Init Binary: docker-init
containerd version: 89623f28b87a6004d4b785663257362d1658a729
runc version: b2567b37d7b75eb4cf325b77297b140ea686ce8f
init version: 949e6fa
Security Options:
 apparmor
 seccomp
  Profile: default
Kernel Version: 4.4.0-87-generic
Operating System: Ubuntu 16.04.5 LTS
OSType: linux
Architecture: x86_64
CPUs: 3
Total Memory: 3.859GiB
Name: onos-tutorial
ID: 3REW:TEZI:44BC:ZJJK:PX6B:4FDL:ARGD:JGYO:DWRU:E7PM:UWWM:5CDO
Docker Root Dir: /var/lib/docker
Debug Mode (client): false
Debug Mode (server): false
Registry: https://index.docker.io/v1/
Labels:
Experimental: false
Insecure Registries:
 127.0.0.0/8
Live Restore Enabled: false

WARNING: No swap limit support
sdn@onos-tutorial:~$
```

VI. SDN CONTROLLER (ONOS)

❖ **Setup ONOS Cluster**

- **Check Topology (mininet: Spine Leaf, GEANT, USA MPLS)**
- **Check GUI and CLI**
- **Setup ONOS Cluster**



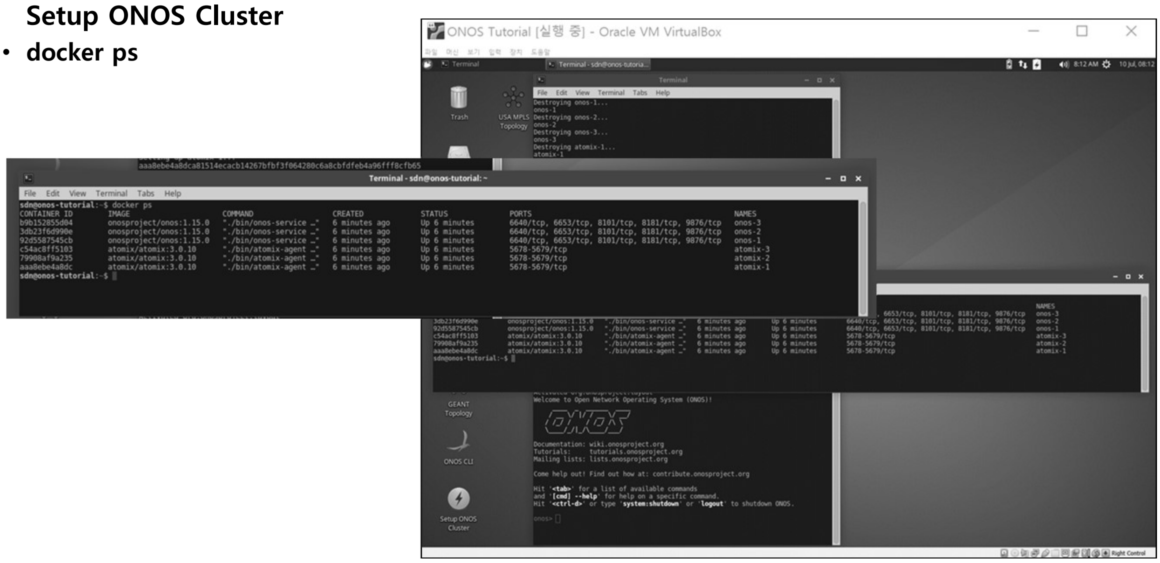


```
Destroying onos-1...
onos-1
Destroying onos-2...
onos-2
Destroying onos-3...
onos-3
Destroying atomix-1...
atomix-1
Destroying atomix-2...
atomix-2
Destroying atomix-3...
atomix-3
Deleted Containers:
ef7db60114256d5fb37d3cd51099627af62526ed2850550adde0222c6bc84fa3
89b9d2e520c121226f5b5e2c9b869f9ca1e0a5628242b5adb8aa57f112afeeee
b53d3b15089f85b4e1713846db52649b71d853c119f1e56be9d85056039813a2
2b3616a1b5b6bcce4d7c025c6ad0bd6c91fcc2ff6ee8ead5985a20f92b891165
db9058baa4a5b7b17761131e26a9f2fa85f4a06b02c8eb95e85588330c1f7c77
d24798d3a4c810039ed35f2a373306cd028d6436dd27d1fa2b2b83f03174031b

Total reclaimed space: 1.171GB
Setting up atomix-1...
aaa8ebe4a8dca81514ecacb14267bfbf3f064280c6a8cbfdfeb4a96fff8cfb65
Setting up atomix-2...
79908af9a235810ee2a8de21f937be07d3ad8b4ca7dc483507f15a9aade2acb5
Setting up atomix-3...
c54ac8ff5103ae8d62b17df1df663f532c6996490645978a229a87565acf75fd
Setting up onos-1...
92d5587545cbd92dfd41d544c0fdac14ac3dd8a7e9c5a09dff27b15440fecbc8
Setting up onos-2...
3db23f6d990e1cbafe6422b39a9e6e25eb9db56ddcc785d78c47adce69fdf968
Setting up onos-3...
b9b152855d047fa5c597e5216712f80a442cbc72281a7cec2600064480e65353
Waiting for onos-1 startup...
Waiting for onos-2 startup...
Waiting for onos-3 startup...
Activating OpenFlow and ProxyARP applications...
Activated org.onosproject.openflow
Activated org.onosproject.proxyarp
Activated org.onosproject.layout
Welcome to Open Network Operating System (ONOS)!

Documentation: wiki.onosproject.org
Tutorials:     tutorials.onosproject.org
Mailing lists: lists.onosproject.org

Come help out! Find out how at: contribute.onosproject.org

Hit '<tab>' for a list of available commands
and '[cmd] --help' for help on a specific command.
Hit '<ctrl-d>' or type 'system:shutdown' or 'logout' to shutdown ONOS.

onos>
```

VI. SDN CONTROLLER (ONOS)

❖ **Setup ONOS Cluster**

- **docker ps**



ONOS Tutorial [실행 중] - Oracle VM VirtualBox
Terminal - sdn@onos-tutorial: ~
File Edit View Terminal Tabs Help
Trash
USA MPLS Topology
GEANT Topology
ONOS CLI
Setup ONOS Cluster

```
sdn@onos-tutorial:~$ docker ps
CONTAINER ID        IMAGE                      COMMAND                  CREATED             STATUS              PORTS                                                   NAMES
b9b152855d04        onosproject/onos:1.15.0    "./bin/onos-service …"   6 minutes ago       Up 6 minutes        6640/tcp, 6653/tcp, 8101/tcp, 8181/tcp, 9876/tcp        onos-3
3db23f6d990e        onosproject/onos:1.15.0    "./bin/onos-service …"   6 minutes ago       Up 6 minutes        6640/tcp, 6653/tcp, 8101/tcp, 8181/tcp, 9876/tcp        onos-2
92d5587545cb        onosproject/onos:1.15.0    "./bin/onos-service …"   6 minutes ago       Up 6 minutes        6640/tcp, 6653/tcp, 8101/tcp, 8181/tcp, 9876/tcp        onos-1
c54ac8ff5103        atomix/atomix:3.0.10       "./bin/atomix-agent …"   6 minutes ago       Up 6 minutes        5678-5679/tcp                                           atomix-3
79908af9a235        atomix/atomix:3.0.10       "./bin/atomix-agent …"   6 minutes ago       Up 6 minutes        5678-5679/tcp                                           atomix-2
aaa8ebe4a8dc        atomix/atomix:3.0.10       "./bin/atomix-agent …"   6 minutes ago       Up 6 minutes        5678-5679/tcp                                           atomix-1
sdn@onos-tutorial:~$
```

```
Destroying onos-1...
onos-1
Destroying onos-2...
onos-2
Destroying onos-3...
onos-3
Destroying atomix-1...
atomix-1
```

```
Welcome to Open Network Operating System (ONOS)!

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Come help out! Find out how at: contribute.onosproject.org

Hit '<tab>' for a list of available commands
and '[cmd] --help' for help on a specific command.
Hit '<ctrl-d>' or type 'system:shutdown' or 'logout' to shutdown ONOS.

onos>
```
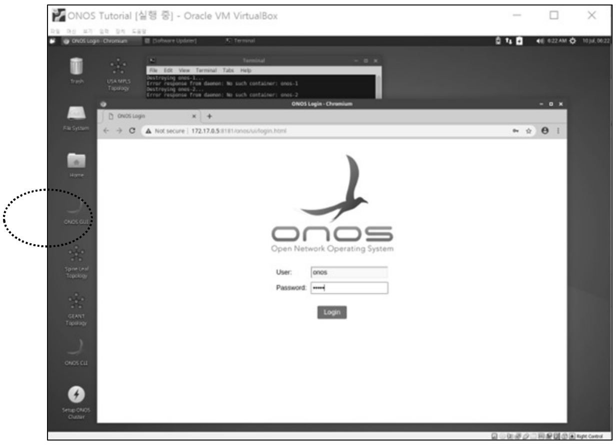

VI. SDN CONTROLLER (ONOS)

❖ **Launch ONOS GUI**

- **ONOS GUI**
- **로그인: Login as user onos with password rocks**



User: onos

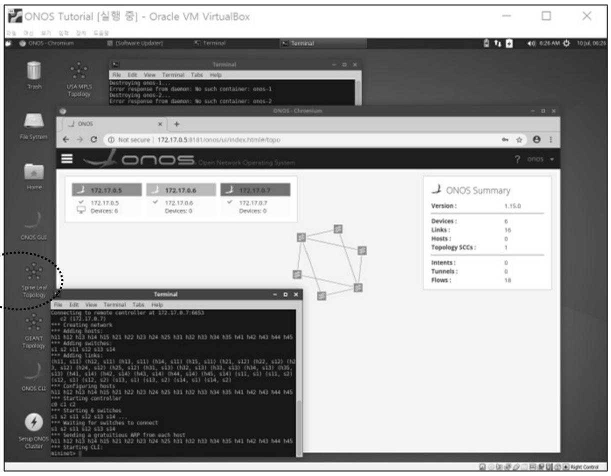
Password: •••••

```
Destroying onos-1...
Error response from daemon: No such container: onos-1
Destroying onos-2...
Error response from daemon: No such container: onos-2
```

VI. SDN CONTROLLER (ONOS)

❖ Select Leaf-Spine

- double click on the Spine Leaf Topology icon on your desktop
- Check mininet



ONOS Tutorial [실행 중] - Oracle VM VirtualBox

```
Destroying onos-1...
Error response from daemon: No such container: onos-1
Destroying onos-2...
Error response from daemon: No such container: onos-2
```

172.17.0.5:8181/onos/ui/index.html#/topo

172.17.0.5	172.17.0.6	172.17.0.7
172.17.0.5 Devices: 6	172.17.0.6 Devices: 0	172.17.0.7 Devices: 0

ONOS Summary

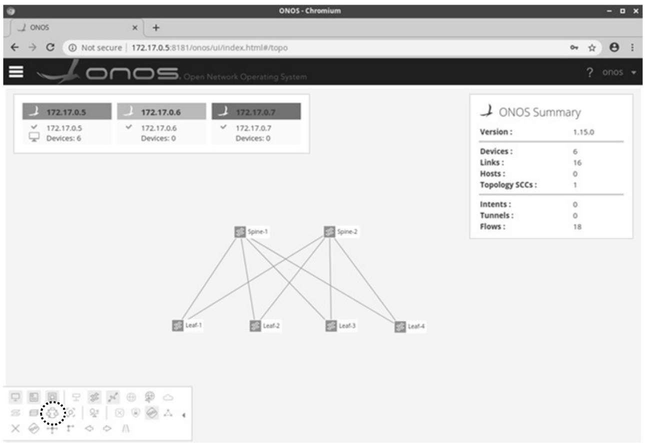
Version : 1.15.0
Devices : 6
Links : 16
Hosts : 0
Topology SCCs : 1
Intents : 0
Tunnels : 0
Flows : 18

```
Connecting to remote controller at 172.17.0.7:6653
   c2 (172.17.0.7)
*** Creating network
*** Adding hosts:
h11 h12 h13 h14 h15 h21 h22 h23 h24 h25 h31 h32 h33 h34 h35 h41 h42 h43 h44 h45
*** Adding switches:
s1 s2 s11 s12 s13 s14
*** Adding links:
(h11, s11) (h12, s11) (h13, s11) (h14, s11) (h15, s11) (h21, s12) (h22, s12) (h2
3, s12) (h24, s12) (h25, s12) (h31, s13) (h32, s13) (h33, s13) (h34, s13) (h35,
s13) (h41, s14) (h42, s14) (h43, s14) (h44, s14) (h45, s14) (s11, s1) (s11, s2)
(s12, s1) (s12, s2) (s13, s1) (s13, s2) (s14, s1) (s14, s2)
*** Configuring hosts
h11 h12 h13 h14 h15 h21 h22 h23 h24 h25 h31 h32 h33 h34 h35 h41 h42 h43 h44 h45
*** Starting controller
c0 c1 c2
*** Starting 6 switches
s1 s2 s11 s12 s13 s14 ...
*** Waiting for switches to connect
s1 s2 s11 s12 s13 s14
*** Sending a gratuitous ARP from each host
h11 h12 h13 h14 h15 h21 h22 h23 h24 h25 h31 h32 h33 h34 h35 h41 h42 h43 h44 h45
*** Starting CLI:
mininet>
```

VI. SDN CONTROLLER (ONOS)

❖ Topology View

- ‘L’ key to cycle between friendly labels, device ids and no labels.
- To toggle between showing and hiding hosts, you can press the ‘H’ key.



ONOS - Chromium

172.17.0.5:8181/onos/ui/index.html#/topo

172.17.0.5	172.17.0.6	172.17.0.7
172.17.0.5 Devices: 6	172.17.0.6 Devices: 0	172.17.0.7 Devices: 0

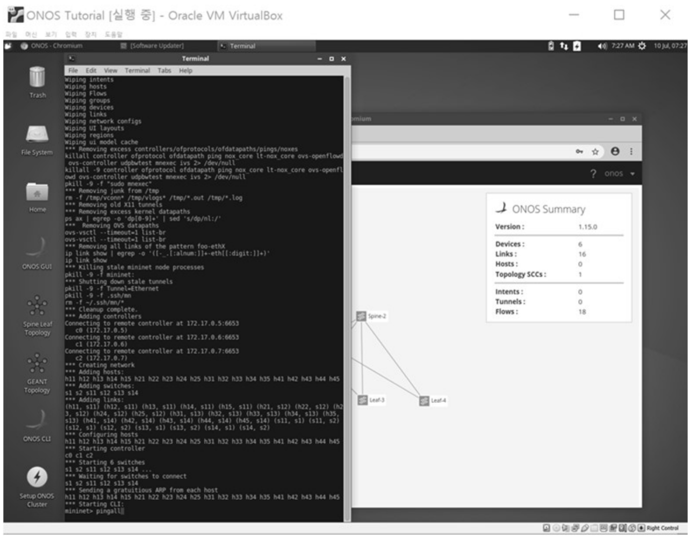
ONOS Summary

Version : 1.15.0
Devices : 6
Links : 16
Hosts : 0
Topology SCCs : 1
Intents : 0
Tunnels : 0
Flows : 18

VI. SDN CONTROLLER (ONOS)

❖ **Ping**

- **pingall (mininet)**



```
Wiping intents
Wiping hosts
Wiping Flows
Wiping groups
Wiping devices
Wiping links
Wiping network configs
Wiping UI layouts
Wiping regions
Wiping ui model cache
*** Removing excess controllers/ofprotocols/ofdatapaths/pings/noxes
killall controller ofprotocol ofdatapath ping nox_core lt-nox_core ovs-openflowd
 ovs-controller udpbwtest mnexec ivs 2> /dev/null
killall -9 controller ofprotocol ofdatapath ping nox_core lt-nox_core ovs-openfl
owd ovs-controller udpbwtest mnexec ivs 2> /dev/null
pkill -9 -f "sudo mnexec"
*** Removing junk from /tmp
rm -f /tmp/vconn* /tmp/vlogs* /tmp/*.out /tmp/*.log
*** Removing old X11 tunnels
*** Removing excess kernel datapaths
ps ax | egrep -o 'dp[0-9]+' | sed 's/dp/nl:/'
***  Removing OVS datapaths
ovs-vsctl --timeout=1 list-br
ovs-vsctl --timeout=1 list-br
*** Removing all links of the pattern foo-ethX
ip link show | egrep -o '([-_.[:alnum:]]+-eth[[:digit:]]+)'
ip link show
*** Killing stale mininet node processes
pkill -9 -f mininet:
*** Shutting down stale tunnels
pkill -9 -f Tunnel=Ethernet
pkill -9 -f .ssh/mn
rm -f ~/.ssh/mn/*
*** Cleanup complete.
*** Adding controllers
Connecting to remote controller at 172.17.0.5:6653
   c0 (172.17.0.5)
Connecting to remote controller at 172.17.0.6:6653
   c1 (172.17.0.6)
Connecting to remote controller at 172.17.0.7:6653
   c2 (172.17.0.7)
*** Creating network
*** Adding hosts:
h11 h12 h13 h14 h15 h21 h22 h23 h24 h25 h31 h32 h33 h34 h35 h41 h42 h43 h44 h45
*** Adding switches:
s1 s2 s11 s12 s13 s14
*** Adding links:
(h11, s11) (h12, s11) (h13, s11) (h14, s11) (h15, s11) (h21, s12) (h22, s12) (h2
3, s12) (h24, s12) (h25, s12) (h31, s13) (h32, s13) (h33, s13) (h34, s13) (h35,
s13) (h41, s14) (h42, s14) (h43, s14) (h44, s14) (h45, s14) (s11, s1) (s11, s2)
(s12, s1) (s12, s2) (s13, s1) (s13, s2) (s14, s1) (s14, s2)
*** Configuring hosts
h11 h12 h13 h14 h15 h21 h22 h23 h24 h25 h31 h32 h33 h34 h35 h41 h42 h43 h44 h45
*** Starting controller
c0 c1 c2
*** Starting 6 switches
s1 s2 s11 s12 s13 s14 ...
*** Waiting for switches to connect
s1 s2 s11 s12 s13 s14
*** Sending a gratuitious ARP from each host
h11 h12 h13 h14 h15 h21 h22 h23 h24 h25 h31 h32 h33 h34 h35 h41 h42 h43 h44 h45
*** Starting CLI:
mininet> pingall
```

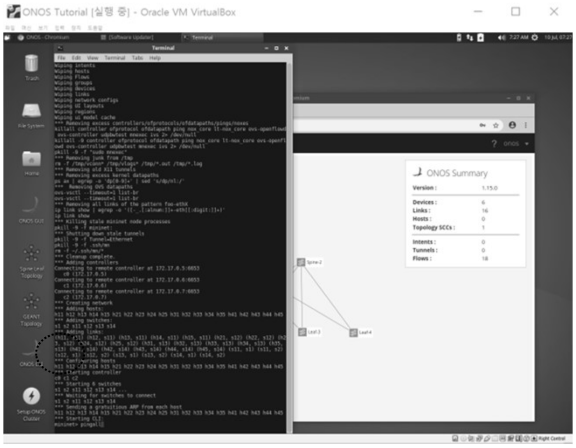
ONOS Summary

Version :	1.15.0
Devices :	6
Links :	16
Hosts :	0
Topology SCCs :	1
Intents :	0
Tunnels :	0
Flows :	18

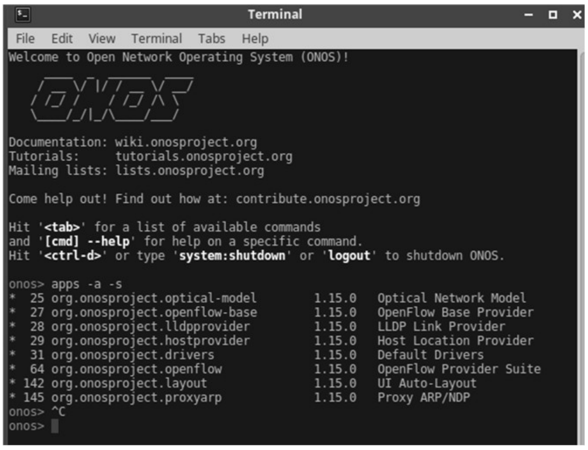
VI. SDN CONTROLLER (ONOS)

❖ **CLI**

- **pingall (mininet without 'Switch' Application @ ONOS)**
- **apps -a -s (ONOS CLI)**



ONOS Summary: Version : 1.15.0; Devices : 6; Links : 16; Hosts : 0; Topology SCCs : 1; Intents : 0; Tunnels : 0; Flows : 18
mininet> pingall



```
Welcome to Open Network Operating System (ONOS)!

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Mailing lists: lists.onosproject.org

Come help out! Find out how at: contribute.onosproject.org

Hit '<tab>' for a list of available commands
and '[cmd] --help' for help on a specific command.
Hit '<ctrl-d>' or type 'system:shutdown' or 'logout' to shutdown ONOS.

onos> apps -a -s
*  25 org.onosproject.optical-model       1.15.0   Optical Network Model
*  27 org.onosproject.openflow-base       1.15.0   OpenFlow Base Provider
*  28 org.onosproject.lldpprovider        1.15.0   LLDP Link Provider
*  29 org.onosproject.hostprovider        1.15.0   Host Location Provider
*  31 org.onosproject.drivers             1.15.0   Default Drivers
*  64 org.onosproject.openflow            1.15.0   OpenFlow Provider Suite
* 142 org.onosproject.layout              1.15.0   UI Auto-Layout
* 145 org.onosproject.proxyarp            1.15.0   Proxy ARP/NDP
onos> ^C
onos>
```
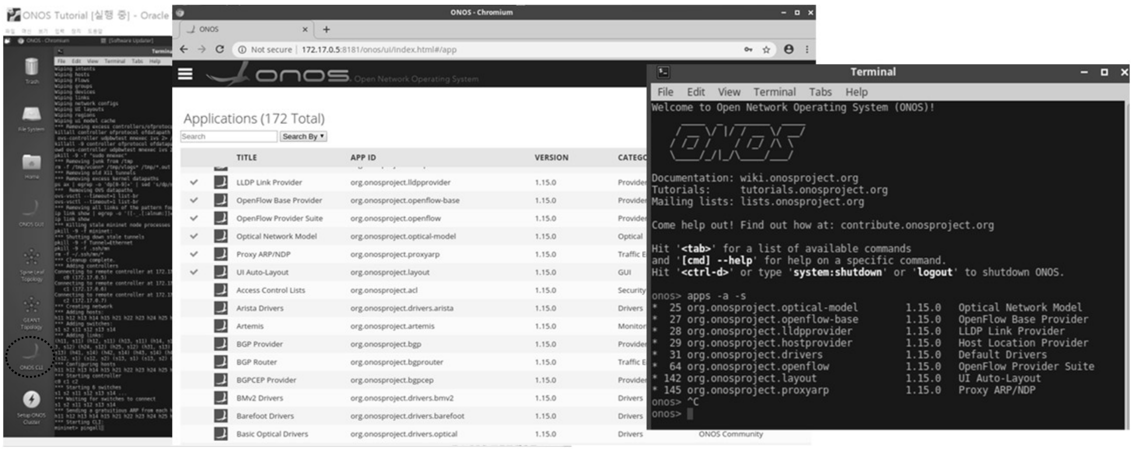

VI. SDN CONTROLLER (ONOS)

❖ Applications

- apps -a -s (ONOS CLI)
- Applications (GUI)



ONOS Tutorial [실행 중] - Oracle
ONOS - Chromium
ONOS
Not secure | 172.17.0.5:8181/onos/ui/index.html#/app
onos. Open Network Operating System
Search
Search By ▾

Applications (172 Total)

	TITLE	APP ID	VERSION	CATEGO
✓	LLDP Link Provider	org.onosproject.lldpprovider	1.15.0	Provider
✓	OpenFlow Base Provider	org.onosproject.openflow-base	1.15.0	Provider
✓	OpenFlow Provider Suite	org.onosproject.openflow	1.15.0	Provider
✓	Optical Network Model	org.onosproject.optical-model	1.15.0	Optical
✓	Proxy ARP/NDP	org.onosproject.proxyarp	1.15.0	Traffic E
✓	UI Auto-Layout	org.onosproject.layout	1.15.0	GUI
	Access Control Lists	org.onosproject.acl	1.15.0	Security
	Arista Drivers	org.onosproject.drivers.arista	1.15.0	Drivers
	Artemis	org.onosproject.artemis	1.15.0	Monitor
	BGP Provider	org.onosproject.bgp	1.15.0	Provider
	BGP Router	org.onosproject.bgprouter	1.15.0	Traffic E
	BGPCEP Provider	org.onosproject.bgpcep	1.15.0	Provider
	BMv2 Drivers	org.onosproject.drivers.bmv2	1.15.0	Drivers
	Barefoot Drivers	org.onosproject.drivers.barefoot	1.15.0	Drivers
	Basic Optical Drivers	org.onosproject.drivers.optical	1.15.0	Drivers

```
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and '[cmd] --help' for help on a specific command.
Hit '<ctrl-d>' or type 'system:shutdown' or 'logout' to shutdown ONOS.

onos> apps -a -s
*  25 org.onosproject.optical-model       1.15.0   Optical Network Model
*  27 org.onosproject.openflow-base       1.15.0   OpenFlow Base Provider
*  28 org.onosproject.lldpprovider        1.15.0   LLDP Link Provider
*  29 org.onosproject.hostprovider        1.15.0   Host Location Provider
*  31 org.onosproject.drivers             1.15.0   Default Drivers
*  64 org.onosproject.openflow            1.15.0   OpenFlow Provider Suite
* 142 org.onosproject.layout              1.15.0   UI Auto-Layout
* 145 org.onosproject.proxyarp            1.15.0   Proxy ARP/NDP
onos> ^C
onos>
```
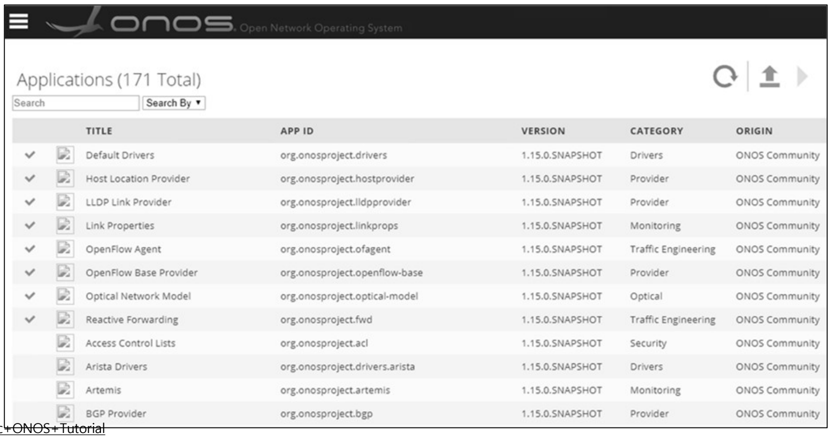

VI. SDN CONTROLLER (ONOS)

❖ Start 'Switch' App

- Check reactive forward (GUI)
- app activate org.onosproject.fwd (ONOS CLI)



Applications (171 Total)

	TITLE	APP ID	VERSION	CATEGORY	ORIGIN
✓	Default Drivers	org.onosproject.drivers	1.15.0.SNAPSHOT	Drivers	ONOS Community
✓	Host Location Provider	org.onosproject.hostprovider	1.15.0.SNAPSHOT	Provider	ONOS Community
✓	LLDP Link Provider	org.onosproject.lldpprovider	1.15.0.SNAPSHOT	Provider	ONOS Community
✓	Link Properties	org.onosproject.linkprops	1.15.0.SNAPSHOT	Monitoring	ONOS Community
✓	OpenFlow Agent	org.onosproject.ofagent	1.15.0.SNAPSHOT	Traffic Engineering	ONOS Community
✓	OpenFlow Base Provider	org.onosproject.openflow-base	1.15.0.SNAPSHOT	Provider	ONOS Community
✓	Optical Network Model	org.onosproject.optical-model	1.15.0.SNAPSHOT	Optical	ONOS Community
✓	Reactive Forwarding	org.onosproject.fwd	1.15.0.SNAPSHOT	Traffic Engineering	ONOS Community
	Access Control Lists	org.onosproject.acl	1.15.0.SNAPSHOT	Security	ONOS Community
	Arista Drivers	org.onosproject.drivers.arista	1.15.0.SNAPSHOT	Drivers	ONOS Community
	Artemis	org.onosproject.artemis	1.15.0.SNAPSHOT	Monitoring	ONOS Community
	BGP Provider	org.onosproject.bgp	1.15.0.SNAPSHOT	Provider	ONOS Community

Source: https://wiki.onosproject.org/display/ONOS/Basic+ONOS+Tutorial

VI. SDN CONTROLLER (ONOS)

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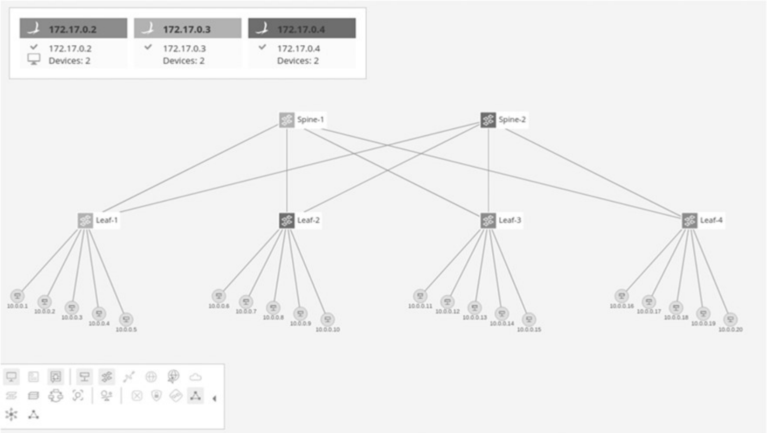
❖ **Host View**

- **'H' key**
- **onos> topo-layout access**



172.17.0.2
✓ 172.17.0.2
Devices: 2

172.17.0.3
✓ 172.17.0.3
Devices: 2

172.17.0.4
✓ 172.17.0.4
Devices: 2

JS Lab

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VI. SDN CONTROLLER (ONOS)

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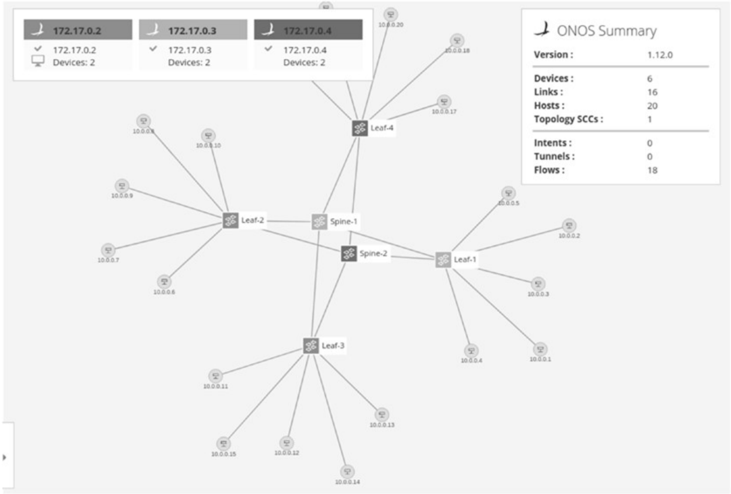
❖ **Node 구성 요소**

- **Master 구성 요소**



172.17.0.2
✓ 172.17.0.2
Devices: 2

172.17.0.3
✓ 172.17.0.3
Devices: 2

172.17.0.4
✓ 172.17.0.4
Devices: 2

ONOS Summary

Version :	1.12.0
Devices :	6
Links :	16
Hosts :	20
Topology SCCs :	1
Intents :	0
Tunnels :	0
Flows :	18

JS Lab

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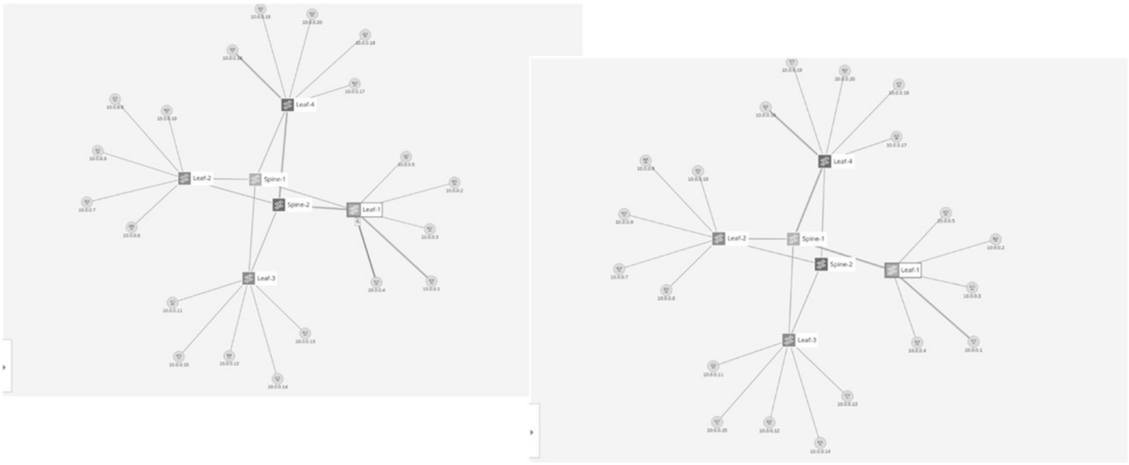
VI. SDN CONTROLLER (ONOS)

❖ Topology Operations

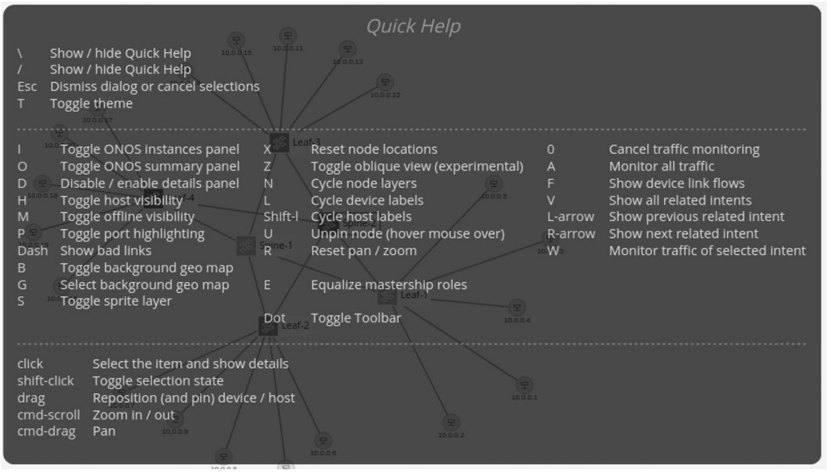
- **Topology Operations**



VI. SDN CONTROLLER (ONOS)

❖ Help

- **Shortcut Keys**



Quick Help

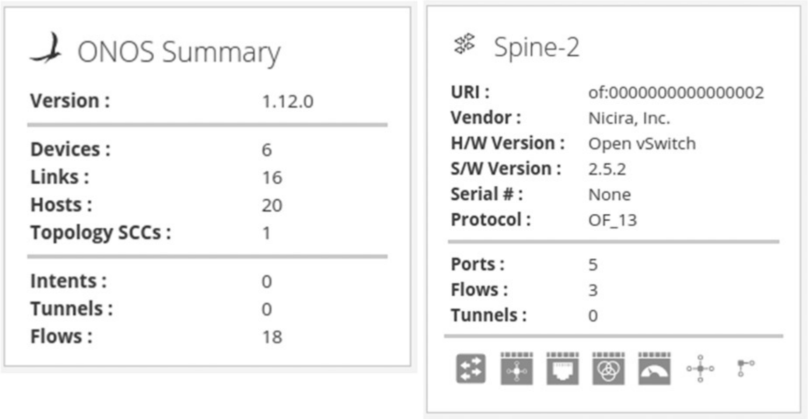
\	Show / hide Quick Help
/	Show / hide Quick Help
Esc	Dismiss dialog or cancel selections
T	Toggle theme

I	Toggle ONOS instances panel	X	Reset node locations	0	Cancel traffic monitoring
O	Toggle ONOS summary panel	Z	Toggle oblique view (experimental)	A	Monitor all traffic
D	Disable / enable details panel	N	Cycle node layers	F	Show device link flows
H	Toggle host visibility	L	Cycle device labels	V	Show all related intents
M	Toggle offline visibility	Shift-l	Cycle host labels	L-arrow	Show previous related intent
P	Toggle port highlighting	U	Unpin node (hover mouse over)	R-arrow	Show next related intent
Dash	Show bad links	R	Reset pan / zoom	W	Monitor traffic of selected intent
B	Toggle background geo map				
G	Select background geo map	E	Equalize mastership roles		
S	Toggle sprite layer				
		Dot	Toggle Toolbar		

click	Select the item and show details
shift-click	Toggle selection state
drag	Reposition (and pin) device / host
cmd-scroll	Zoom in / out
cmd-drag	Pan

VI. SDN CONTROLLER (ONOS)

- panes
  - Overview pane
  - Details pane



ONOS Summary

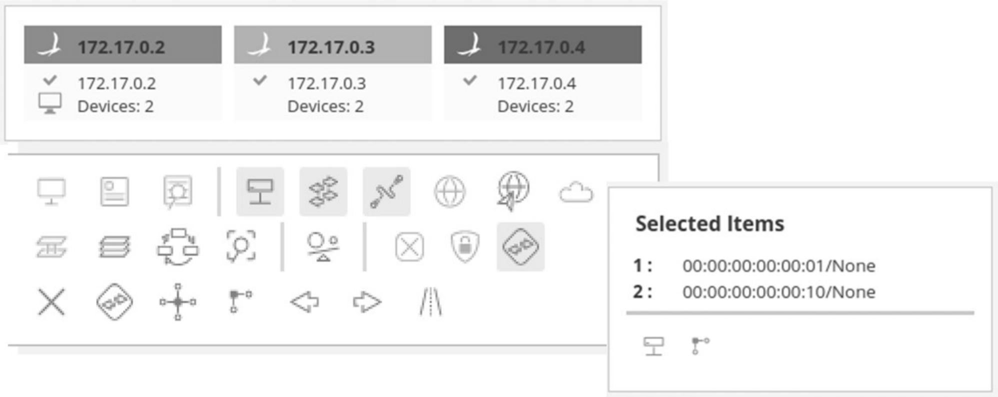
Version :	1.12.0
Devices :	6
Links :	16
Hosts :	20
Topology SCCs :	1
Intents :	0
Tunnels :	0
Flows :	18

Spine-2

URI :	of:0000000000000002
Vendor :	Nicira, Inc.
H/W Version :	Open vSwitch
S/W Version :	2.5.2
Serial # :	None
Protocol :	OF_13
Ports :	5
Flows :	3
Tunnels :	0

VI. SDN CONTROLLER (ONOS)

- Node 구성 요소
  - Instances pane
  - Toolbar pane
  - Intent



172.17.0.2	172.17.0.3	172.17.0.4
✓ 172.17.0.2 Devices: 2	✓ 172.17.0.3 Devices: 2	✓ 172.17.0.4 Devices: 2

Selected Items

1 : 00:00:00:00:00:01/None
2 : 00:00:00:00:00:10/None

VI. SDN CONTROLLER (ONOS)

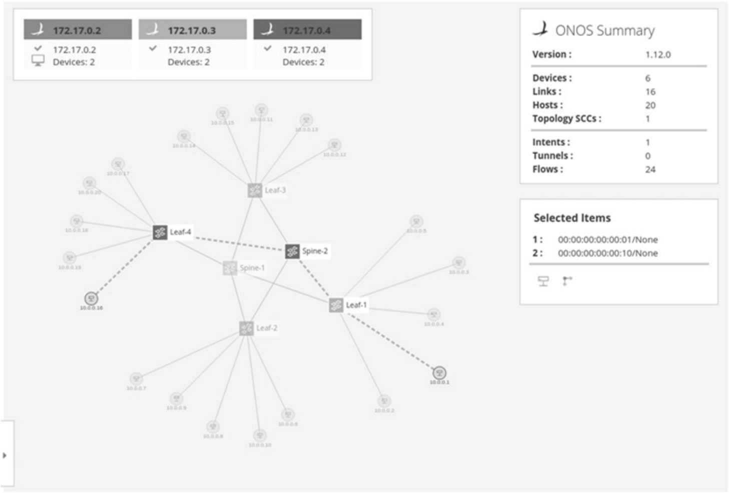
❖ **Intent Operations (선택)**

- **Intent command (CLI)**
  - o onos> add-host-intent 00:00:00:00:00:01/None 00:00:00:00:00:10/None
  - o Host to Host intent submitted:
  - o HostToHostIntent{id=0x0, key=0x0, appId=DefaultApplicationId{id=2, name=org.onosproject.cli}, priority=100, resources=[00:00:00:00:00:01/None, 00:00:00:00:00:10/None], selector=DefaultTrafficSelector{criteria=[]}, treatment=DefaultTrafficTreatment{immediate=[NOACTION], deferred=[], transition=None, meter=[], cleared=false, StatTrigger=null, metadata=null}, constraints=[LinkTypeConstraint{inclusive=false, types=[OPTICAL]}], resourceGroup=null, one=00:00:00:00:00:01/None, two=00:00:00:00:00:10/None}
  - o onos> app deactivate fwd
  - o Deactivated org.onosproject.fwd

  - o mininet> link s2 s11 down
  - o mininet> link s2 s11 up
  - o mininet> bgIperf h11 h41
  - o mininet> xterm hxx hyy hzz

VI. SDN CONTROLLER (ONOS)

❖ **Topology View for Intent**



172.17.0.2 ✓ 172.17.0.2 Devices: 2

172.17.0.3 ✓ 172.17.0.3 Devices: 2

172.17.0.4 ✓ 172.17.0.4 Devices: 2

ONOS Summary

Version : 1.12.0

Devices : 6
Links : 16
Hosts : 20
Topology SCCs : 1

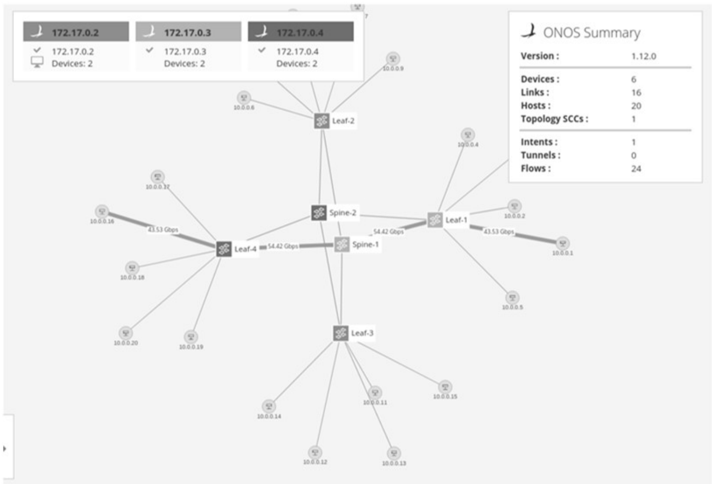
Intents : 1
Tunnels : 0
Flows : 24

Selected Items

1 : 00:00:00:00:00:01/None
2 : 00:00:00:00:00:10/None

VI. SDN CONTROLLER (ONOS)

- **Topology View for Intent**
  - **Show all traffic: Press 'A' key**



172.17.0.2	172.17.0.2 Devices: 2
172.17.0.3	172.17.0.3 Devices: 2
172.17.0.4	172.17.0.4 Devices: 2

ONOS Summary

Version :	1.12.0
Devices :	6
Links :	16
Hosts :	20
Topology SCCs :	1
Intents :	1
Tunnels :	0
Flows :	24

THANK YOU