5G 데스트베드 (시연/실습)

(v3.0 2023)

2023년 4월

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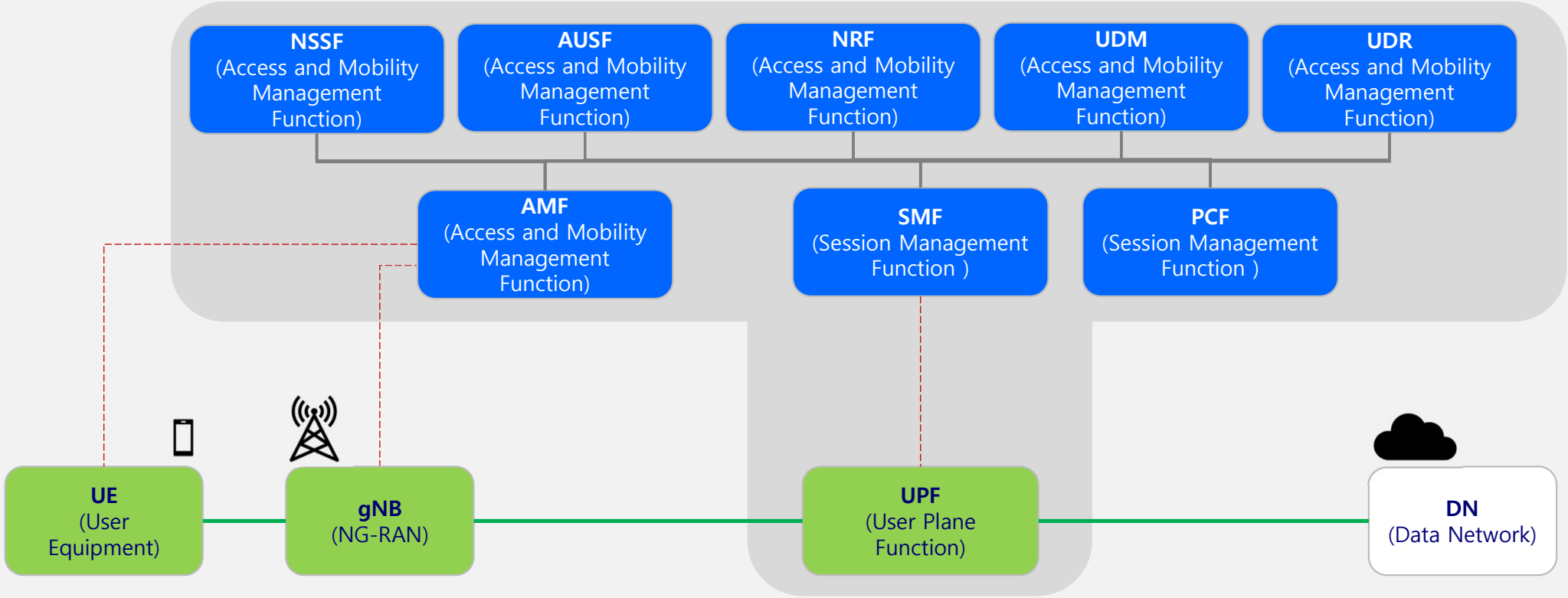
I. 개요


5 VM
VM1 for 5C Core
VM6 for Router
VM3 for UEs
VM2 for gNB
VM4 for UPF1 (Internet)
VM5 for UPF2 (IMS)
UE Whitebox
gNB @ Open SDR
UE Whitebox
상용 gNB
2 VM
UE/gNB
5G Core
Cloud Native

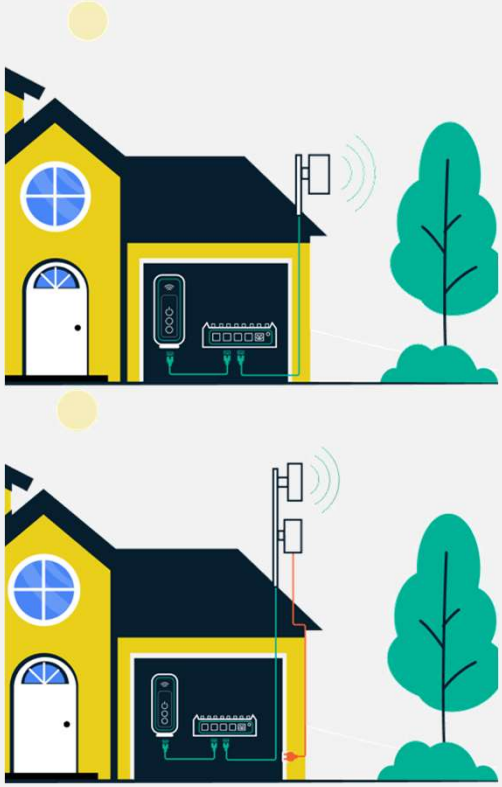
I. 개요

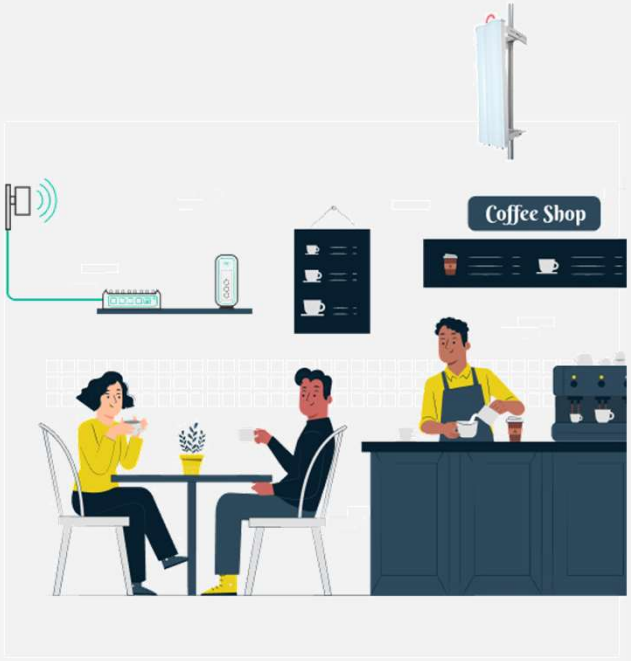
❖ 5G Network 기능 구성



I. 개요

❖ CBRS 사용 5G Core 오픈소스 기반 제조사(예): 리눅스재단의 Magma 사용 'FreedomFI'





Source: https://freedomfi.com/catalog/

CBRS 또는 시민 광대역 라디오 서비스는 3.5GHz 대역("밴드 48")의 150MHz 스펙트럼(3.55~3.7GHz) 이다.
CBRS는 150MHz(3.55~3.7GHz)의 미국 전용 스펙트럼이며 사설 모바일 네트워크에 사용할 수 있다.

I. 개요

❖ Comparisons for Open SDR

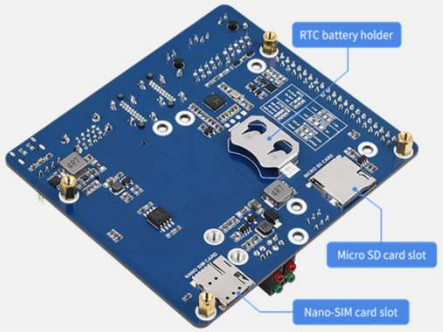
	HackRF One	Ettus B200	Ettus B210	BladeRF x40	RTL-SDR	LimeSDR
Frequency Range	1MHz-6GHz	70MHz-6GHz	70MHz-6GHz	300MHz-3.8GHz	22MHz-2.2GHz	100kHz-3.8GHz
RF Bandwidth	20MHz	61.44MHz	61.44MHz	40MHz	3.2MHz	61.44MHz
Sample Depth	8 bits	12 bits	12 bits	12 bits	8 bits	12 bits
Sample Rate	20MSPS	61.44MSPS	61.44MSPS	40MSPS	3.2MSPS	61.44MSPS (Limited by USB 3.0 data rate)
Transmitter Channels	1	1	2	1	0	2
Receivers	1	1	2	1	1	2
Duplex	Half	Full	Full	Full	N/A	Full
Interface	USB 2.0	USB 3.0	USB 3.0	USB 3.0	USB 2.0	USB 3.0
Programmable Logic Gates	64 macrocell CPLD	75k	100k	40k (115k avail)	N/A	40k
Chipset	MAX5864, MAX2837, RFFC5072	AD9364	AD9361	LMS6002M	RTL2832U	LMS7002M
Open Source	Full	Schematic, Firmware	Schematic, Firmware	Schematic, Firmware	No	Full
Oscillator Precision	+/-20ppm	+/-2ppm	+/-2ppm	+/-1ppm	?	+/-1ppm initial, +/-4ppm stable
Transmit Power	-10dBm+ (15dBm @ 2.4GHz)	10dBm+	10dBm+	6dBm	N/A	0 to 10dBm (depending on frequency)
Price ('23. 04)	₩ 206,577	₩ 805,646	₩ 1,262,499	₩ 865,133	₩ 45,831	₩ 969,759

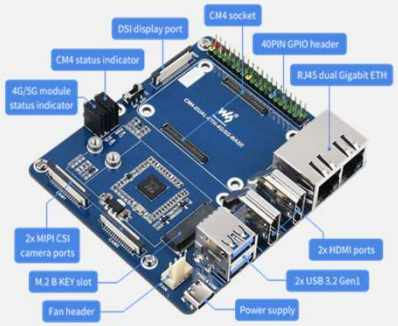



I. 개요

❖ 5G/4G Mini-Computer: CM4-DUAL-ETH-4G/5G-BASE

- **Waveshare CM4-DUAL-ETH-4G/5G-BASE**





Source: https://www.waveshare.com/cm4-dual-eth-4g-5g-base.htm

I. 개요

❖ 5G/4G Mini-Computer: SIM8200EA-M2 5G HA

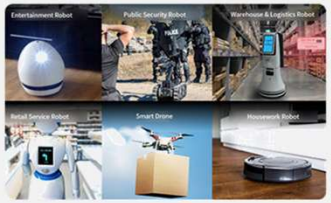
- SIM8200EA-M2 함께 제공, 지원 5G/4G/3G, 지원 5G SA 및 NSA
- 라즈베리 파이 SIM8200EA-M2 5G HAT 안테나 5G/4G/3G 지원 스냅드래곤 X55 온보드 멀티 모드 멀티 밴드

▲ Connecting Raspberry Pi to Internet

NETWORKED MEDICAL TREATMENT

INTELLIGENT AGRICULTURE

SMART CITY



SMART ROBOTS

Source: https://ko.aliexpress.com/store/722716?spm=a2g0o.detail.100005.1.544371dbwNQAUb

I. 개요

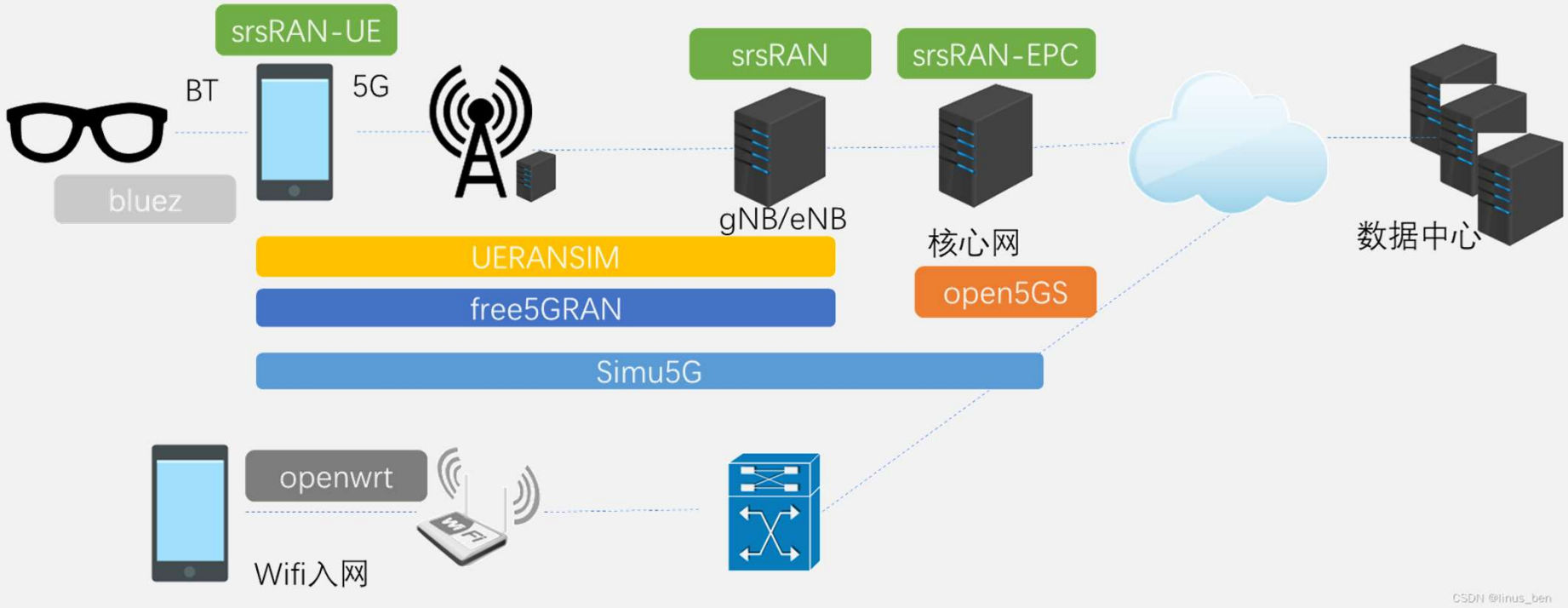
❖ Quectel 5G @ MS Azure

- Quectel RM500-GL 5G 모뎀을 사용하여 5G 또는 LTE를 통해 Azure Percept DK 연결

https://docs.microsoft.com/ko-kr/azure/azure-percept/connect-over-cellular-usb-quectel

I. 개요

❖ 5G Core 오픈소스 비교: Magma, Open5GS, Free5GC



Source: https://icode.best/i/15410850088842?fbclid=IwAR1YIChYXMxuCVki9tPVD_usVW44d2k-0SlhOjYHoguClrjnVw53Fq6R9bw

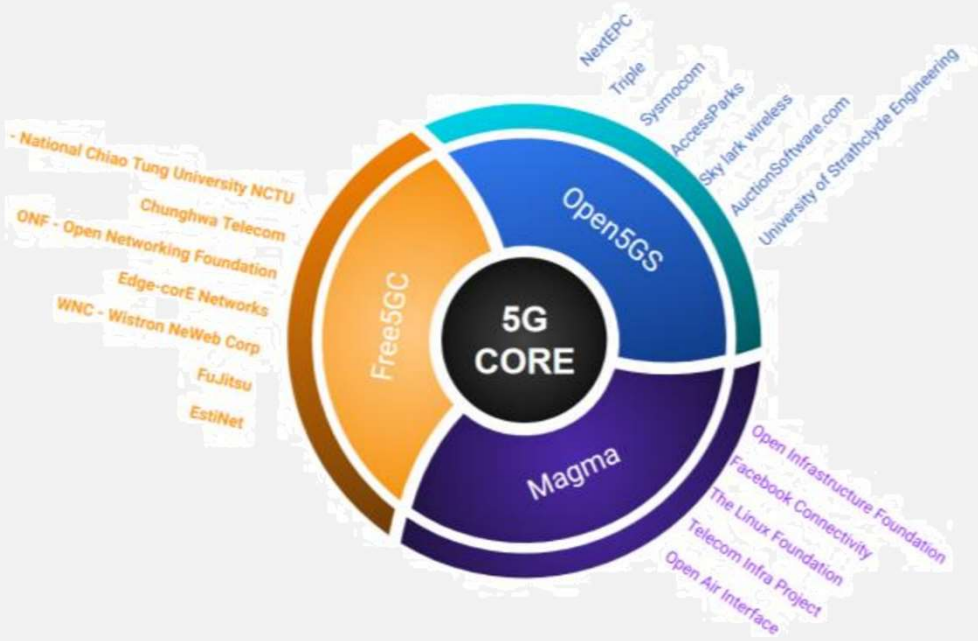
I. 개요

❖ 5G Core 오픈소스 비교: Magma, Open5GS, Free5GC

5G 코어 구현을 위한 프레임워크 비교 분석 (2021)

TABLE I. ELEMENTS NECESSARY TO DEPLOY

Magma	Open5GS	Free5GC
Docker/Container + bare metal	Docker/Container	Virtual Machine



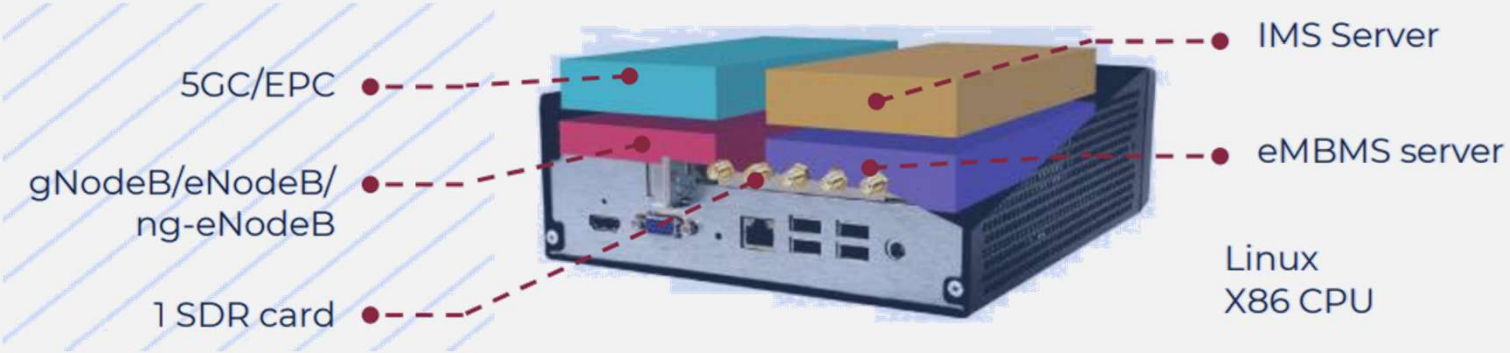
핵심 5G 개발의 주요 멤버

Source: 2021 International Conference on Information Science and Communications Technologies (ICISCT) | 978-1-6654-3258-0/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICISCT52966.2021.9670414

I. 개요

❖ AMARI Callbox mini

- Supported number of cells 1
- Number of active UEs Up to 500 UEs
- MIMO 2x2
- 200 Mbps (DL), 75 Mbps (UL)



Source: https://www.amarisoft.com/products/test-measurements/amari-lte-callbox/

I. 개요

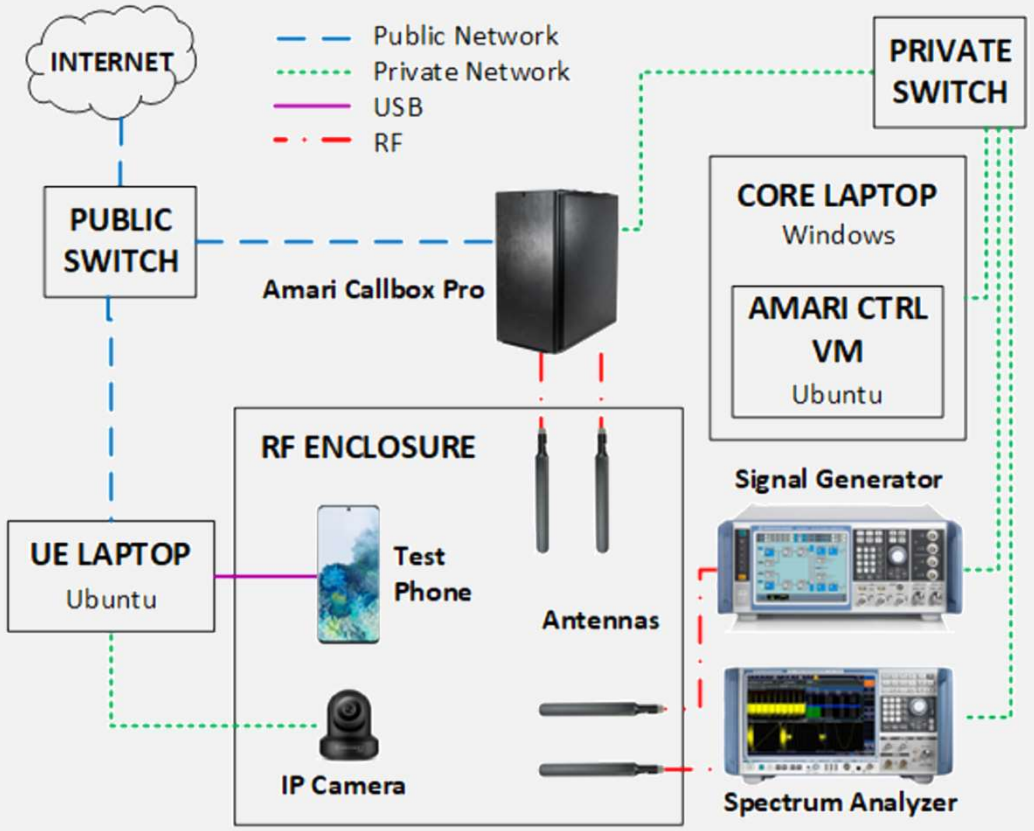
❖ Amarisoft UE Simbox

- Supported number of cells 1
- Number of active UEs Up to 1000 UEs
- MIMO 4x4 (500MHz~6GHz)
- 800 Mbps (DL), 150 Mbps (UL)

Source: https://www.amarisoft.com/products/test-measurements/amari-ue-simbox/

I. 개요

❖ Overview of Indoor System Architecture (IEEE)

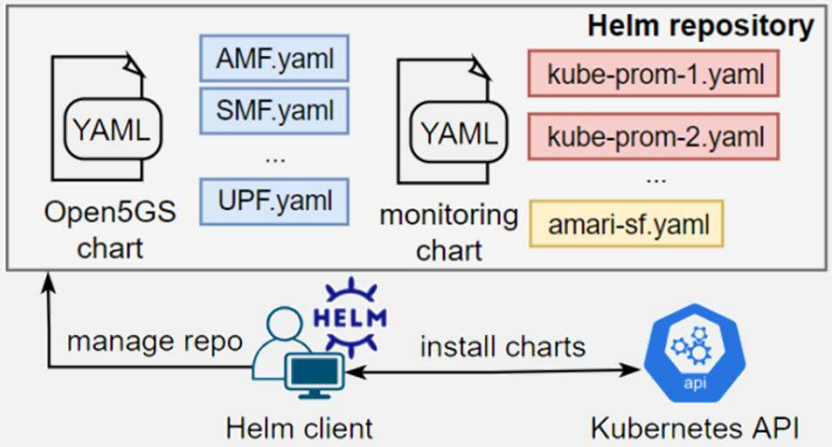


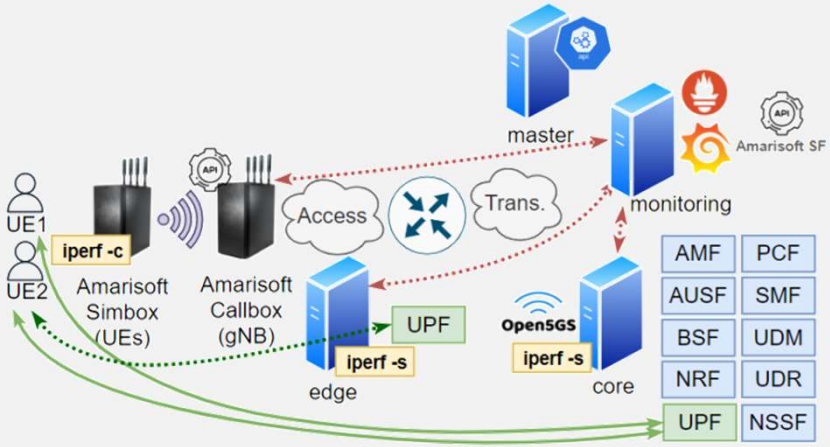
Source: Development of a Data-Driven Mobile 5G Testbed: Platform for Experimental Research (2021 IEEE International Mediterranean Conference on Communications and Networking)

I. 개요

❖ **Cloud-native 5G 시험 플랫폼 (예): over-the-air transmissions and end-to-end monitoringof active UEs Up to 500 UEs**

- **Helm and Kubernetes flowchart:** Open5GS 차트는 파란색의 NF 템플릿(예: AMF)으로 구성되어 있는 반면, 모니터링 차트에는 빨간색의 kube-Prometheus용 템플릿과 노란색의 Amarisoft 샘플링 기능이 포함되어 있다.
- **MEC-enabled 5G testbed:** 데이터 플레인은 녹색으로 표시했다. (MEC 데이터 플레인의 경우 점선 화살표). 모니터링 연결은 빨간색 점선 화살표로 표시했다.

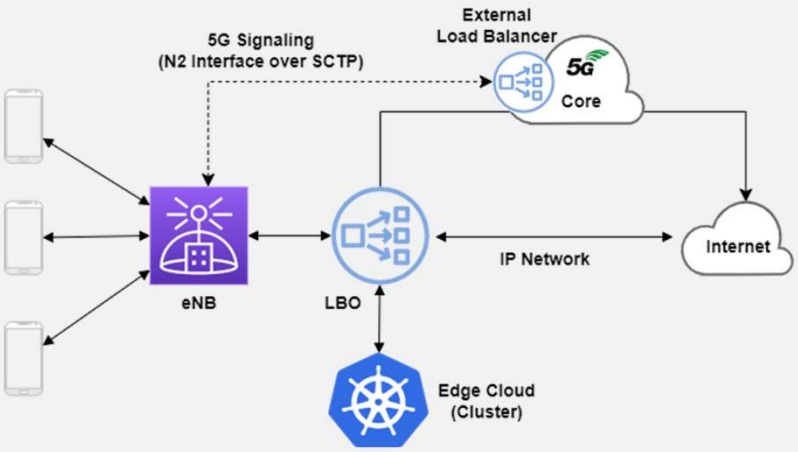


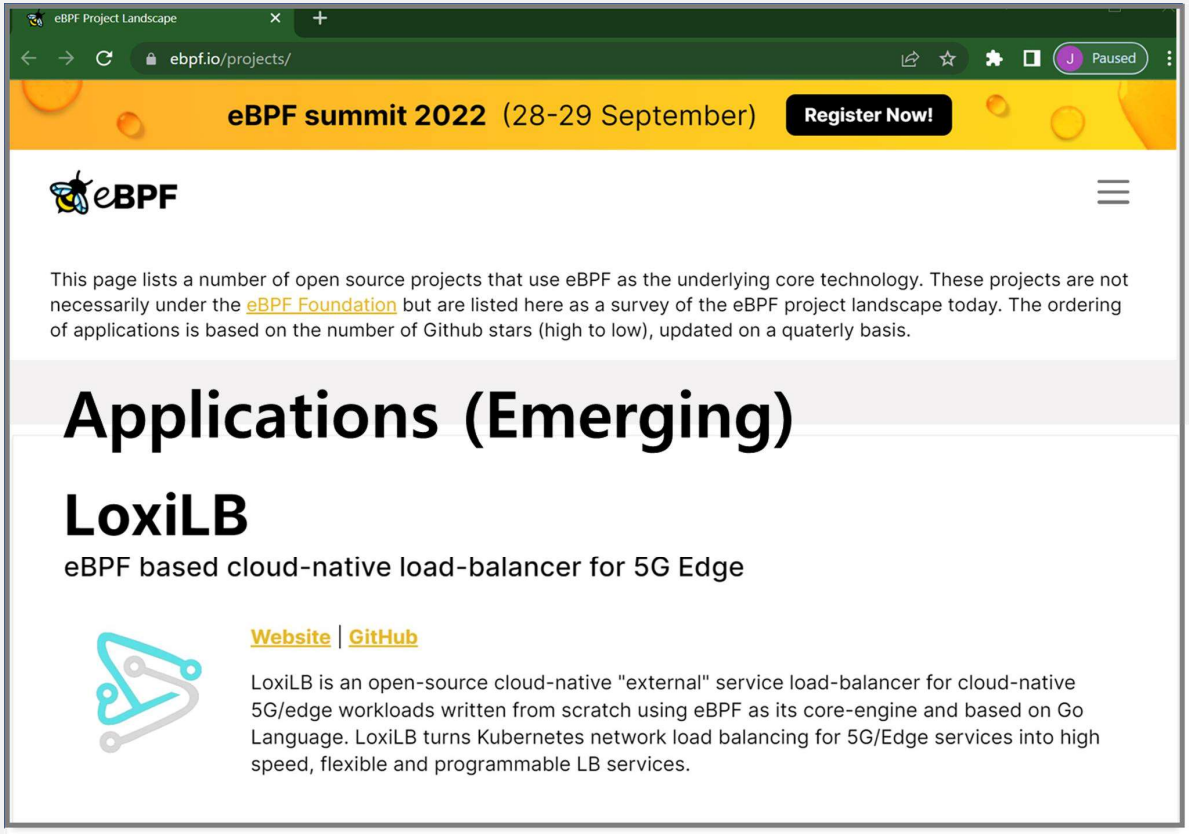


Source: https://arxiv.org/pdf/2207.11936.pdf?fbclid=IwAR2CjT8A2FlzQl9BXxv6h3TO-SjZclxjj8nr6XhNnVMmywjTKe3PGhsD1_M

I. 개요

❖ 5G Edge/LB





Source: https://www.loxilb.io/

Source: https://ebpf.io/applications/?fbclid=IwAR3ZUv1TitcEgo1Pag8dpluaTwQdRHEYWcQW0kpuqLHtXuFUlOpT63Q37Jw

I. 개요

❖ 5G 테스트베드 환경

I. 개요

❖ LTE and NR Frequency Band List (FR1, FR2)

FR1

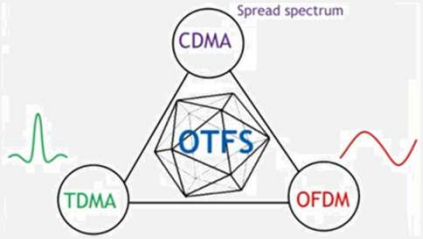
LTE Operating Band	NR Operating Band	Uplink Low	Uplink High	Downlink Low	Downlink High	Band Gap (MHz)	Duplex Mode
1	n1	1920 MHz	1980 MHz	2110 MHz	2170 MHz	130.00	FDD
2	n2	1850 MHz	1910 MHz	1930 MHz	1990 MHz	20	FDD
3	n3	1710 MHz	1785 MHz	1805 MHz	1880 MHz	20	FDD
4		1710 MHz	1755 MHz	2110 MHz	2155 MHz	355	FDD
5	n5	824 MHz	849 MHz	869 MHz	894MHz	20	FDD
7	n7	2500 MHz	2570 MHz	2620 MHz	2690 MHz	50	FDD
8	n8	880 MHz	915 MHz	925 MHz	960 MHz	10	FDD
9		1749.9 MHz	1784.9 MHz	1844.9 MHz	1879.9 MHz	600	FDD
10		1710 MHz	1770 MHz	2110 MHz	2170 MHz	340	FDD
11		1427.9 MHz	1447.9 MHz	1475.9 MHz	1495.9 MHz	280	FDD
12	n12	699 MHz	716 MHz	729 MHz	746 MHz	13	FDD
13		777 MHz	787 MHz	746 MHz	756 MHz	41	FDD
14	n14	788 MHz	798 MHz	758 MHz	768 MHz	40	FDD
17		704 MHz	716 MHz	734 MHz	746 MHz	18	FDD
18	n18	815 MHz	830 MHz	860 MHz	875 MHz	30	FDD
19		830 MHz	845 MHz	875 MHz	890 MHz	30	FDD
20	n20	832 MHz	862 MHz	791 MHz	821 MHz	71	FDD
21		1447.9 MHz	1462.9 MHz	1495.9 MHz	1510.9 MHz	33	FDD
22		3410 MHz	3490 MHz	3510 MHz	3590 MHz	20	FDD
24		1626.5 MHz	1660.5 MHz	1525 MHz	1559 MHz	135.5	FDD
25	n25	1850 MHz	1915 MHz	1930 MHz	1995 MHz	15	FDD
26	n26	814 MHz	849 MHz	859 MHz	894MHz	10	FDD
27		807 MHz	824 MHz	852 MHz	869 MHz	28	FDD
28	n28	703 MHz	748 MHz	758 MHz	803 MHz	10	FDD
29	n29	N/A	N/A	717 MHz	728 MHz	717	SDL
30	n30	2305 MHz	2315 MHz	2350 MHz	2360 MHz	35	FDD
31		452.5 MHz	457.5 MHz	462.5 MHz	467.5 MHz	50	FDD
32		N/A	N/A	1452 MHz	1496 MHz		SDL
33		1900 MHz	1920 MHz	1900 MHz	1920 MHz		TDD
34	n34	2010 MHz	2025 MHz	2010 MHz	2025 MHz		TDD
35		1850 MHz	1910 MHz	1850 MHz	1910 MHz		TDD
36		1930 MHz	1990 MHz	1930 MHz	1990 MHz		TDD
37		1910 MHz	1930 MHz	1910 MHz	1930 MHz		TDD
38	n38	2570 MHz	2620 MHz	2570 MHz	2620 MHz		TDD
39	n39	1880 MHz	1920 MHz	1880 MHz	1920 MHz		TDD
40	n40	2300 MHz	2400 MHz	2300 MHz	2400 MHz		TDD
41	n41	2496 MHz	2690 MHz	2496 MHz	2690 MHz		TDD
42		3400 MHz	3600 MHz	3400 MHz	3600 MHz		TDD
43		3600 MHz	3800 MHz	3600 MHz	3800 MHz		TDD
44		703 MHz	803 MHz	703 MHz	803 MHz		TDD
45		1447 MHz	1467 MHz	1447 MHz	1467 MHz		TDD

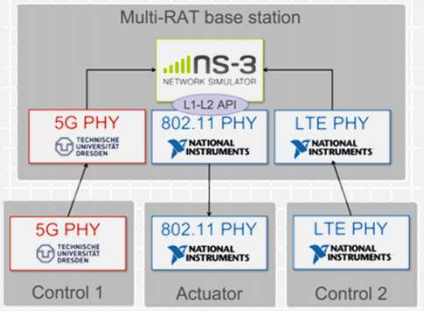
FR1

LTE Operating Band	NR Operating Band	Uplink Low	Uplink High	Downlink Low	Downlink High	Band Gap (MHz)	Duplex Mode
46		5150 MHz	5925 MHz	5150 MHz	5925 MHz		TDD
47		5855 MHz	5925 MHz	5855 MHz	5925 MHz		TDD
48	n48	3550 MHz	3700 MHz	3550 MHz	3700 MHz		TDD
49		3550 MHz	3700 MHz	3550 MHz	3700 MHz		TDD
50	n50	1432 MHz	1517 MHz	1432 MHz	1517 MHz		TDD
51	n51	1427 MHz	1432 MHz	1427 MHz	1432 MHz		TDD
52		3300 MHz	3400 MHz	3300 MHz	3400 MHz		TDD
53	n53	2483.5 MHz	2495 MHz	2483.5 MHz	2495 MHz		TDD
65	n65	1920 MHz	2010 MHz	2110 MHz	2200 MHz	100	FDD
66	n66	1710 MHz	1780 MHz	2110 MHz	2200 MHz	330	FDD
67		N/A	N/A	738 MHz	758 MHz		SDL
68		698 MHz	728 MHz	753 MHz	783 MHz	25	FDD
69		N/A	N/A	2570 MHz	2620 MHz		SDL
70	n70	1695 MHz	1710 MHz	1995 MHz	2020 MHz	285	FDD
71	n71	663 MHz	698 MHz	617 MHz	652 MHz	81	FDD
72		451 MHz	456 MHz	461 MHz	466 MHz	5	FDD
73		450 MHz	455 MHz	460 MHz	465 MHz	5	FDD
74	n74	1427 MHz	1470 MHz	1475 MHz	1518 MHz	5	FDD
75	n75	N/A	N/A	1432 MHz	1517 MHz		SDL
76	n76	N/A	N/A	1427 MHz	1432 MHz		SDL
85		698 MHz	716 MHz	728 MHz	746 MHz	12	FDD
87		410 MHz	415 MHz	420 MHz	425 MHz	5	FDD
88		412 MHz	417 MHz	422 MHz	427 MHz	5	FDD
	n77	3300 MHz	4200 MHz	3300 MHz	4200 MHz		TDD
	n78	3300 MHz	3800 MHz	3300 MHz	3800 MHz		TDD
	n79	4400 MHz	5000 MHz	4400 MHz	5000 MHz		TDD
	n80	1710 MHz	1785 MHz	N/A	N/A		SUL
	n81	880 MHz	915 MHz	N/A	N/A		SUL
	n82	832 MHz	862 MHz	N/A	N/A		SUL
	n83	703 MHz	748 MHz	N/A	N/A		SUL
	n84	1920 MHz	1980 MHz	N/A	N/A		SUL
	n86	1710 MHz	1780 MHz	N/A	N/A		SUL
	n89	824 MHz	849 MHz	N/A	N/A		SUL
	n90	2496 MHz	2690 MHz	2496 MHz	2690 MHz		TDD
	n91	832 MHz	862 MHz	1427 MHz	1432 MHz	565	
	n92	832 MHz	862 MHz	1432 MHz	1517 MHz	570	
	n93	880 MHz	915 MHz	1427 MHz	1432 MHz	512	
	n94	880 MHz	915 MHz	1432 MHz	1517 MHz	517	
	n95	2010 MHz	2025 MHz	N/A	N/A		SUL
XGP		2545 MHz	2575 MHz	2545 MHz	2575 MHz	30	TDD

FR2

LTE Operating Band	NR Operating Band	Uplink Low	Uplink High	Downlink Low	Downlink High	Band Gap (GHz)	Duplex Mode
	n257	26.5 GHz	29.5 GHz	26.5 GHz	29.5 GHz		TDD
	n258	24.25 GHz	27.5 GHz	24.25 GHz	27.5 GHz		TDD
	n260	37 GHz	40 GHz	37 GHz	40 GHz		TDD
	n261	27.5 GHz	28.35 GHz	27.5 GHz	28.35 GHz		TDD

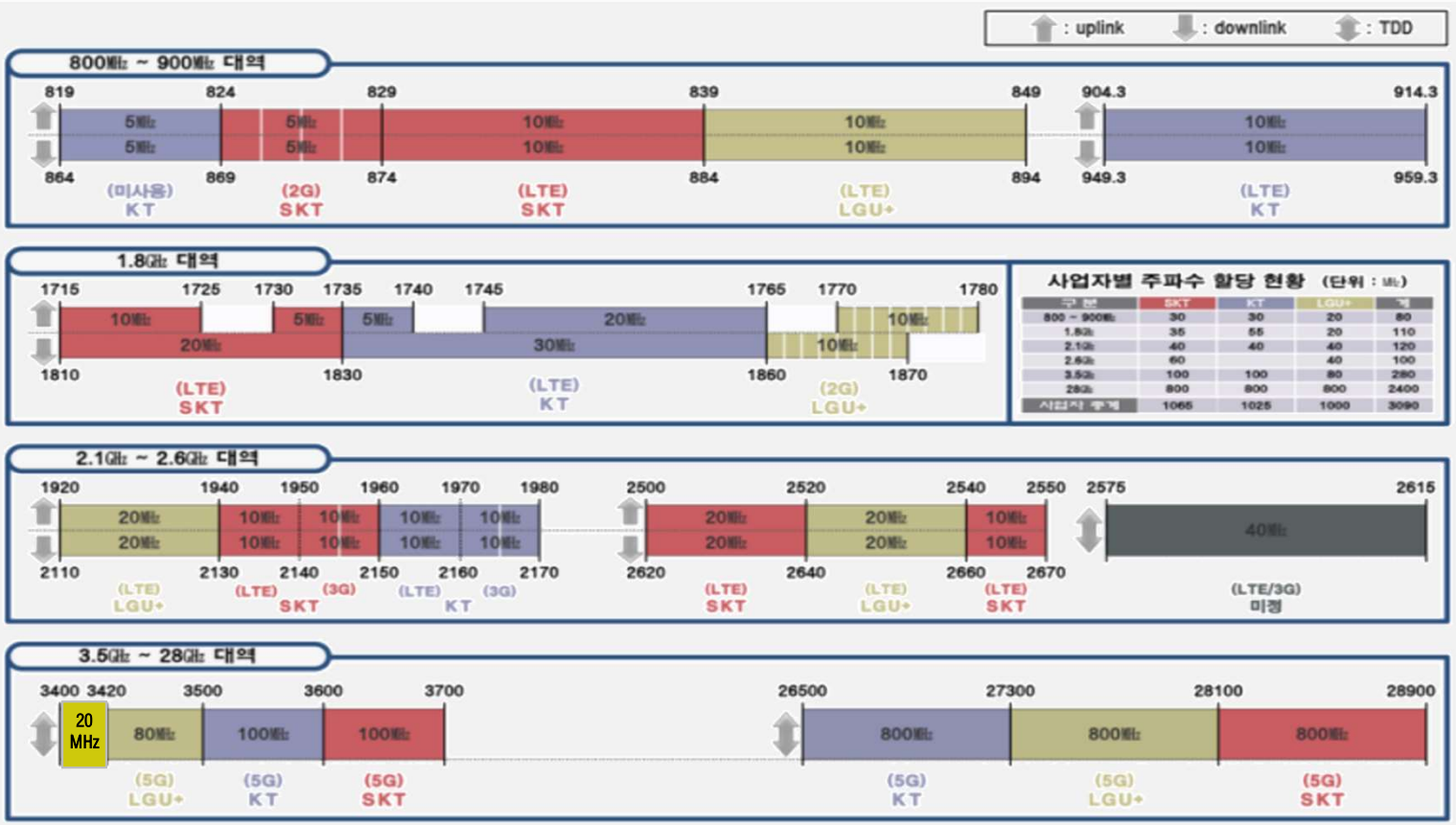




Source: Qorvo, Qualcomm, https://www.cohere-tech.com/press-releases/coheres-universal-spectrum-multiplier-software-doubles-both-4g-and-5g-spectrum-performance

I. 개요

❖ 국내 이동통신 사업자 주파수 할당 현황 (2020.01)



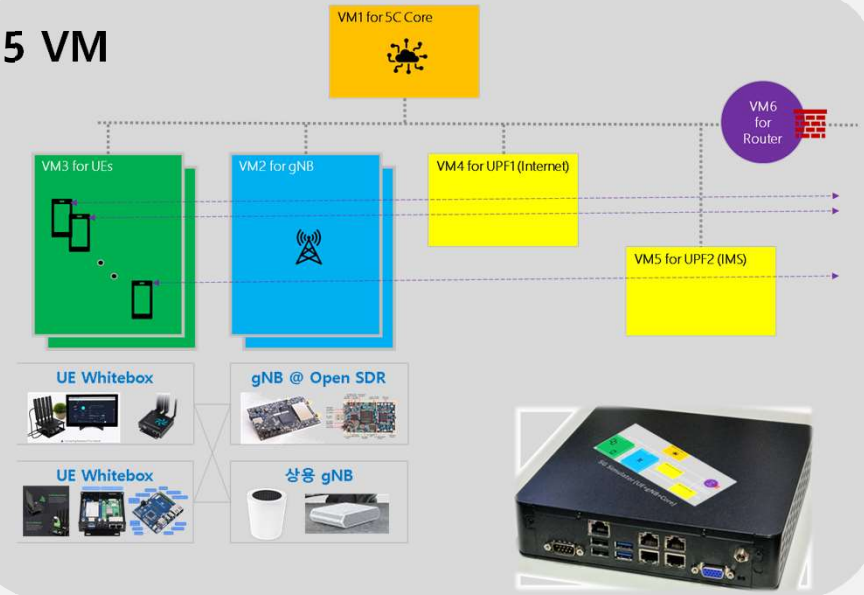
Source: 과기정통부, KCA

I. 개요

❖ 구성

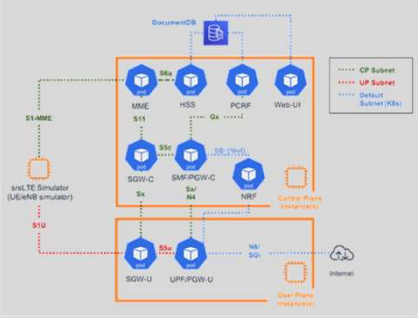
- 5 VM: 5G Core Control Plane, 5G Core User Plane(UPF1/UPF2), gNB, UE
- 2 VM: 5G Core CP/UP, gNB/UE
- Cloud Native: CNF (5G Core / gNB / UE)

5 VM



2 VM

Cloud Native



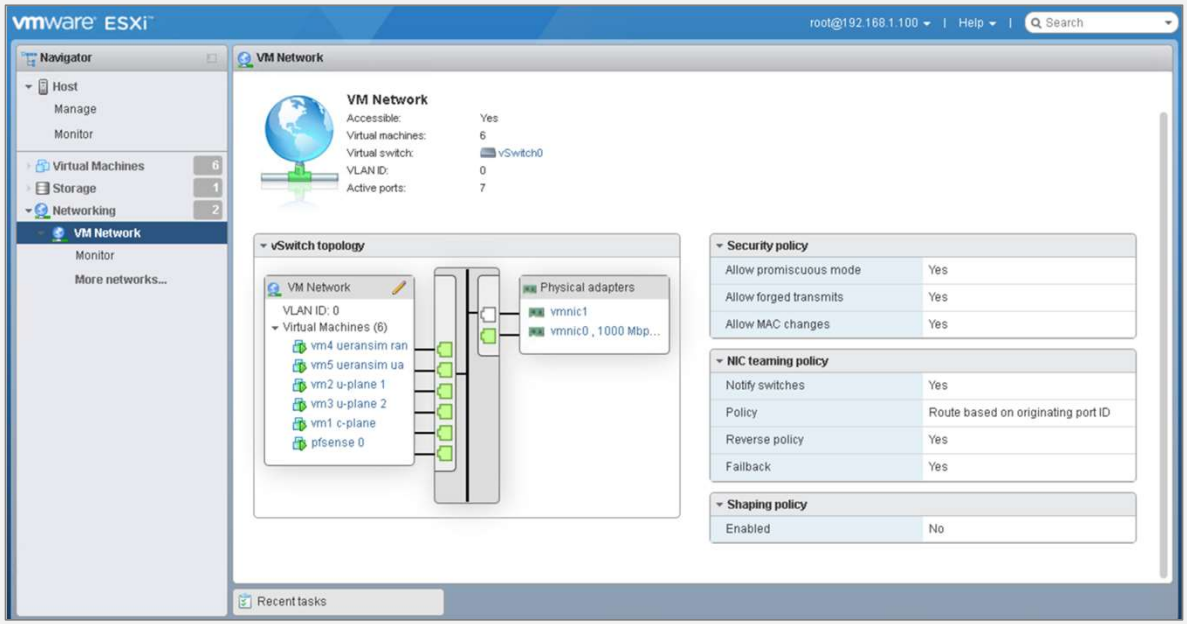
I. 개요

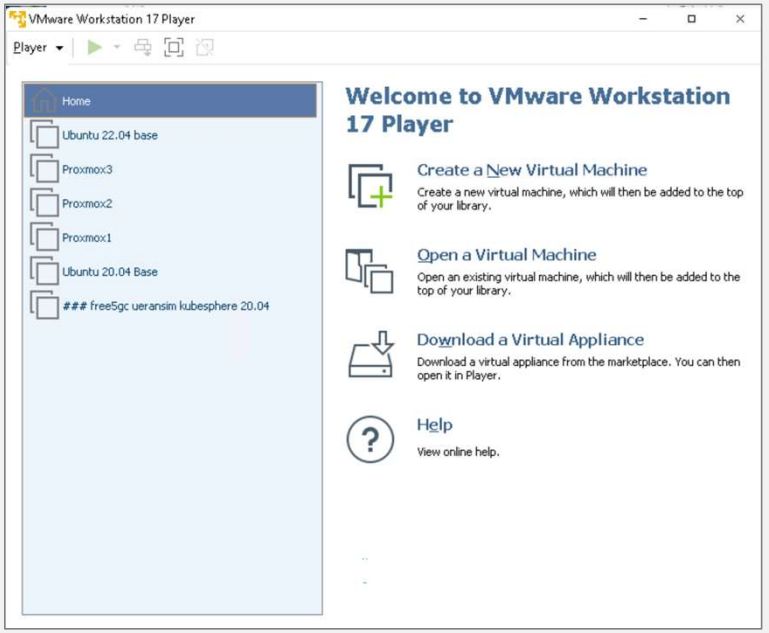
❖ 시연 사용 VM

- Open5GS/UERANSIM @ VMware ESXi (for 6 VMs): Converted VMs for VMware Workstation
  - ✓ https://drive.google.com/file/d/1osTdiOKsZ7lokL2JV6ZbbFBishJWhm6O/view?usp=sharing
- Free5GC @ VMware Workstation Player (1 for 2 VMs):
  - ✓ https://drive.google.com/drive/folders/1-56NGWElOLZ7q-u3_pGPW1tkAAVRfmBS?usp=sharing
- Cloud Native Testbed @ VMware Workstation Player (1 VM for Ubuntu 22.04):
  - ✓ https://drive.google.com/drive/folders/1T8S02-GZUyxFsSR6IM6tPd_v--0jJ4L-?usp=sharing
- Cloud Native Testbed @ VMware Workstation Player (1 VM for Ubuntu 20.04):
  - ✓ https://drive.google.com/drive/folders/1eqmbJylQT1hFFWLmn_gx6TzZXcdgtVbc?usp=sharing

❖ Hypervisor 설치

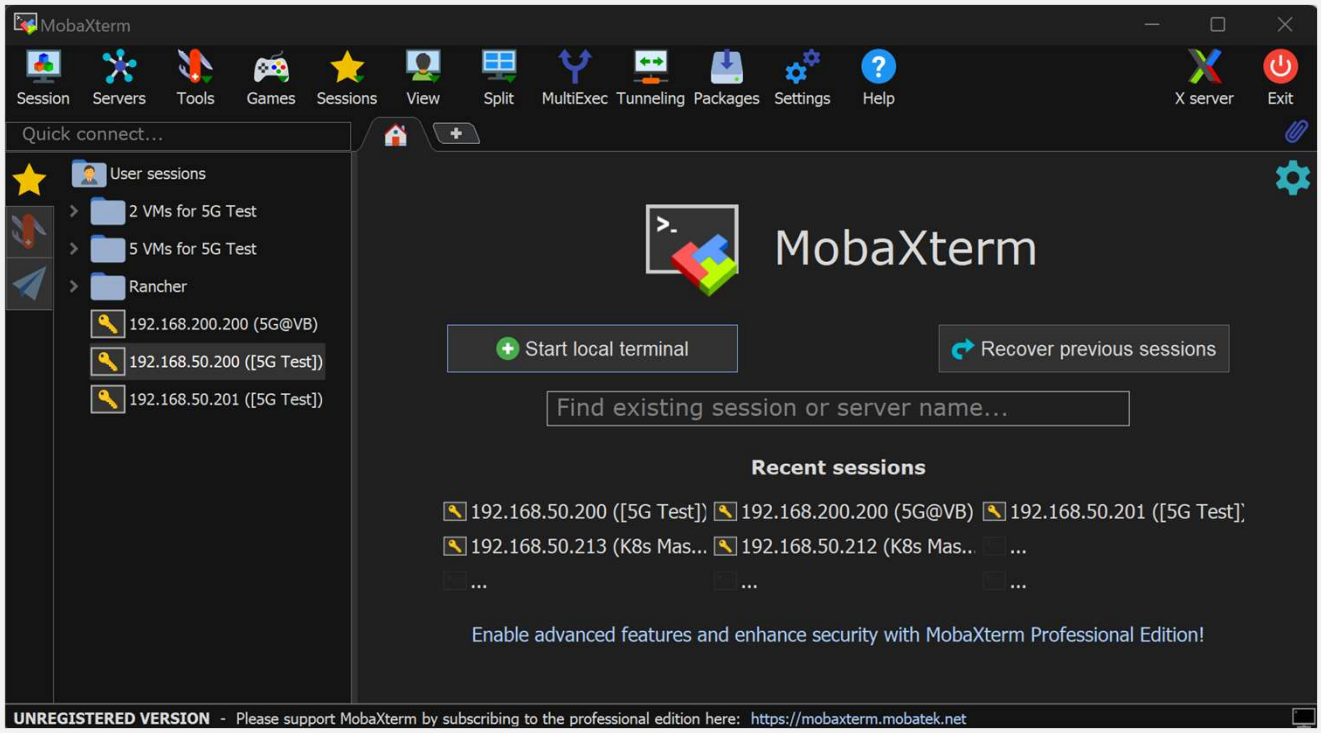
- **ESXi download (시연):**
  - ✓https://customerconnect.vmware.com/downloads/get-download?downloadGroup=ESXI800
- **VMware Workstation Player download:**
  - ✓https://www.vmware.com/kr/products/workstation-player/workstation-player-evaluation.html





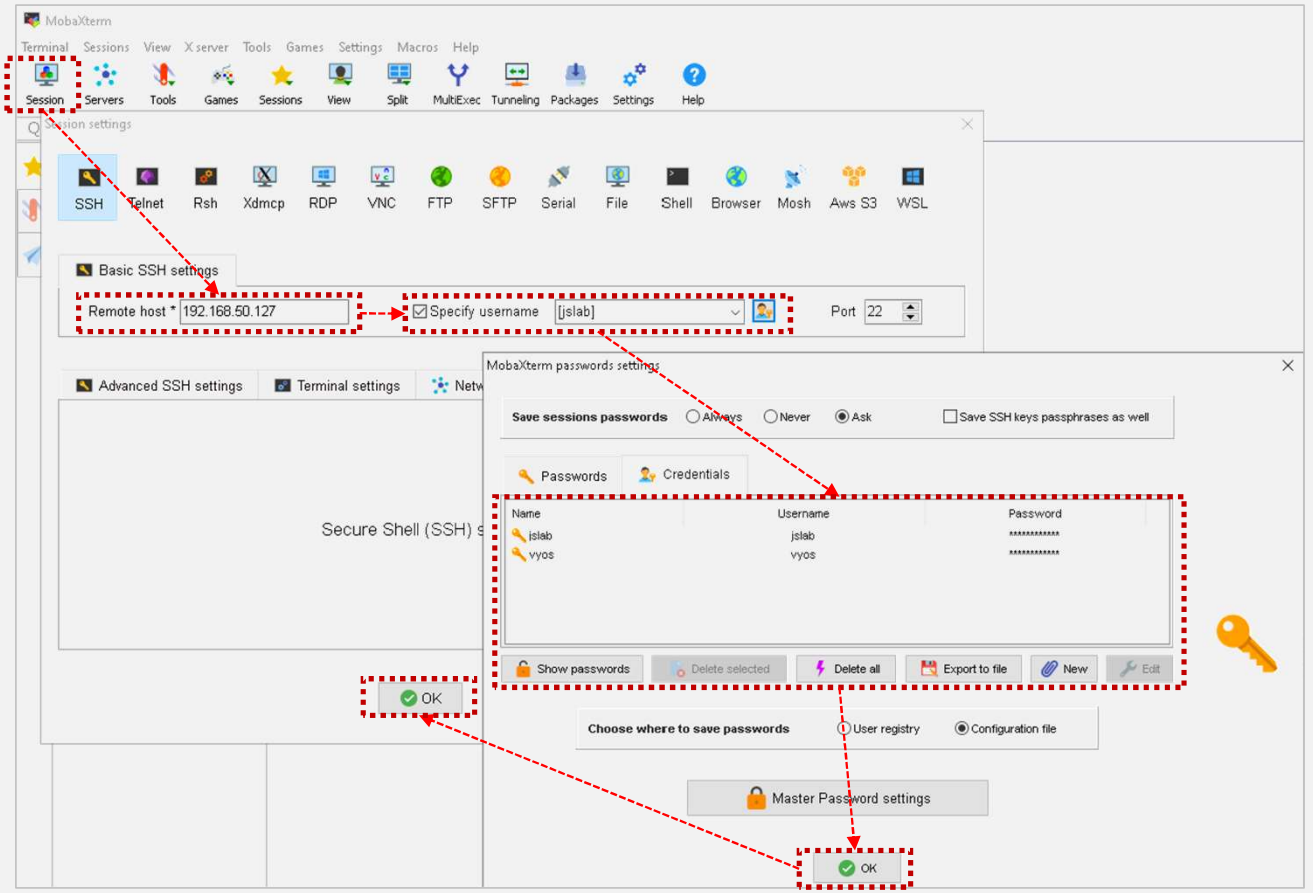
❖ SSH 터미널 설치

- **MovaXterm download:**
  - ✓ https://mobaxterm.mobatek.net/download.html



I. 개요

❖ SSH 터미널 접속



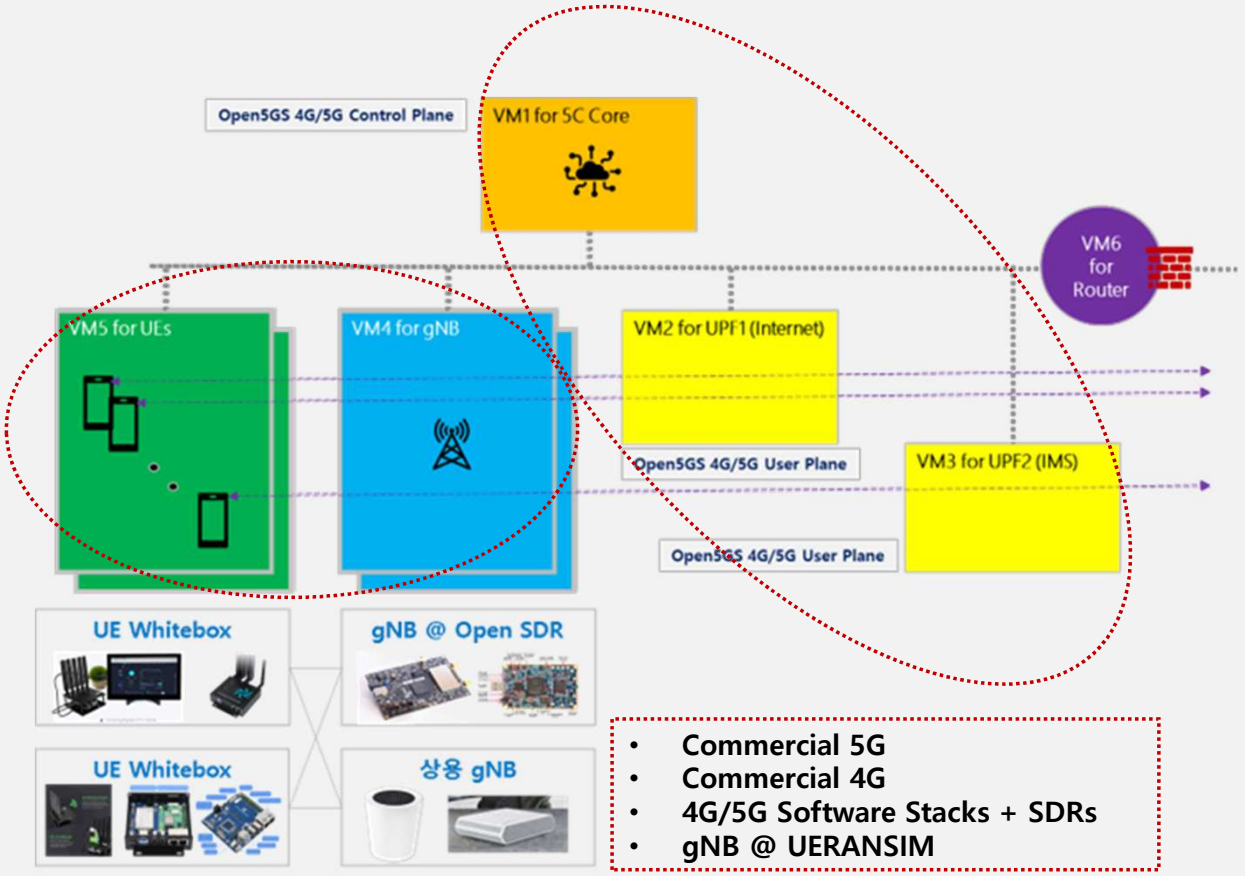
Source: https://mobaxterm.mobatek.net/download.html

II. Testbed 1 (5 VMs)

II. TESTBED 1 (5 VM)

❖ 오픈소스 Open5GS 개요

- Open5GS 4G/5G Control Plane
- Open5GS 4G/5G User Plane
- 호환 상용 5G (gNB)
- 호환 상용 4G (eNB)
- 호환 4G/5G Software Stacks + SDRs
- 호환 gNB @ UERANSIM



II. TESTBED 1 (5 VM)

❖ Open5GS 호환 하드웨어 (eNodeBs / gNodeBs tested)

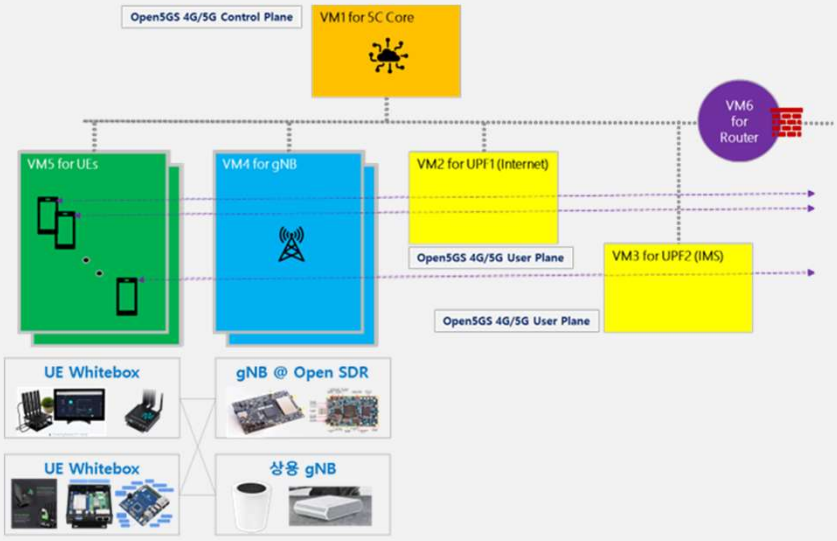
- **Commercial 5G (호환)**
  - Airfill S5G AFBU-SL14CN (DU + CU) + AFRU-352-I Indoor Radio (n77 and n78)
  - Airspan 5G OpenRange vCU + Airspan 5G OpenRange vDU + Airspan 5G OpenRANGE06 AirVelocity 2700 RU
  - Airspan AirSpeed 2900
  - Airspan AirStrand 2200
  - CableFree Small Cell Outdoor radios (5G n77, n78 and other bands)
  - CableFree Small Cell Indoor radios (5G n77, n78 and other bands)
  - CableFree Macro (BBU+RRH) radios (4G and 5G, various bands)
  - Ericsson Baseband 6630 (21.Q3 Software) + Radio 2217, Radio 2219 (4G and 5G, various bands)
  - Ericsson StreetMacro 6701 (21.Q3 Software) (5G mmWave, n261) (Baseband 6318 and AIR 1281 packaged together)
  - Huawei BTS5900
  - LIONS RANathon O-CU and O-DU + RANathon RS8601 Indoor O-RU + RANathon XG8600 Fronthaul Gateway
  - NOKIA AEQE (SW: 5G20A)
  - NOKIA AEQD (SW: 5G20A)
  - NOKIA AEQP (SW: 5G21A)

Source: https://open5gs.org/open5gs/docs/hardware/01-genodebs/

II. TESTBED 1 (5 VM)

❖ Open5GS 호환 하드웨어 (eNodeBs / gNodeBs tested)

- **4G/5G Software Stacks + SDRs (호환)**
  - Amarisoft + LimeSDR, USRP, Amarisoft PCI Express Card
  - Open Air Interface 5G (NR_SA_F1AP_5GRECORDS branch) + USRP B210
  - srsLTE / srsENB + LimeSDR, USRP, BladeRF x40 (BladeRF Not stable)
- **Misc Radio Hardware (호환)**
  - OpenAirInterface v1.0.3 4G RAN Simulator
  - OsmoBTS controlled ip.access NanoBTS (Used for CSFB with Osmocom)
  - UERANSIM 5G RAN Simulator

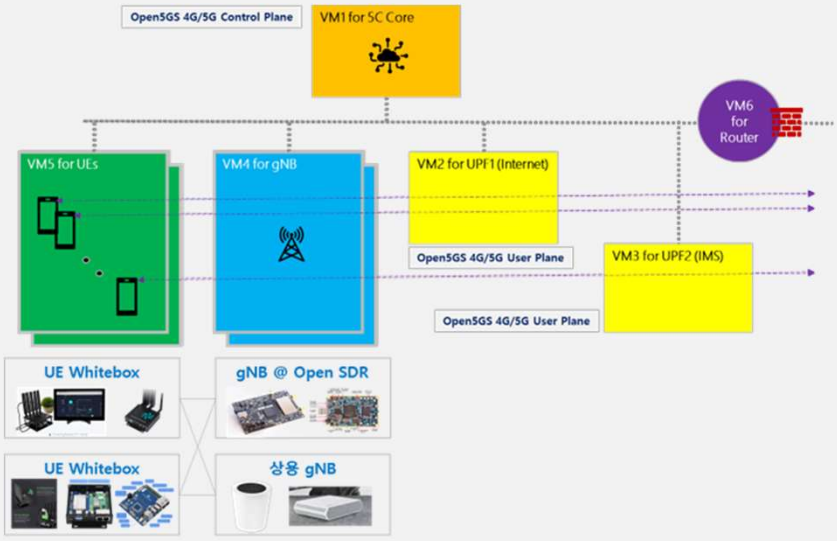


Source: https://open5gs.org/open5gs/docs/hardware/01-genodebs/

II. TESTBED 1 (5 VM)

❖ Open5GS 호환 하드웨어 (eNodeBs tested)

- **Commercial 4G**
  - Accelleran E1010 (LTE TDD B42)
  - AirHarmony 4000
  - AirHarmony 4200
  - AirHarmony 4400
  - Airspan AirSpeed 1030
  - Airspan AirHarmony 1000
  - Baicells Neutrino
  - Baicells Nova 243, Baicells Nova 246, Baicells Nova 249, Baicells Nova 436Q
  - Baicells Nova 227 (EBS & CBRS), Baicells Nova 233
  - Ericsson Baseband 6630 (21Q1 Software)
  - Ericsson RBS 6402 (18.Q1 software, B2 B25 B4 B7 B252 B255)
  - Ericsson RBS 6601 + DUL 20 01 + RUS 01 B8
  - Gemtek WLTGFC-101 (S/W version 2.1.1746.1116)
  - Huawei BTS3900 (S/W version V100R011C10SPC230)
  - Huawei BBU5900 with RRU5304W Band 7 FDD 2600Mhz 40W Version V100R016C10
  - Nokia FW2PC BC28 Flexi Zone G2 Outdoor Micro FDD LTE 700 MHz High Power
  - Nokia FWH1 B38 Flexi Zone Outdoor Micro TD LTE 2600 MHz
  - Nokia FRGY Flexi BTS BBU with Nokia FRCG RRU Band 5 850Mhz FDD 40W. Version 16.1A to 19.0
  - Nokia FW2FA Flexi Zone Mini-Macro Outdoor BTS, 2x20w Band 39
  - Nokia FWGR Flexi Zone Mini-Macro Outdoor BTS, 2x20w Band 1
  - Ruckus Q710 and Q910

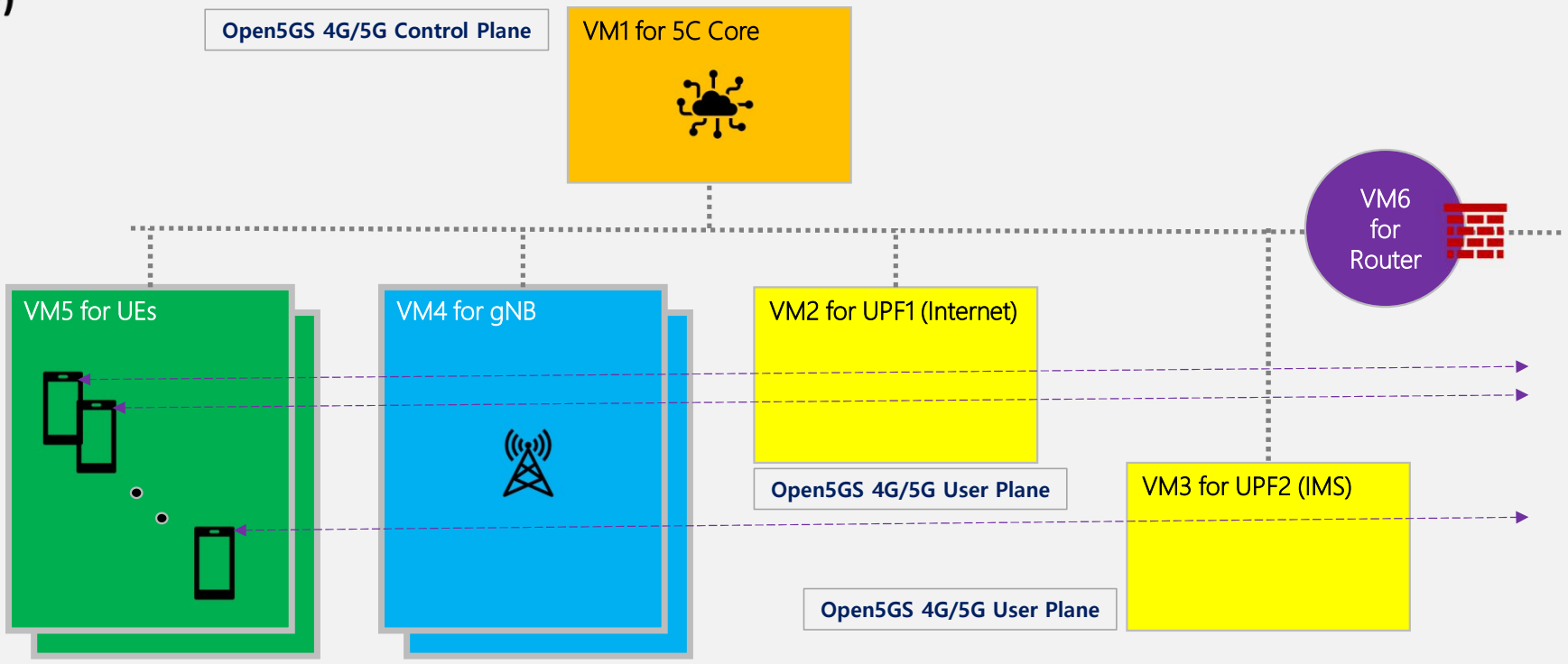


Source: https://open5gs.org/open5gs/docs/hardware/01-genodebs/

II. TESTBED 1 (5 VM)

❖ Build Open5GS

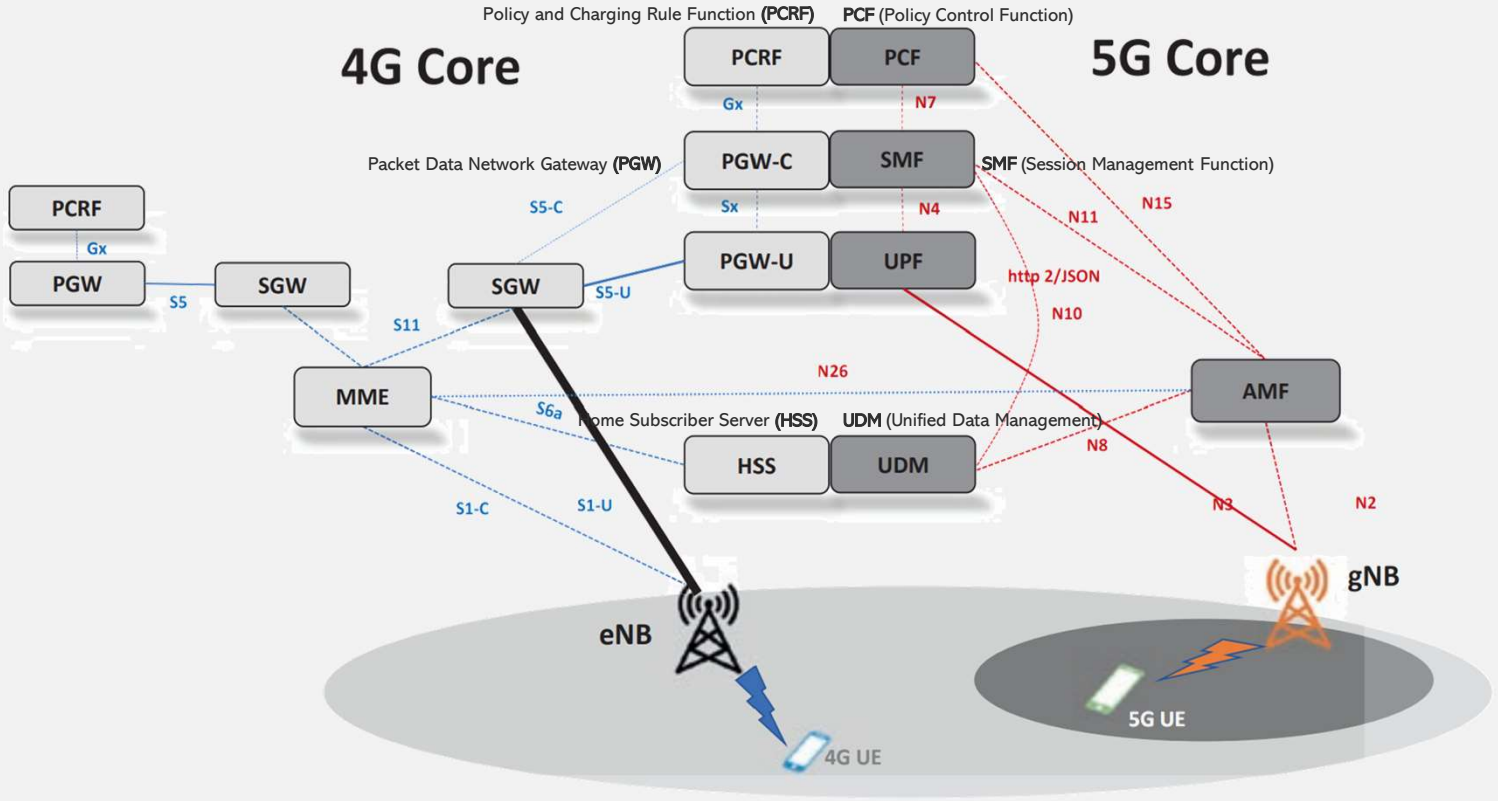
- NSA (4G Core)
- SA (5G Core)



II. TESTBED 1 (5 VM)

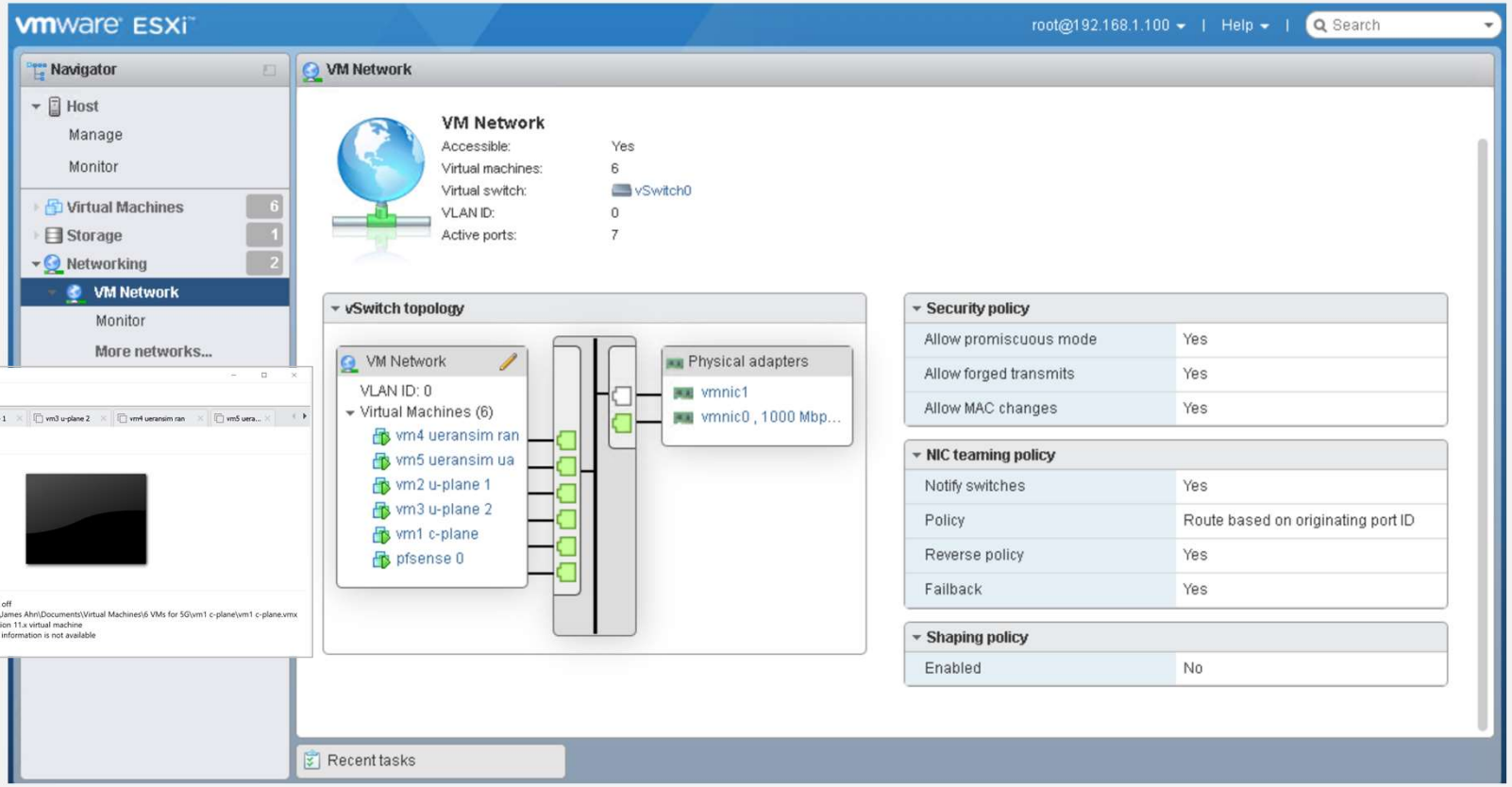
❖ Build Open5GS

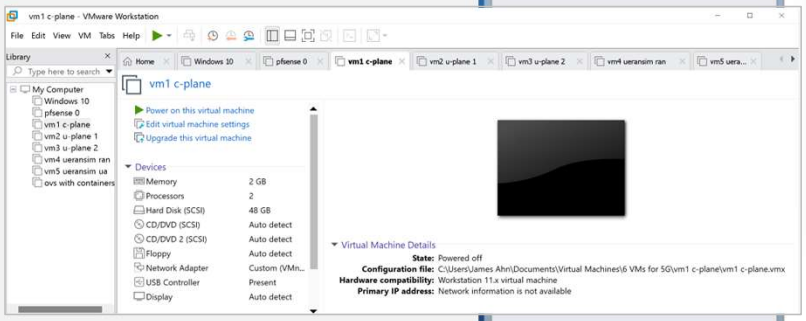
- NSA (4G Core)
- SA (5G Core)

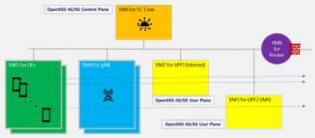


II. TESTBED 1 (5 VM)

❖ VMware ESXi (Type 1 Hypervisor) 실행

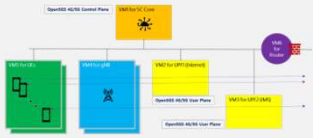


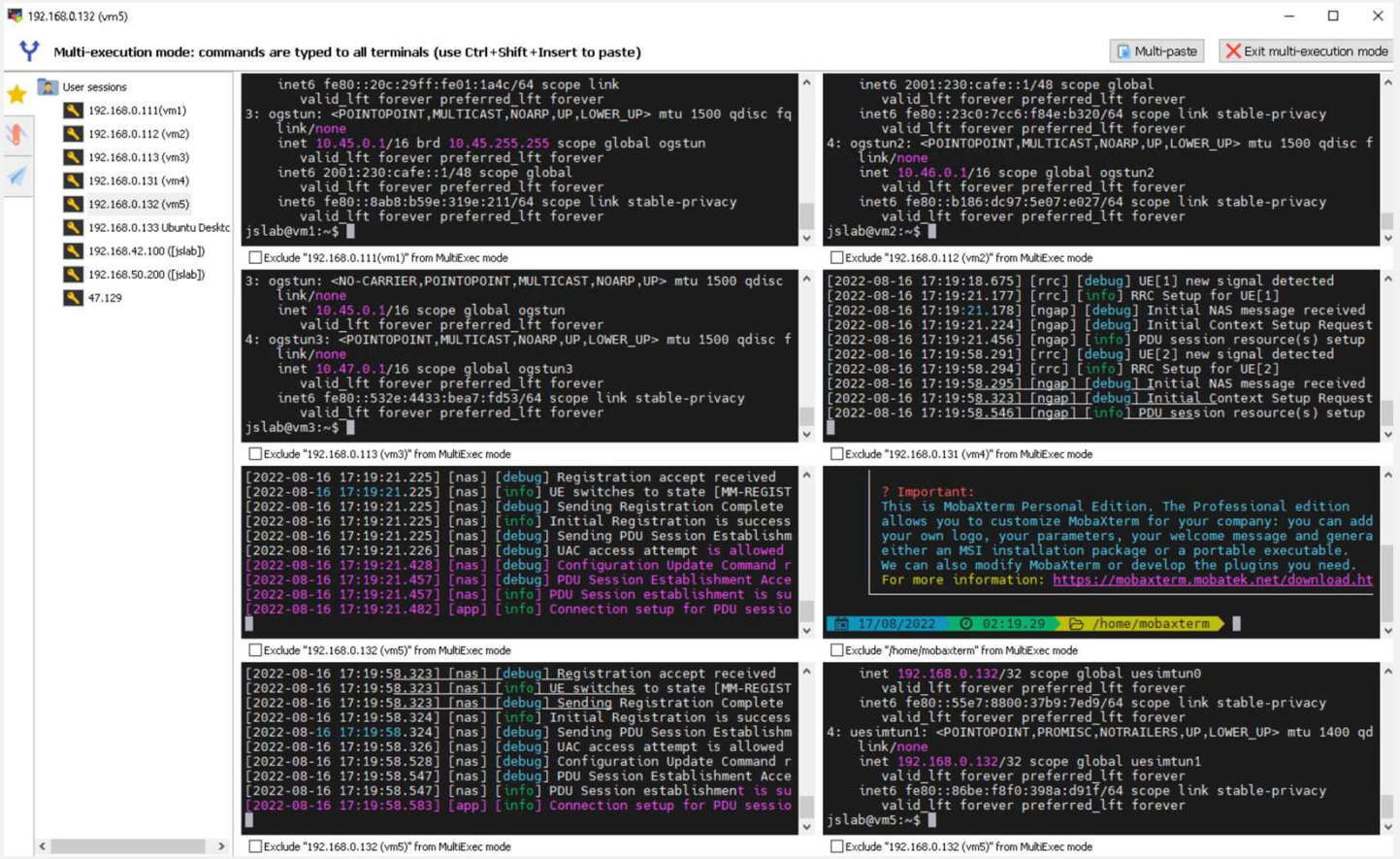




II. TESTBED 1 (5 VM)

❖ VMware ESXi (Type 1 Hypervisor) 실행



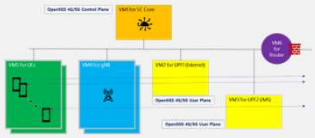


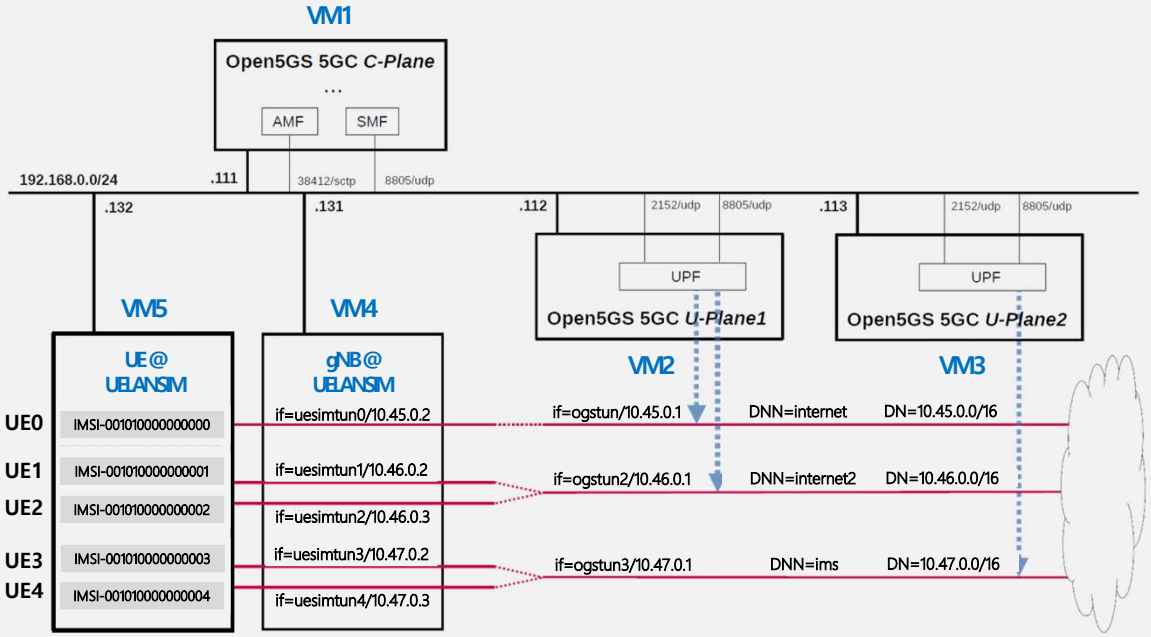
II. TESTBED 1 (5 VM)

❖ Overview of Open5GS 5GC Simulation Mobile Network

- **5 VMs**
  - C-Plane have multiple U-Planes.
  - U-Plane have multiple DNs.
  - Multiple UEs connect to same DN.

VM	SW & Role	IP address	OS	vRAM	HDD (Min)
VM1	Open5GS 5GC C-Plane	192.168.0.111/24	Ubuntu 20.04	2GB	20GB
VM2	Open5GS 5GC U-Plane1	192.168.0.112/24	Ubuntu 20.04	2GB	20GB
VM3	Open5GS 5GC U-Plane2	192.168.0.113/24	Ubuntu 20.04	2GB	20GB
VM4	UERANSIM RAN (gNodeB)	192.168.0.131/24	Ubuntu 20.04	2GB	20GB
VM5	UERANSIM UE	192.168.0.132/24	Ubuntu 20.04	2GB	20GB



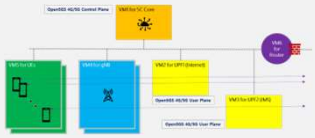


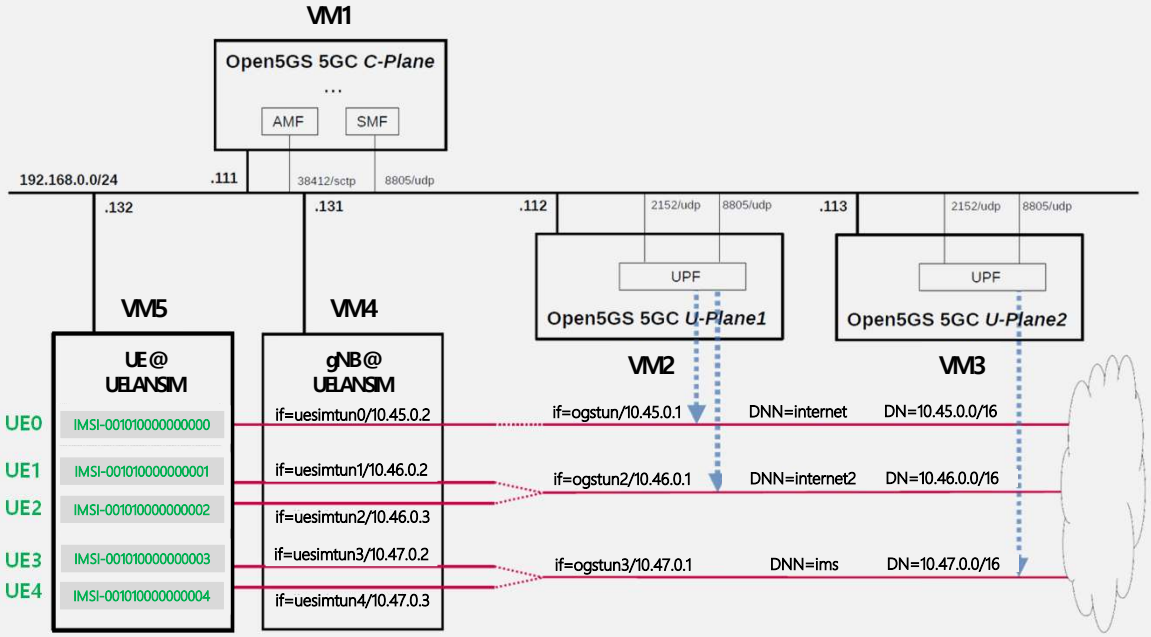
II. TESTBED 1 (5 VM)

❖ Overview of Open5GS 5GC Simulation Mobile Network

- **5 UEs @ VM5**
  - C-Plane have multiple U-Planes.
  - U-Plane have multiple DNs.
  - Multiple UEs connect to same DN.

UE	IMSI	DNN	OP/OPc
UE0	001010000000000	internet	OPc
UE1	001010000000001	internet2	OPc
UE2	001010000000002	internet2	OPc
UE3	001010000000003	ims	OPc
UE4	001010000000004	ims	OPc

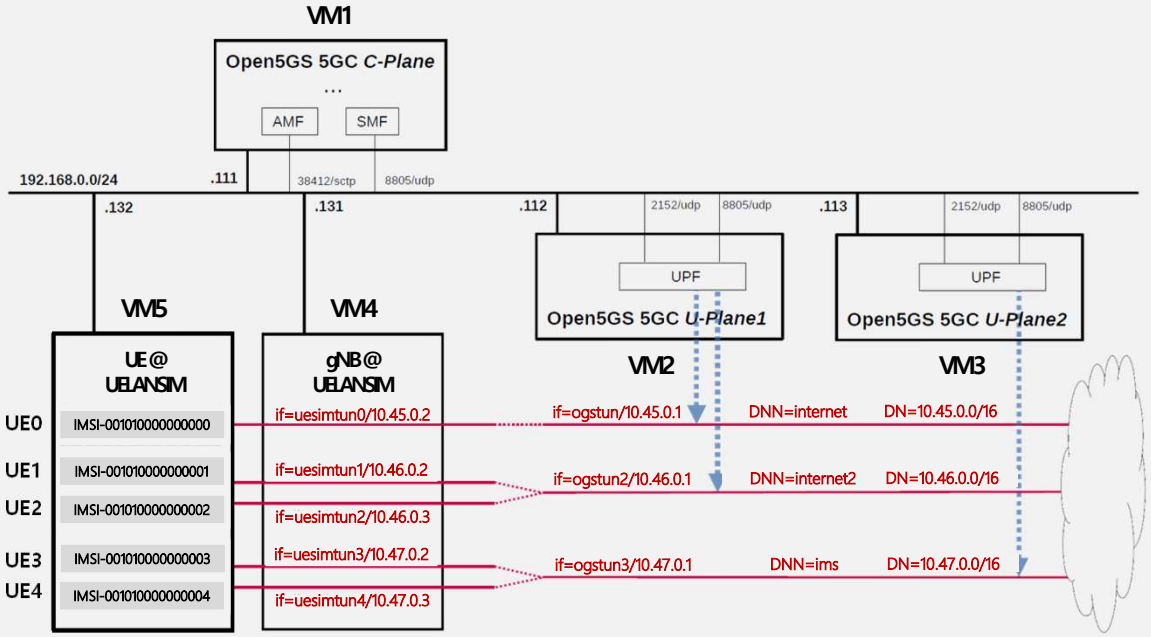




II. TESTBED 1 (5 VM)

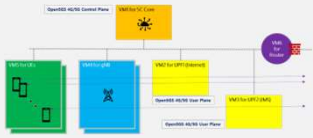
❖ Overview of Open5GS 5GC Simulation Mobile Network

- **3 DNs with 2 UPFs**
  - C-Plane have multiple U-Planes.
  - U-Plane have multiple DNs.
  - Multiple UEs connect to same DN.



DN	TUNnel interface of DN	DNN	TUNnel interface of UE	U-Plane #
10.45.0.0/16	ogstun	internet	uesimtun0	U-Plane1
10.46.0.0/16	ogstun2	internet2	uesimtun1, uesimtun2	U-Plane1
10.47.0.0/16	ogstun3	ims	uesimtun3, uesimtun4	U-Plane2

- Open5GS 5GC U-Plane worked fine on Raspberry Pi 4 Model B.



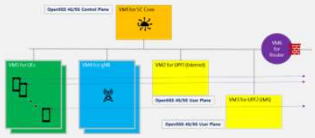
II. TESTBED 1 (5 VM)

❖ Quickstart (Open5GS) for Physical gNB

- Uninstall Open5GS and WebUI

```
$ sudo apt purge open5gs
$ sudo apt autoremove
```

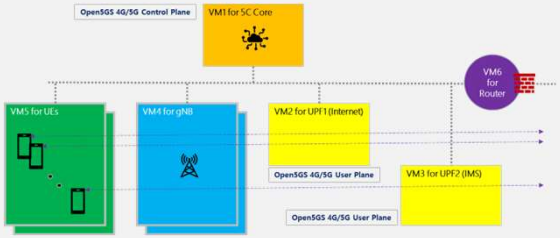
```
## You may need to remove manually /var/log/open5gs unless it is empty.

$ sudo rm -Rf /var/log/open5gs

## The WebUI of Open5GS can be removed as follows:

curl -fsSL https://open5gs.org/open5gs/assets/webui/uninstall | sudo -E bash -
```

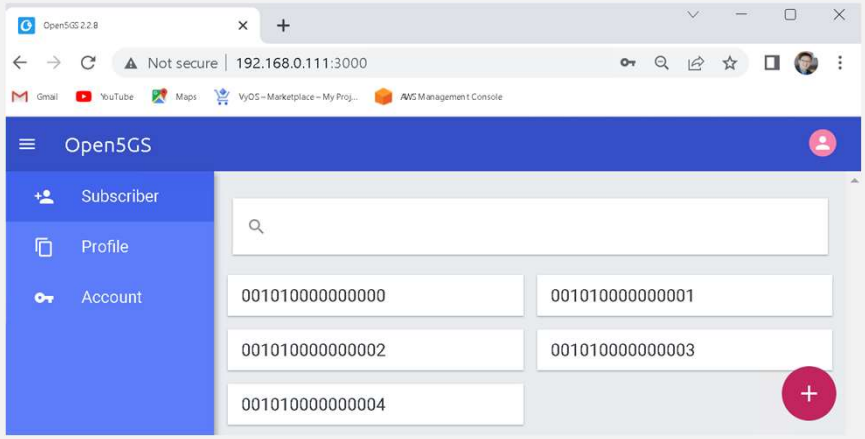


II. TESTBED 1 (5 VM)

❖ Quickstart (Open5GS) for Physical gNB

- Connect to http://localhost:3000 and login with admin account.
  - 192.168.0.111:3000
  - Username : admin
  - Password : 1423
- To add subscriber information
  - Go to Subscriber Menu.
  - Click + Button to add a new subscriber.
  - Fill the IMSI, security context(K, OPc, AMF), and APN of the subscriber.
  - Click SAVE Button



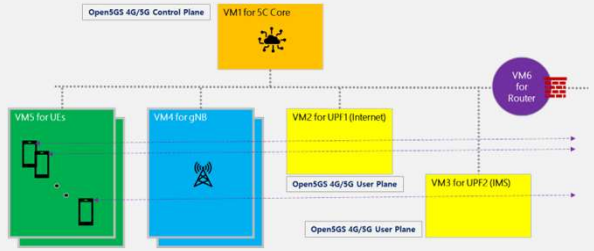


II. TESTBED 1 (5 VM)

❖ configure the TUNnel interface and NAPT

- configure the TUNnel interface and NAPT. (sudo -i) @ User Plane 1 (vm2)
  - sudo ip tuntap add name ogstun mode tun
  - sudo ip addr add 10.45.0.1/16 dev ogstun
  - sudo ip link set ogstun up
  - sudo iptables -t nat -A POSTROUTING -s 10.45.0.0/16 ! -o ogstun -j MASQUERADE
  - sudo ip tuntap add name ogstun2 mode tun
  - sudo ip addr add 10.46.0.1/16 dev ogstun2
  - sudo ip link set ogstun2 up
  - sudo iptables -t nat -A POSTROUTING -s 10.46.0.0/16 ! -o ogstun2 -j MASQUERADE
- configure the TUNnel interface and NAPT. (sudo -i) @ User Plane 2 (vm3)
  - sudo ip tuntap add name ogstun mode tun
  - sudo ip addr add 10.45.0.1/16 dev ogstun
  - sudo ip link set ogstun up
  - sudo iptables -t nat -A POSTROUTING -s 10.45.0.0/16 ! -o ogstun -j MASQUERADE
  - sudo ip tuntap add name ogstun3 mode tun
  - sudo ip addr add 10.47.0.1/16 dev ogstun3
  - sudo ip link set ogstun3 up
  - sudo iptables -t nat -A POSTROUTING -s 10.47.0.0/16 ! -o ogstun3 -j MASQUERADE

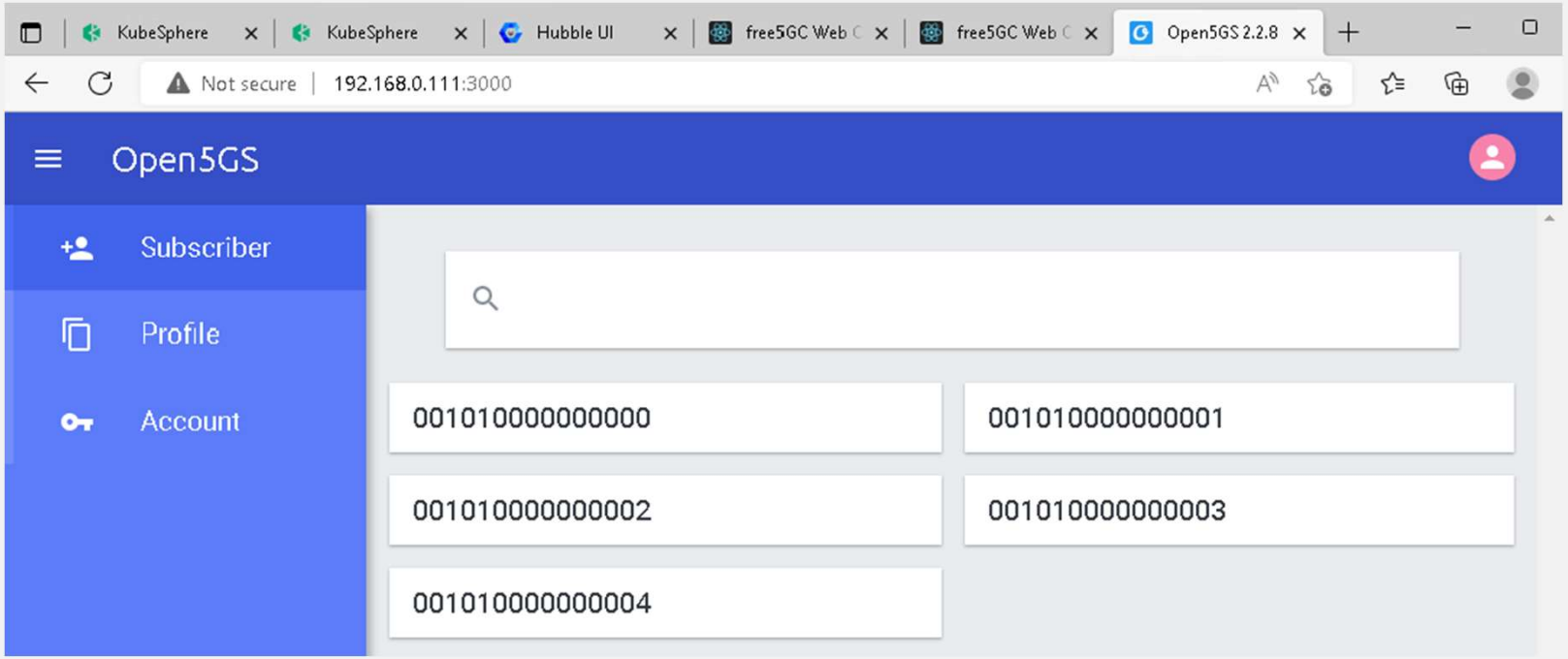
NAPT (Network Address Port Translation)

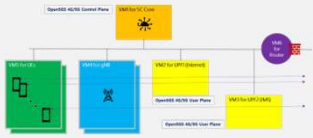


II. TESTBED 1 (5 VM)

❖ Open5GS WebUI

Username : admin
Password : 1423





II. TESTBED 1 (5 VM)

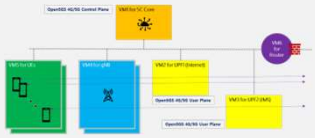
- open5gs-gnb.yaml
- open5gs-ue0.yaml

open5gs-gnb.yaml

```
mcc: '001'          # Mobile Country Code value
mnc: '01'           # Mobile Network Code value (2 or 3 digits)

nci: '0x000000010'  # NR Cell Identity (36-bit)
idLength: 32        # NR gNB ID length in bits [22...32]
tac: 1              # Tracking Area Code

# linkIp: 127.0.0.1   # gNB's local IP address for Radio Link Simulation (Usually same with local IP)
# ngapIp: 127.0.0.1   # gNB's local IP address for N2 Interface (Usually same with local IP)
# gtpIp: 127.0.0.1    # gNB's local IP address for N3 Interface (Usually same with local IP)
linkIp: 192.168.0.131   # gNB's local IP address for Radio Link Simulation (Usually same with local IP)
ngapIp: 192.168.0.131   # gNB's local IP address for N2 Interface (Usually same with local IP)
gtpIp: 192.168.0.131    # gNB's local IP address for N3 Interface (Usually same with local IP)

# List of AMF address information
amfConfigs:
   - address: 192.168.0.111 # 127.0.0.5
     port: 38412

# List of supported S-NSSAIs by this gNB
slices:
  - sst: 1

# Indicates whether or not SCTP stream number errors should be ignored.
ignoreStreamIds: true
```

open5gs-ue0.yaml

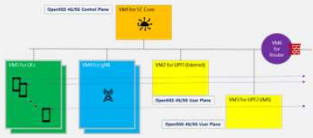
```
# IMSI number of the UE. IMSI = [MCC|MNC|MSISDN] (In total 15 digits)
supi: 'imsi-001010000000000'
# Mobile Country Code value of HPLMN
mcc: '001'
# Mobile Network Code value of HPLMN (2 or 3 digits)
mnc: '01'

# Permanent subscription key
key: '465B5CE8B199B49FAA5F0A2EE238A6BC'
# Operator code (OP or OPC) of the UE
op: 'E8ED289DEBA952E4283B54E88E6183CA'
# This value specifies the OP type and it can be either 'OP' or 'OPC'
opType: 'OPC'
# Authentication Management Field (AMF) value
amf: '8000'
# IMEI number of the device. It is used if no SUPI is provided
imei: '356938035643803'
# IMEISV number of the device. It is used if no SUPI and IMEI is provided
imeiSv: '4370816125816151'

# List of gNB IP addresses for Radio Link Simulation
gnbSearchList:
  - 192.168.0.131  ## 127.0.0.1

# UAC Access Identities Configuration
uacAic:
  mps: false
  mcs: false

# UAC Access Control Class
uacAcc:
  normalClass: 0
  class11: false
  class12: false
  class13: false
  class14: false
  class15: false

# Initial PDU sessions to be established
sessions:
  - type: 'IPv4'
    apn: 'internet'
    slice:
      sst: 1

# Configured NSSAI for this UE by HPLMN
configured-nssai:
  - sst: 1

# Default Configured NSSAI for this UE
default-nssai:
  - sst: 1
```



II. TESTBED 1 (5 VM)

❖ Quickstart (Open5GS)

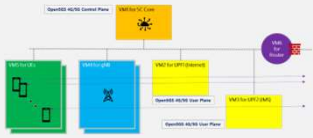
- Connect to http://localhost:3000 and login with admin account.
  - 192.168.0.111:3000
  - Username : admin
  - Password : 1423
- To add subscriber information
  - Go to Subscriber Menu.
  - Click + Button to add a new subscriber.
  - Fill the IMSI, security context(K, OPc, AMF), and APN of the subscriber.
  - Click SAVE Button



II. TESTBED 1 (5 VM)

❖ Quickstart (Open5GS): 유튜브 https://youtu.be/tinkTj_rweY

- sudo systemctl restart open5gs-amfd # AMF 재구동 @ vm1
- sudo systemctl restart open5gs-upfd # UPF 재구동 @ vm2/vm3
- sudo ./nr-gnb -c ~/UERANSIM/config/open5gs-gnb.yaml # @ vm4 /UERANSIM/build/
- sudo build/nr-ue -c config/open5gs-ue0.yaml # UE0 @ vm5 /UERANSIM/
- sudo build/nr-ue -c config/open5gs-ue1.yaml # UE1 @ vm5 /UERANSIM/
- sudo build/nr-ue -c config/open5gs-ue2.yaml # UE2 @ vm5 /UERANSIM/
- sudo build/nr-ue -c config/open5gs-ue3.yaml # UE3 @ vm5 /UERANSIM/
  - ping -I uesimtun0 google.com — sudo tcpdump -i ogstun @ vm2 upf1 — # Ping @ vm5 - UE0
  - ping -I uesimtun1 google.com — sudo tcpdump -i ogstun2 @ vm2 upf1 — # Ping @ vm5 - UE1
  - ping -I uesimtun2 google.com — sudo tcpdump -i ogstun2 @ vm2 upf1 — # Ping @ vm5 - UE2
  - ping -I uesimtun3 google.com — sudo tcpdump -i ogstun3 @ vm3 upf2 — # Ping @ vm5 - UE3
  - sudo tcpdump -i ogstun # Data Capture @ vm2 - UPF1
  - sh nr-binder 10.45.0.2 curl google.com — sudo tcpdump -i ogstun2 @ vm2 upf1 — # UE0 @ vm5 - UERANSIM/build/
  - sh nr-binder 10.45.0.3 ping google.com — sudo tcpdump -i ogstun2 @ vm2 upf1 — # UE1 @ vm5 - UERANSIM/build/
  - sh nr-binder 10.47.0.3 ping google.com — sudo tcpdump -i ogstun2 @ vm2 upf1 — # UE1 @ vm5 - UERANSIM/build/



II. TESTBED 1 (5 VM)

❖ ping, curl, docker, python

- # ping command bind directly to uesimtun0

✓ping -I uesimtun0 google.com

- # curl command bind directly to uesimtun0

✓curl -I uesimtun0 -X GET https://httpbin.org/get

- # bind curl command via nr-binder
- # nr-binder use pdu session ip

✓sh ./nr-binder 10.45.0.3 curl -X GET "https://httpbin.org/get"

- # run docker container via nr-binder

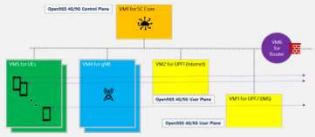
✓sh ./nr-binder 10.45.0.3 sudo docker run -d -p 9091:80 kennethreitz/httpbin

- # bind python application via nr-binder
- # request.pyt is simple python program which send http GET request

✓sh ./nr-binder 10.45.0.3 python3 request.py

- # bind shell scrip via nr-binder
- # httpbin.sh is simple shell script which runs httpbin as docker container

✓sh ./nr-binder 10.45.0.3 ./httpbin.sh



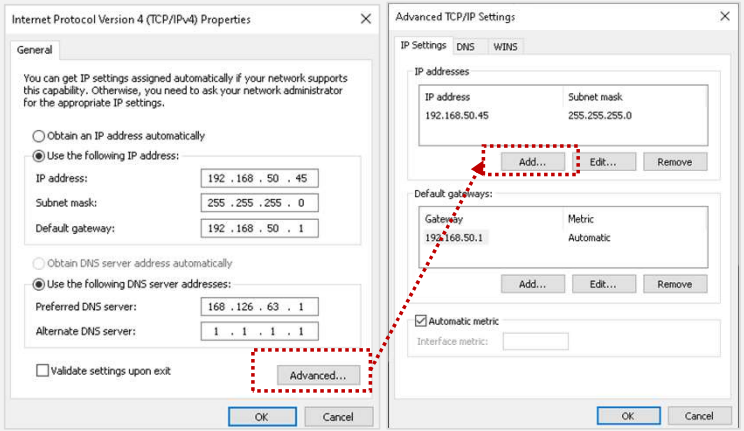
Source: https://medium.com/rahasak/5g-core-network-setup-with-open5gs-and-ueransim-cd0e77025fd7

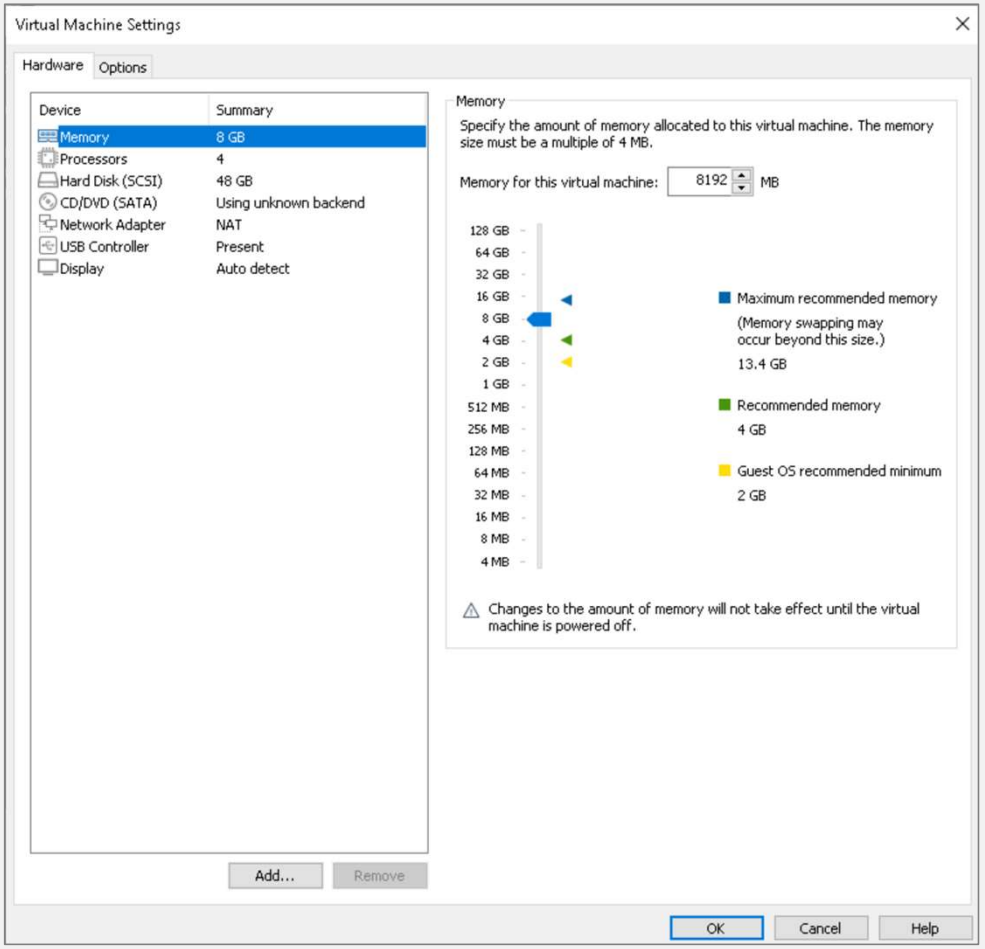
III. Testbed 2 (1 for 2 VMs)

III. TESTBED 2 (2 VM)

❖ VMware Workstation Player

1. vCPU: 4
2. vRAM: 4GB
3. Network(Bridge): MAC 주소 재생성
4. Add Network (Bridge): MAC 주소 재생성 (선택)
5. Uncheck Accelerate 3D Graphic @ Display





오프라인 실습환경에서는
이더넷 인터페이스에
192.168.50.xx 추가

IV. TESTBED 3 (CLOUD NATIVE)

❖ Changes in configuration files

- **Setting Static IP Address (선택@콘솔)**
  - cd /etc/netplan
  - ls
  - cat 00-installer-config.yaml
  - **sudo nano /etc/netplan/00-installer-config.yaml**
  - **sudo netplan try**
  - **sudo netplan apply**
  - **ip a**
  - **sudo apt install net-tools**
  - **route**
- **Change hostname**
  - sudo nano /etc/hostname
  - sudo nano /etc/hosts
  - sudo reboot
- **sudo apt-get update**
- **sudo apt upgrade**

Free5GC

```
# This is the network config written by 'subiquity'
network:
  ethernets:
    ens33:
      dhcp4: false
      addresses: [192.168.220.129/24]
      gateway4: 192.168.220.2
      nameservers:
          addresses: [1.1.1.1,8.8.8.8]
    ens34:
      dhcp4: true
  version: 2
```

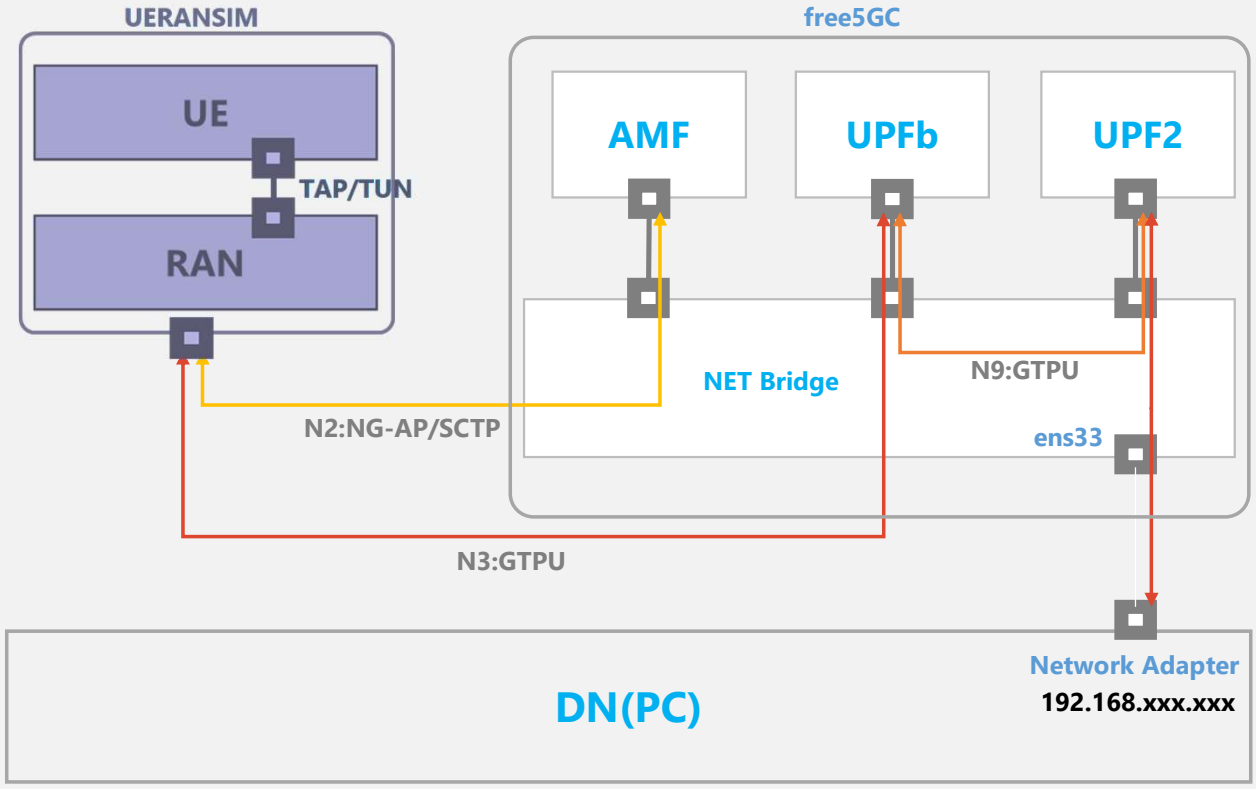
UERANSIM

```
# This is the network config written by 'subiquity'
network:
  ethernets:
    ens33:
      dhcp4: false
      addresses: [192.168.220.130/24]
      gateway4: 192.168.220.2
      nameservers:
          addresses: [1.1.1.1,8.8.8.8]
    ens34:
      dhcp4: true
  version: 2
```

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

III. TESTBED 2 (2 VM)

❖ 실습 구성



부록 1. KUBERNETES 설치

❖ 'Ubuntu Server 16.04/18.04' 설정

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

- 호스트 이름 변경 -

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

- Root 활성화 -

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

- Root 계정 생성 -

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

- SSH Well-known Port 변경 -

```
sudo nano /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 @ Remote -

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

- 고정 IP 주소 설정-

```
sudo nano /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)
```

- Remote for sshd @ Putty

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

III. TESTBED 2 (2 VM)

❖ Testing UERANSIM against free5gc:

- **SSH into free5gc. If you have rebooted free5gc, remember to do:**

✓sudo sysctl -w net.ipv4.ip_forward=1
✓sudo iptables -t nat -A POSTROUTING -o ens33 -j MASQUERADE
✓sudo systemctl stop ufw

✓sudo iptables -I FORWARD 1 -j ACCEPT

✓cd ~/free5gc
✓./run.sh

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

III. TESTBED 2 (2 VM)

❖ 선택 (UERANSIM용 별도 VM 생성시): Setting free5gc and UERANSIM Parameters

- In free5gc VM, we need to edit three files:
  - ✓ ~/free5gc/config/amfcfg.yaml
  - ✓ ~/free5gc/config/smfcfg.yaml
  - ✓ ~/free5gc/NFs/upf/build/config/upfcfg.yaml

```
jslab@free5gc:~$ sudo nano ~/free5gc/config/smfcfg.yaml
```

```
...
  interfaces: # Interface list for this UPF
   - interfaceType: N3 # the type of the interface (N3 or N9)
     endpoints: # the IP address of this N3/N9 interface on this UPF
       - 127.0.0.8
```

```
...
  interfaces: # Interface list for this UPF
   - interfaceType: N3 # the type of the interface (N3 or N9)
     endpoints: # the IP address of this N3/N9 interface on this UPF
       - 192.168.50.229  # 127.0.0.8
```


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

```
jslab@free5gc:~$ sudo nano ~/free5gc/config/amfcfg.yaml
```

```
...
  ngapIpList:  # the IP list of N2 interfaces on this AMF
  - 127.0.0.18
```

```
...
  ngapIpList:  # the IP list of N2 interfaces on this AMF
  - 192.168.50.229  # 127.0.0.8
```

```
jslab@free5gc:~$ sudo nano ~/free5gc/NFs/upf/config/upfcfg.yaml
```

```
...
  gtpu:
  - addr: 127.0.0.8
```

```
...
  gtpu:
  - addr: 192.168.50.229  # 127.0.0.8
```

III. TESTBED 2 (2 VM)

❖ 선택 (UERANSIM용 별도 VM 생성시): Setting UERANSIM:

- In the ueransim VM, there are two files related to free5gc:
  - ✓ ~/UERANSIM/config/free5gc-gnb.yaml
  - ✓ ~/UERANSIM/config/free5gc-ue.yaml

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

```
jslab@jslab-ueransim1:~$ sudo nano ~/UERANSIM/config/free5gc-gnb.yaml
```

```
...
link: 127.0.0.1    # gNB's local IP address for Radio Link Simulation (Usually same with local IP)
ngapIp: 127.0.0.1  # gNB's local IP address for N2 Interface (Usually same with local IP)
gtpIp: 127.0.0.1   # gNB's local IP address for N3 Interface (Usually same with local IP)

# List of AMF address information
amfConfigs:
  - address: 127.0.0.1
```

```
...
  link: 192.168.50.230   # 127.0.0.1  # gNB's local IP address for Radio Link Simulation (Usually same with local IP)
  ngapIp: 192.168.50.230  # 127.0.0.1   # gNB's local IP address for N2 Interface (Usually same with local IP)
  gtpIp: 192.168.50.230  # 127.0.0.1    # gNB's local IP address for N3 Interface (Usually same with local IP)

  # List of AMF address information
  amfConfigs:
    - address: 192.168.50.230  # 127.0.0.1
```

III. TESTBED 2 (2 VM)

❖ 선택 (UERANSIM용 별도 VM 생성시): Setting UERANSIM:

- In the ueransim VM, there are two files related to free5gc:
  - ✓ ~/UERANSIM/config/free5gc-gnb.yaml
  - ✓ ~/UERANSIM/config/free5gc-ue.yaml

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

```
jslab@jslab-ueransim1:~$ sudo nano ~/UERANSIM/config/free5gc-ue.yaml
```

```
# IMSI number of the UE. IMSI = [MCC|MNC|MSISDN] (In total 15 or 16 digits)
supi: 'imsi-208930000000003'
# Mobile Country Code value
mcc: '208'
# Mobile Network Code value (2 or 3 digits)
mnc: '93'

# Permanent subscription key
key: '8baf473f2f8fd09487cccbd7097c6862'
# Operator code (OP or OPC) of the UE
op: '8e27b6af0e692e750f32667a3b14605d'
# This value specifies the OP type and it can be either 'OP' or 'OPC'
opType: 'OP'
# Authentication Management Field (AMF) value
amf: '8000'
# IMEI number of the device. It is used if no SUPI is provided
imei: '356938035643803'
# IMEISV number of the device. It is used if no SUPI and IMEI is provided
imeiSv: '4370816125816151'
```

```
# List of gNB IP addresses for Radio Link Simulation
gnbSearchList:
  - 192.168.50.230

# Initial PDU sessions to be established
sessions:
  - type: 'IPv4'
    apn: 'internet'
    slice:
      sst: 0x01
      sd: 0x010203

# List of requested S-NSSAIs by this UE
slices:
  - sst: 0x01
    sd: 0x010203
```

III. TESTBED 2 (2 VM)

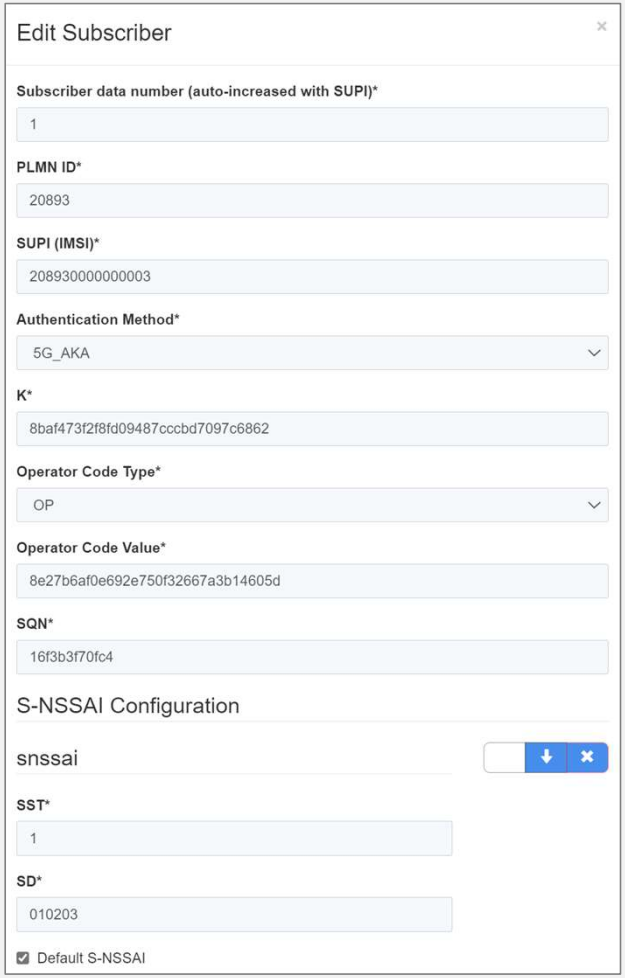
- **WebUI (admin/free5gc)**

AMF Information [SUPI:imsi-208930000000003]

Information Entity	Value
AccessType	3GPP_ACCESS
CmState	CONNECTED
Guti	20893cafe0000000003
Mcc	208
Mnc	93
Supi	imsi-208930000000003
Tac	000001
Dnn	internet
PduSessionId	1
Sd	010203
SmContextRef	urn:uuid:229c36e9-78fb-456a-8e67-6f7fbae34b37
Sst	1

SMF Information [SUPI:imsi-208930000000003]

Information Entity	Value
AnType	3GPP_ACCESS
Dnn	internet
LocalSEID	
PDUAddress	10.60.0.1
PDUSessionID	1
RemoteSEID	
Sd	010203
Sst	1



III. TESTBED 2 (2 VM)

❖ **After reboot with UERANSIM@Ubuntu.Server

- ./run.sh # @ free5gc
- go run server.go # @ free5gc/webconsole (admin/free5gc)
- sudo ./nr-gnb -c ../config/free5gc-gnb.yaml # gNB
- sudo build/nr-ue -c config/free5gc-ue.yaml # UE
- ping -I uesimtun0 google.com # ping

https://github.com/free5gc/free5gc/wiki/Installation

```
cd gtp5g
make
sudo make install
```

5G 코어 실행
```
jslab@free5gc:~/free5gc$ ./run.sh
```

웹콘솔실행
```
jslab@free5gc:~/free5gc/webconsole$ go run server.go
```

gNB실행
```
jslab@free5gc:~/UERANSIM/build$ sudo ./nr-gnb -c ../config/free5gc-gnb.yaml
```

UE실행
```
jslab@free5gc:~/UERANSIM$ sudo build/nr-ue -c config/free5gc-ue.yaml
```

Ping 실행
```
jslab@free5gc:~$ ping -I uesimtun0 google.com
```

sudo tar -C /usr/local -zxvf go1.17.8.linux-amd64.tar.gz @ free5gc

Source: https://github.com/free5gc/free5gc/wiki/Installation

III. TESTBED 2 (2 VM)

❖ **After rebootwith UERANSIM@Ubuntu.Desktop

- sudo ./nr-gnb -c ../config/free5gc-gnb.yaml # gNB
- sudo build/nr-ue -c config/free5gc-ue.yaml # UE
- ping -I uesimtun0 google.com # ping

gNB실행

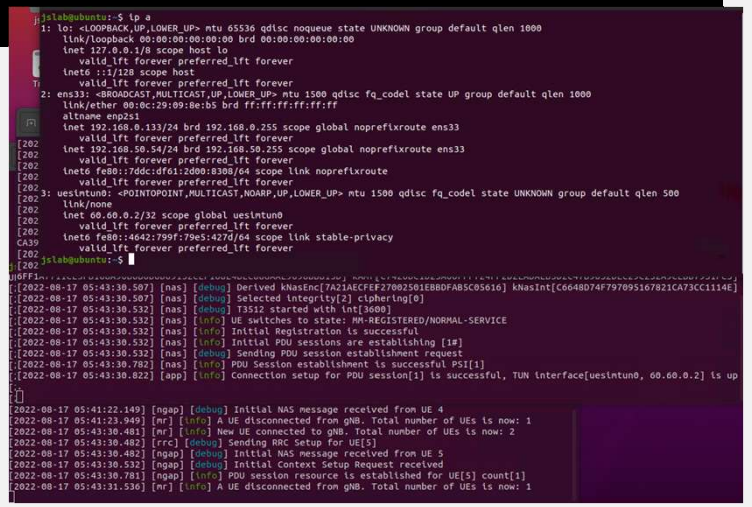
```
jslab@free5gc:~/UERANSIM/build$ sudo ./nr-gnb -c ../config/free5gc-gnb.yaml
```

UE실행

```
jslab@free5gc:~/UERANSIM$ sudo build/nr-ue -c config/free5gc-ue.yaml
```

Ping 실행

```
jslab@free5gc:~$ ping -I uesimtun0 google.com
```



IV. Testbed 3 (Cloud Native)

IV. TESTBED 3 (CLOUD NATIVE)

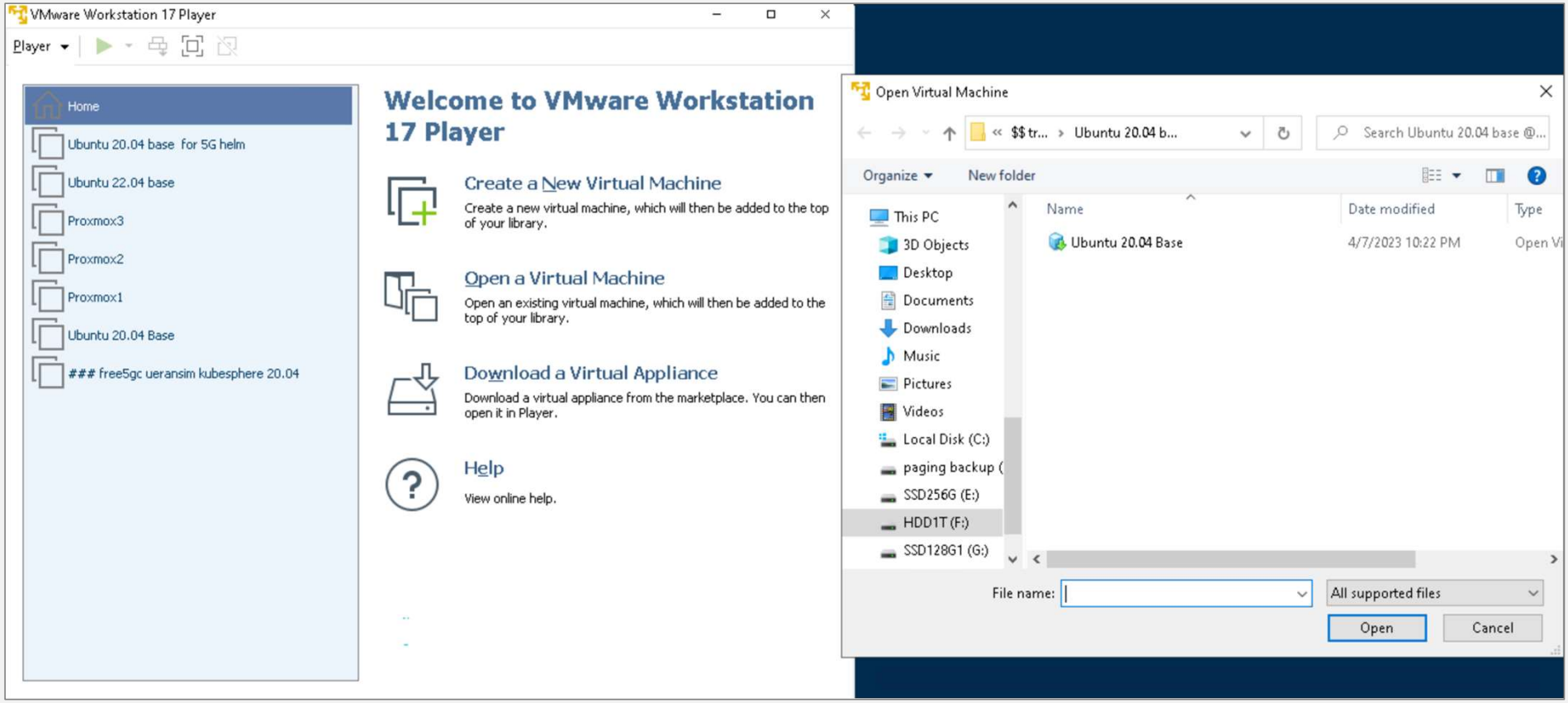
❖ **Prerequisites for Setup free5gc on one single one**

- A Kubernetes cluster supporting SCTP
- Kubernetrs worker nodes with kernel 5.0.0-23-generic and containing gtp5g kernel module (required for the Free5GC UPF element).
- Multus-CNI.
- Helm3.
- Kubectl (optional).
- A Persistent Volume (size 8Gi).
- A physical network interface on each Kubernetes node named eth0.
- A physical network interface on each Kubernetes node named eth1 to connect the UPF to the Data Network.

Source: https://github.com/Orange-OpenSource/towards5gs-helm/blob/main/docs/demo/Setup-free5gc-and-test-with-UERANSIM.md

IV. TESTBED 3 (CLOUD NATIVE)

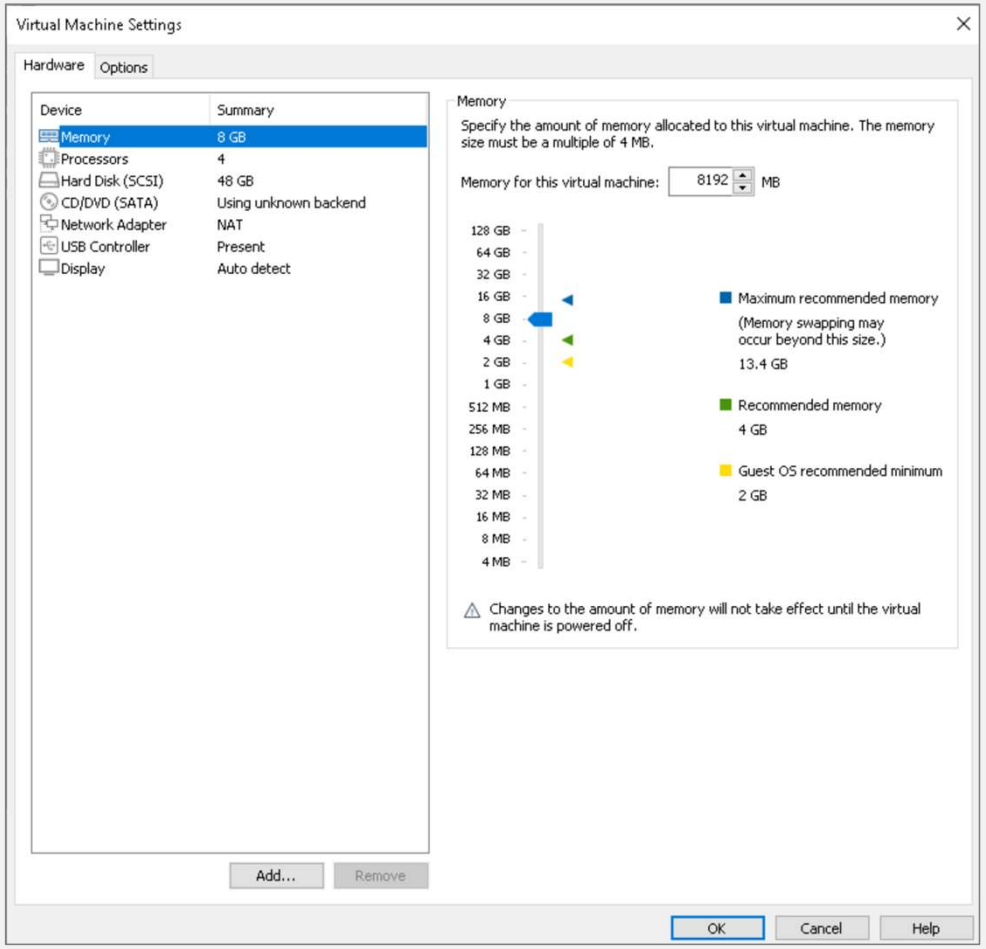
❖ Open a Virtual Machine



IV. TESTBED 3 (CLOUD NATIVE)

❖ VMware Workstation Player

1. vCPU: 4
2. vRAM: 8GB
3. Network(NAT): 192.168.42.100/24
4. Add Network (Bridge)
5. Uncheck Accelerate 3D Graphic @ Display



부록 참조

IV. TESTBED 3 (CLOUD NATIVE)

❖ Changes in configuration files

- **Setting Static IP Address (선택@콘솔)**
  - cd /etc/netplan
  - ls
  - cat 00-installer-config.yaml
  - **sudo nano /etc/netplan/00-installer-config.yaml**
  - **sudo netplan try**
  - **sudo netplan apply**
  - **ip a**
  - **sudo apt install net-tools**
  - **route**
- **Change hostname**
  - sudo nano /etc/hostname
  - sudo nano /etc/hosts
  - sudo reboot
- **sudo apt-get update**
- **sudo apt upgrade**

```
# This is the network config written by 'subiquity'
network:
  ethernets:
    ens33:
      dhcp4: false
      addresses: [192.168.220.128/24]
      routes:
          - to: default
            via: 192.168.220.2
      nameservers:
         addresses: [1.1.1.1,8.8.8.8]
  version: 2
```

IV. TESTBED 3 (CLOUD NATIVE)

❖ Prerequisite for Free5GC@Helm

- sudo touch /etc/systemd/network/eth0.netdev
- sudo touch /etc/systemd/network/eth0.network
- sudo nano /etc/systemd/network/eth0.netdev

```
=========
[NetDev]
Name=eth0
Kind=dummy
=========
```

- sudo nano /etc/systemd/network/eth0.network

```
=========
[Match]
Name=eth0
[Network]
Address=10.100.50.100
Mask=255.255.255.0
=========
```

- sudo systemctl restart systemd-networkd
- ip a

❖ Prerequisite for Free5GC@Helm

- sudo touch /etc/systemd/network/eth1.netdev
- sudo touch /etc/systemd/network/eth1.network
- sudo nano /etc/systemd/network/eth1.netdev

```
=========
[NetDev]
Name=eth1
Kind=dummy
=========
```

- sudo nano /etc/systemd/network/eth1.network

```
=========
[Match]
Name=eth1
[Network]
Address=10.100.100.100
Mask=255.255.255.0
=========
```

- sudo systemctl restart systemd-networkd
- ip a

Source: https://medium.com/@chauhan.inderpreet/5g-core-free5gc-on-kubernetes-microk8s-fa23104891f7

IV. TESTBED 3 (CLOUD NATIVE)

❖ Kubernetes and Helm

- **Pod:** 쿠버네티스 포드는 Linux 컨테이너를 하나 이상 모아 놓은 것으로, 쿠버네티스 애플리케이션의 최소 단위, 강하게 결합된 여러 개의 컨테이너로 구성된 포드도 있고, 단일 컨테이너로만 이루어진 포드도 있다.
- **Service:** 쿠버네티스의 서비스(Service)는 파드에 탑재된 애플리케이션이 외부와 상호 통신이 가능하도록 만들어준다. Pod가 서버와 같이 영구적인 것이 아니라 일회적인 것이기 때문에 문제가 생기면 문제가 생긴 Pod를 삭제한 뒤 새로운 Pod를 생성하며 가변적 Service를 생성한다.
- **Namespace:** 쿠버네티스에서, 네임스페이스 는 단일 클러스터 내에서의 리소스 그룹 격리 메커니즘을 제공한다. 리소스의 이름은 네임스페이스 내에서 유일해야 하며, 네임스페이스 간에서 유일할 필요는 없다. 네임스페이스 기반 스코핑은 네임스페이스 기반 오브젝트 (예: 디플로이먼트, 서비스 등) 에만 적용 가능하며 클러스터 범위의 오브젝트 (예: 스토리지클래스, 노드, 퍼시스턴트볼륨 등) 에는 적용 불가능하다.
- **Helm(헬름):** 헬름은 쿠버네티스 차트를 관리하기 위한 도구이다. 차트는 사전 구성된 쿠버네티스 리소스의 패키지다.
- **Multus CNI:** Multus CNI는 단일 Pod에 여러 네트워크 인터페이스를 연결하고 각각을 다른 주소 범위로 연결할 수 있도록 하는 고급 네트워크 구성 기능을 제공하는 CNI 플러그인

Source: https://aws.amazon.com/blogs/opensource/open-source-mobile-core-network-implementation-on-amazon-elastic-kubernetes-service/

IV. TESTBED 3 (CLOUD NATIVE)

❖ Deploying 5G core network with Free5GC, Kubernetes and Helm

1. git clone https://github.com/PrinzOwO/gtp5g.git
2. cd gtp5g/
3. sudo apt install make
4. sudo apt install gcc
5. make
6. sudo make install
7. lsmod|grep -i gtp

```
sudo su - root
cd /home/jslab/multus-cni/
```

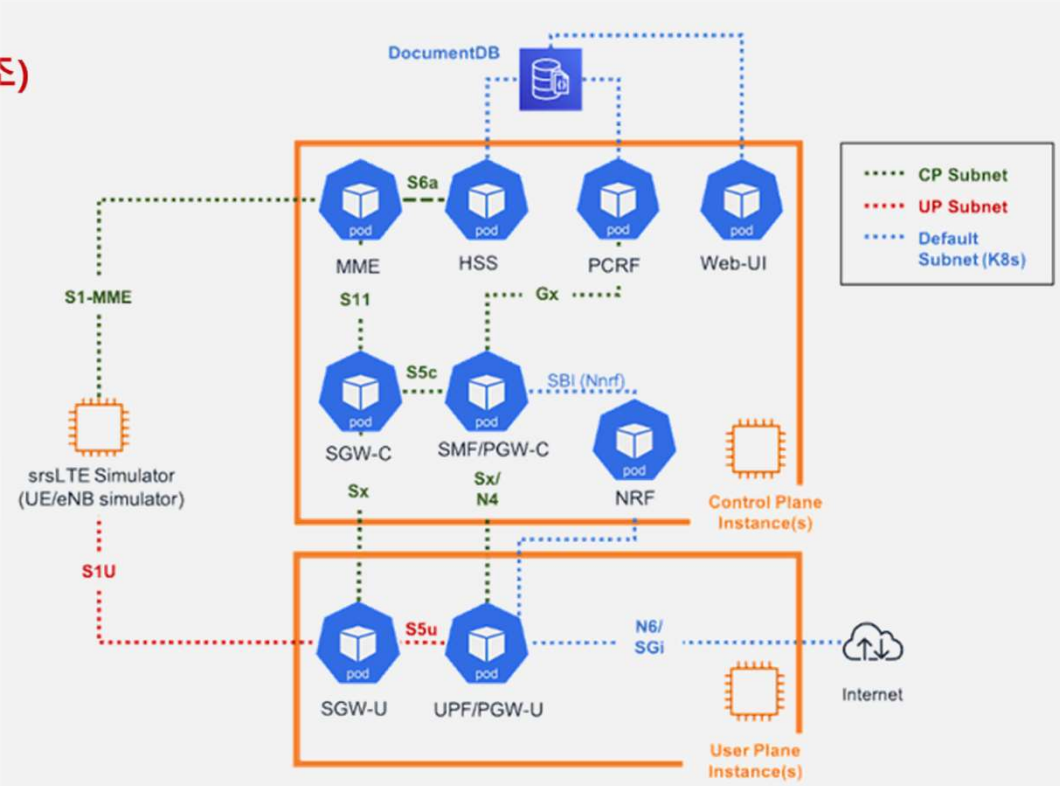
UPF는 예전의 gtp5g 문제가 있어서 오래된 20.04를 사용합니다 (이번에는 여러 사정으로 인해 Master Node만 22.04를 사용합니다).

Source: https://qiita.com/wzm/items/0dbe928ed891d82380d6
Source: https://qiita.com/wzm/items/5c8a9ca811c146b0142c

IV. TESTBED 3 (CLOUD NATIVE)

❖ Kubernetes 설치

- Kubernetes 설치 (87쪽 '부록 1. Kubernetes 설치' 참조)
- Helm Operations (107쪽 '부록 2. Helm Operations' 참조)



Source: https://medium.com/@chauhan.inderpreet/5g-core-free5gc-on-kubernetes-microk8s-fa23104891f7

IV. TESTBED 3 (CLOUD NATIVE)

❖ Deploying 5G core network with Open5GS, Kubernetes and Helm

```
sudo su - root
cd /home/jslab/multus-cni/
```

1. sudo kubectl version -o yaml
2. sudo helm list -A
3. git clone https://github.com/k8snetworkplumbingwg/multus-cni.git && cd multus-cni
4. dir
5. cd deployments
6. cat multus-daemonset-thick.yml | kubectl apply -f -
7. sudo kubectl get pods --all-namespaces
8. helm repo add jslabrepo5gs https://gradiant.github.io/openverso-charts/
9. helm repo update
10. helm repo list
11. helm search repo
12. sudo kubectl create namespace jslab5gs
13. sudo helm -n jslab5gs install jslab5gs-v1 jslabrepo5gs/open5gs
14. sudo helm -n jslab5gs uninstall jslab5gs-v1
15. kubectl get svc -n jslab5gs
16. watch kubectl get pods -n jslab5gs
17. helm show values jslabrepo5gs/open5gs

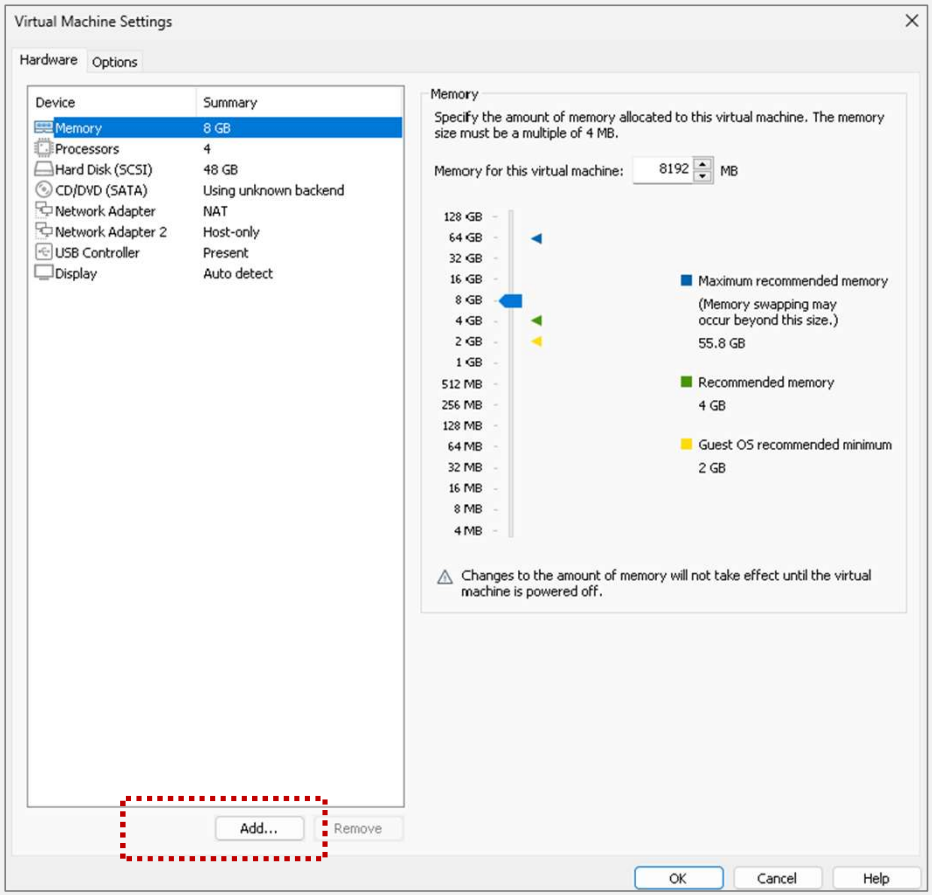
Add vNIC(host only adapter) for WebUI

IV. TESTBED 3 (CLOUD NATIVE)

❖ Deploying 5G core network with Open5GS, Kubernetes and Helm

- Add vNIC(host only adapter)

```
# This is the network config written by 'subiquity'
network:
  ethernets:
    ens33:
      dhcp4: false
      addresses: [192.168.220.128/24]
      routes:
          - to: default
            via: 192.168.220.2
      nameservers:
         addresses: [1.1.1.1,8.8.8.8]
    ens34:
      dhcp4: true
  version: 2
```

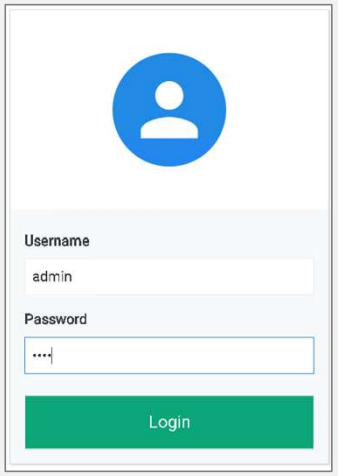


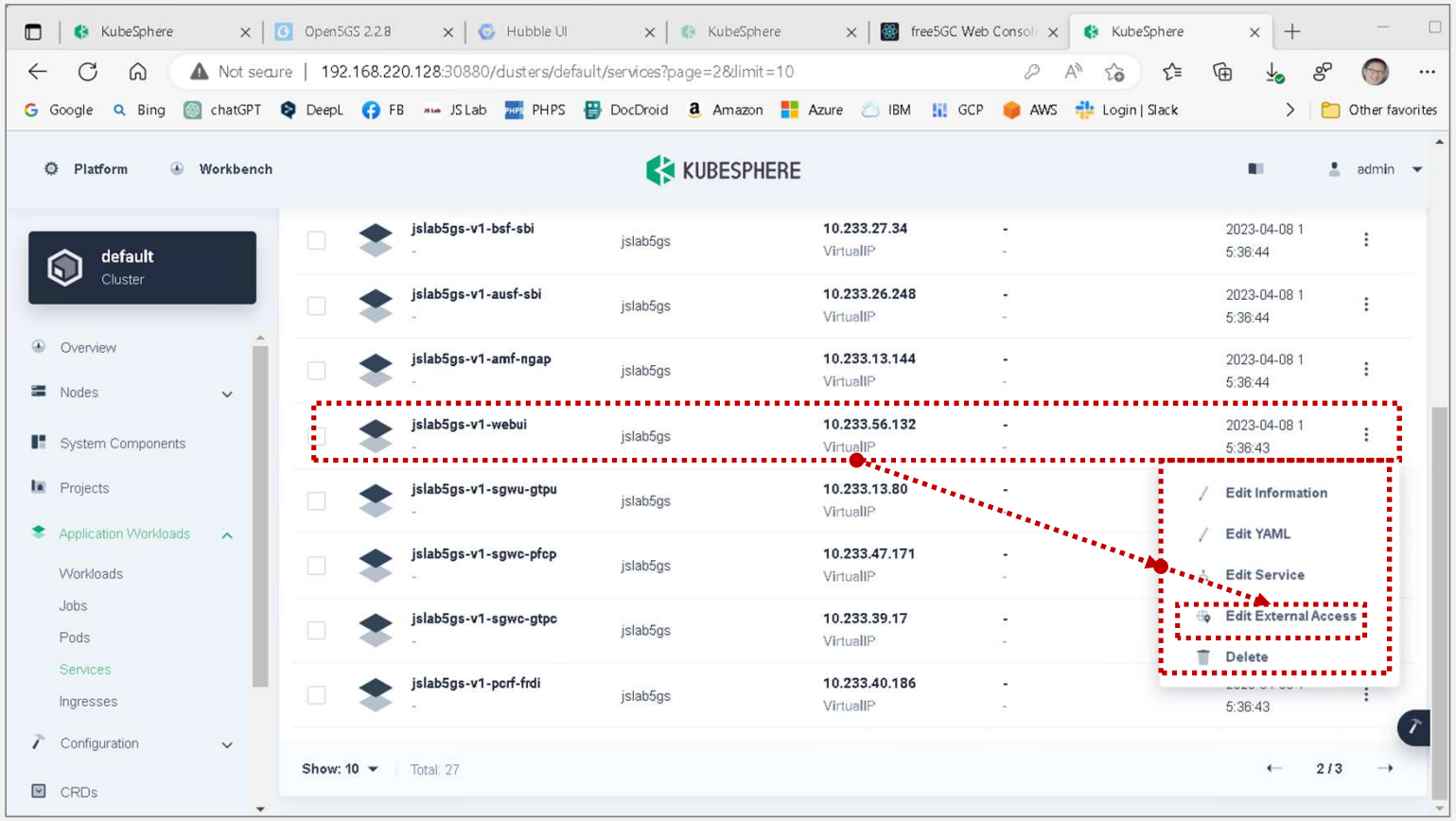
IV. TESTBED 3 (CLOUD NATIVE)

❖ External WebUI

1. **WebUI**
2. **Extension**
3. **Exit Eternal Access (NodePort)**

Username : admin
Password : 1423

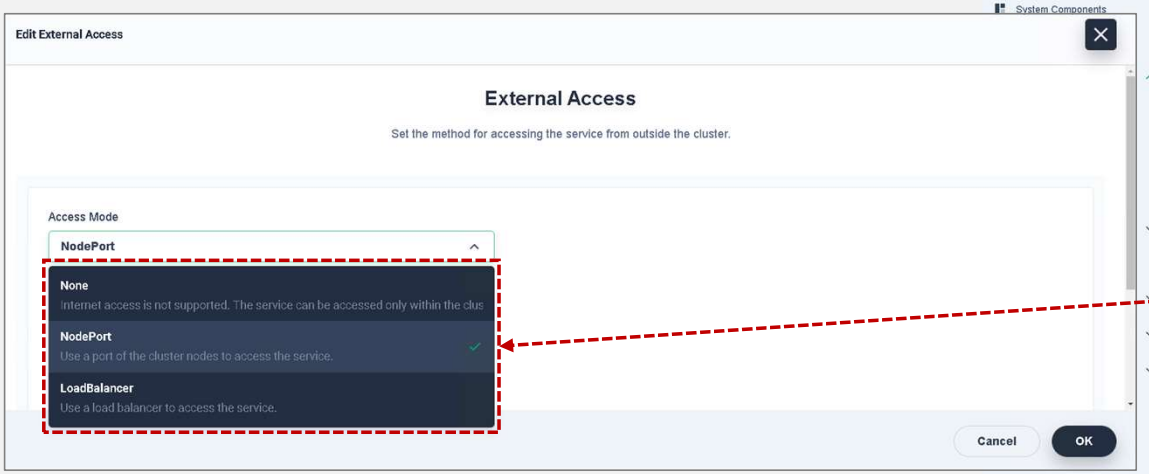


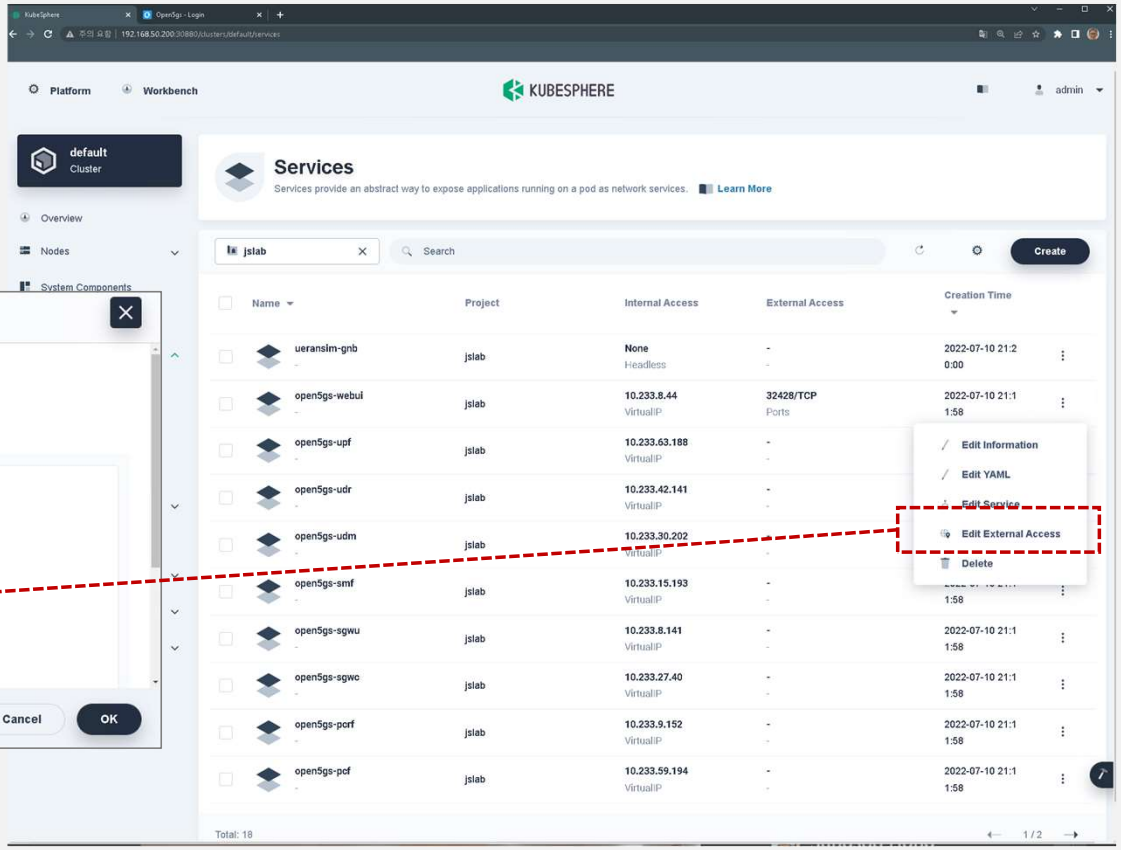


IV. TESTBED 3 (CLOUD NATIVE)

❖ Deploying 5G core network on Kubernetes: 포트 노출 정책

1. None
2. External Access for NodePort
3. External Access for LoadBalancer





IV. TESTBED 3 (CLOUD NATIVE)

❖ Helm Chart to deploy UERANSIM (선택)

1. helm search repo
2. sudo helm -n jslab5gs install ueransim-gnb jslabrepo5gs/ueransim-gnb
3. sudo helm -n jslab5gs uninstall ueransim-gnb
4. sudo helm -n jslab5gs install ueransim-ues jslabrepo5gs/ueransim-ues
5. sudo helm -n jslab5gs uninstall ueransim-ues

```
root@jslab:~# sudo helm -n jslab5gs install ueransim-gnb jslabrepo5gs/ueransim-gnbNAME: ueransim-gnb
LAST DEPLOYED: Sat Apr  8 07:34:17 2023
NAMESPACE: jslab5gs
STATUS: deployed
REVISION: 1
TEST SUITE: None
NOTES:
ueransim-gnb successfully installed!
Check gnodeb log with:
```
kubectl -n jslab5gs logs deployment/ueransim-gnb
```
--
No embedded ues where deployed.

You can deploy ues connected to this gnodeb with openverso/ueransim-ues chart:
```
helm install -n jslab5gs ueransim-ues openverso/ueransim-ues --set gnb.hostname=ueransim-gnb
```
```

IV. TESTBED 3 (CLOUD NATIVE)

❖ Helm Chart to deploy UERANSIM

1. helm show values jslabrepo5gs/ueransim-gnb

```
name: ueransim-gnb
amf:
  # if set amf.ip takes precedence over amf.hostname
  ip: ""
  hostname: open5gs-amf-ngap
interfaces:
  n2:
    dev: eth0
  n3:
    dev: eth0
  radio:
    dev: eth0
mcc: '999'
mnc: '70'
sst: 1
sd: "0x111111"
tac: '0001'
```

```
resources:
  limits: {}
  requests: {}
podSecurityContext:
  enabled: false
containerSecurityContext:
  enabled: false
podLabels: {}
podAnnotations: {}
affinity: {}
nodeSelector: {}
tolerations: []
```

```
ues:
  enabled: false
  count: 1
  initialMSISDN: '0000000001'
  key: 465B5CE8B199B49FAA5F0A2EE238A6BC
  op: E8ED289DEBA952E4283B54E88E6183CA
  opType: OPC
  apnList:
    - type: 'IPv4'
      apn: 'internet'
      slice:
        sst: 1
        sd: "0x111111"
      emergency: false
  resources:
    limits: {}
    requests: {}
  podSecurityContext:
    enabled: false
  containerSecurityContext:
    enabled: false
  podLabels: {}
  podAnnotations: {}
  affinity: {}
  nodeSelector: {}
  tolerations: []
```

부록 2. HELM OPERATIONS

❖ Prerequisite for Free5GC@Helm

- sudo touch /etc/systemd/network/eth0.netdev
- sudo touch /etc/systemd/network/eth0.network
- sudo nano /etc/systemd/network/eth0.netdev

```
=========
[NetDev]
Name=eth0
Kind=dummy
=========
```

- sudo nano /etc/systemd/network/eth0.network

```
=========
[Match]
Name=eth0
[Network]
Address=10.100.50.100
Mask=255.255.255.0
=========
```

- sudo systemctl restart systemd-networkd
- ip a

❖ Prerequisite for Free5GC@Helm

- sudo touch /etc/systemd/network/eth1.netdev
- sudo touch /etc/systemd/network/eth1.network
- sudo nano /etc/systemd/network/eth1.netdev

```
=========
[NetDev]
Name=eth1
Kind=dummy
=========
```

- sudo nano /etc/systemd/network/eth1.network

```
=========
[Match]
Name=eth1
[Network]
Address=10.100.100.100
Mask=255.255.255.0
=========
```

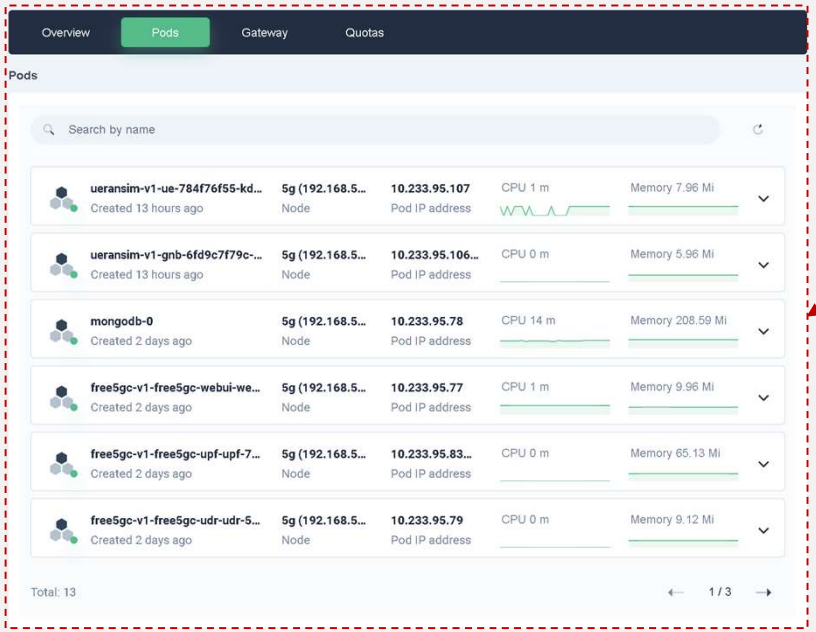
- sudo systemctl restart systemd-networkd
- ip a

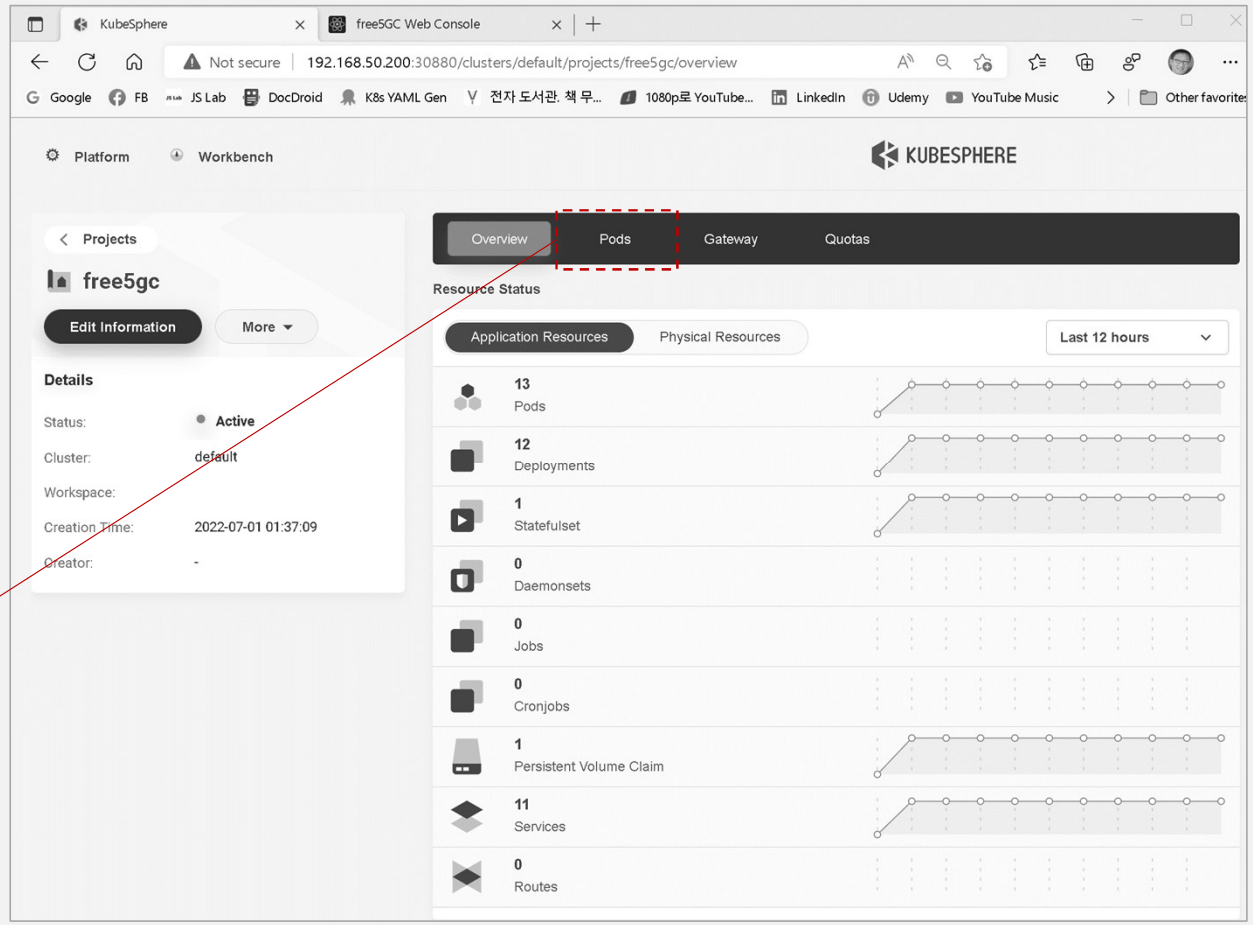
Source: https://medium.com/@chauhan.inderpreet/5g-core-free5gc-on-kubernetes-microk8s-fa23104891f7

IV. TESTBED 3 (CLOUD NATIVE)

❖ 오픈소스 5G Core (예)

- Cloud Native (K8s)
- Project
- Pods (CPU/Memory/...)

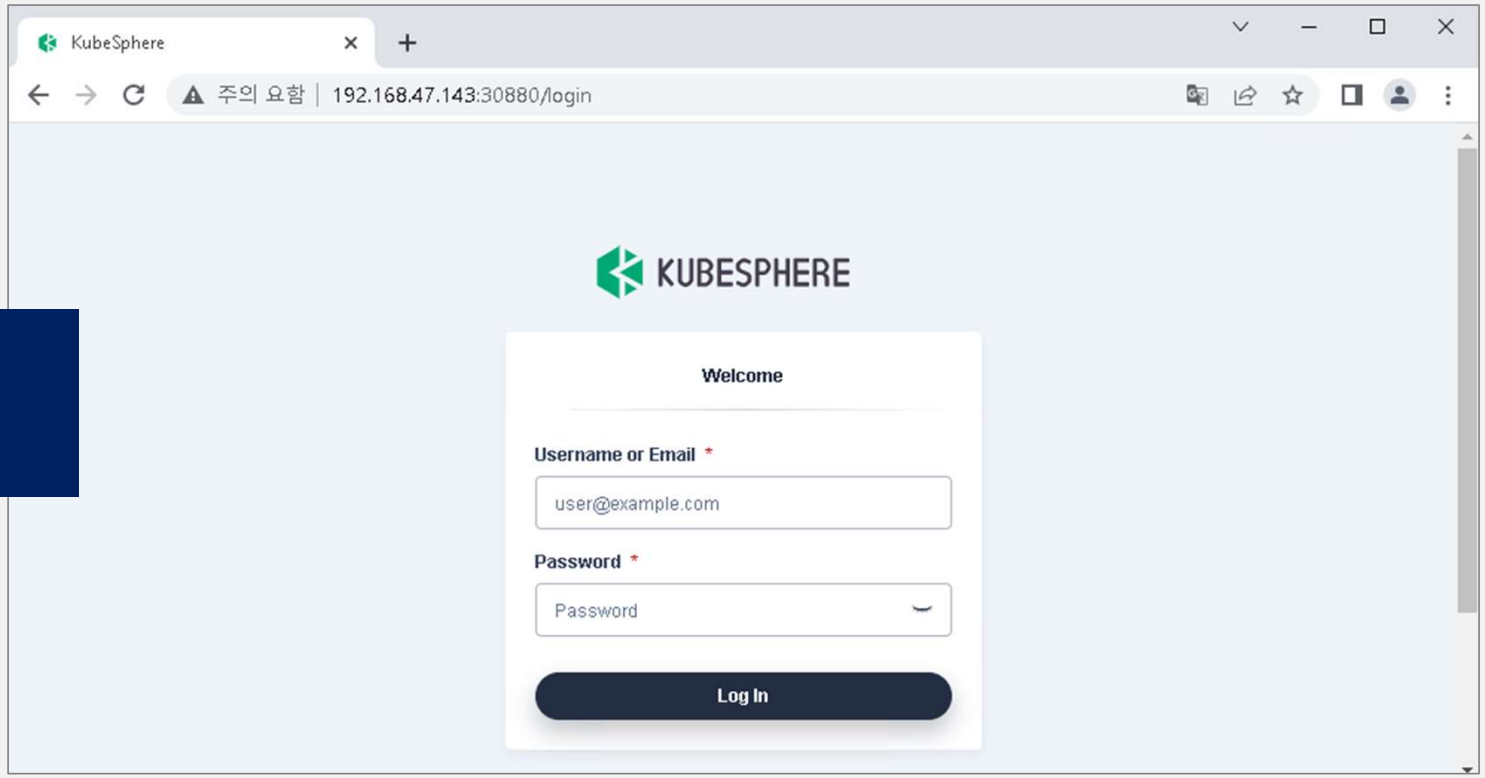




IV. TESTBED 3 (CLOUD NATIVE)

❖ Dashboard

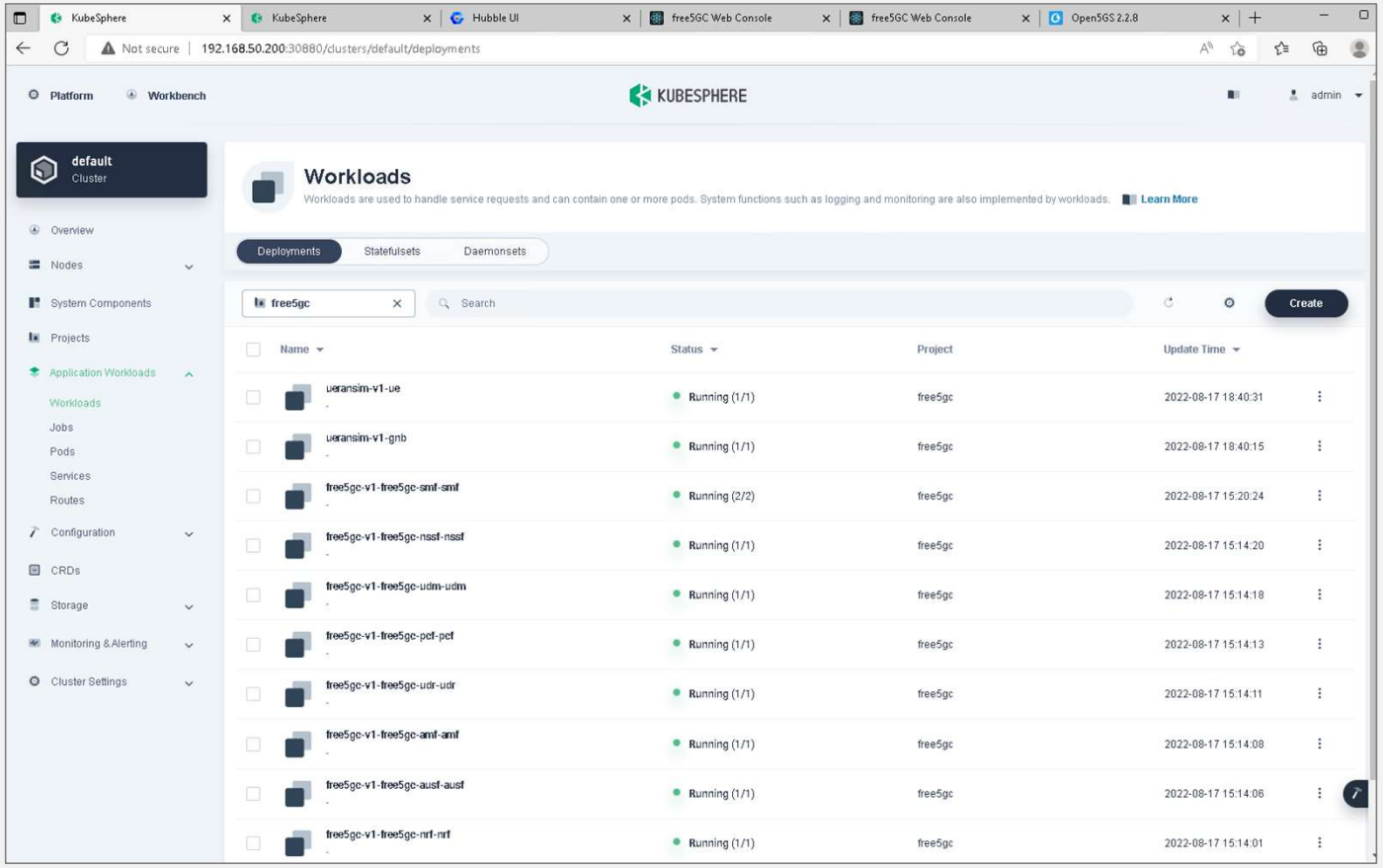
- http://127.0.0.1:30880




```
Console: http://127.0.0.1:30880
Account: admin
Password:JSLab123
```

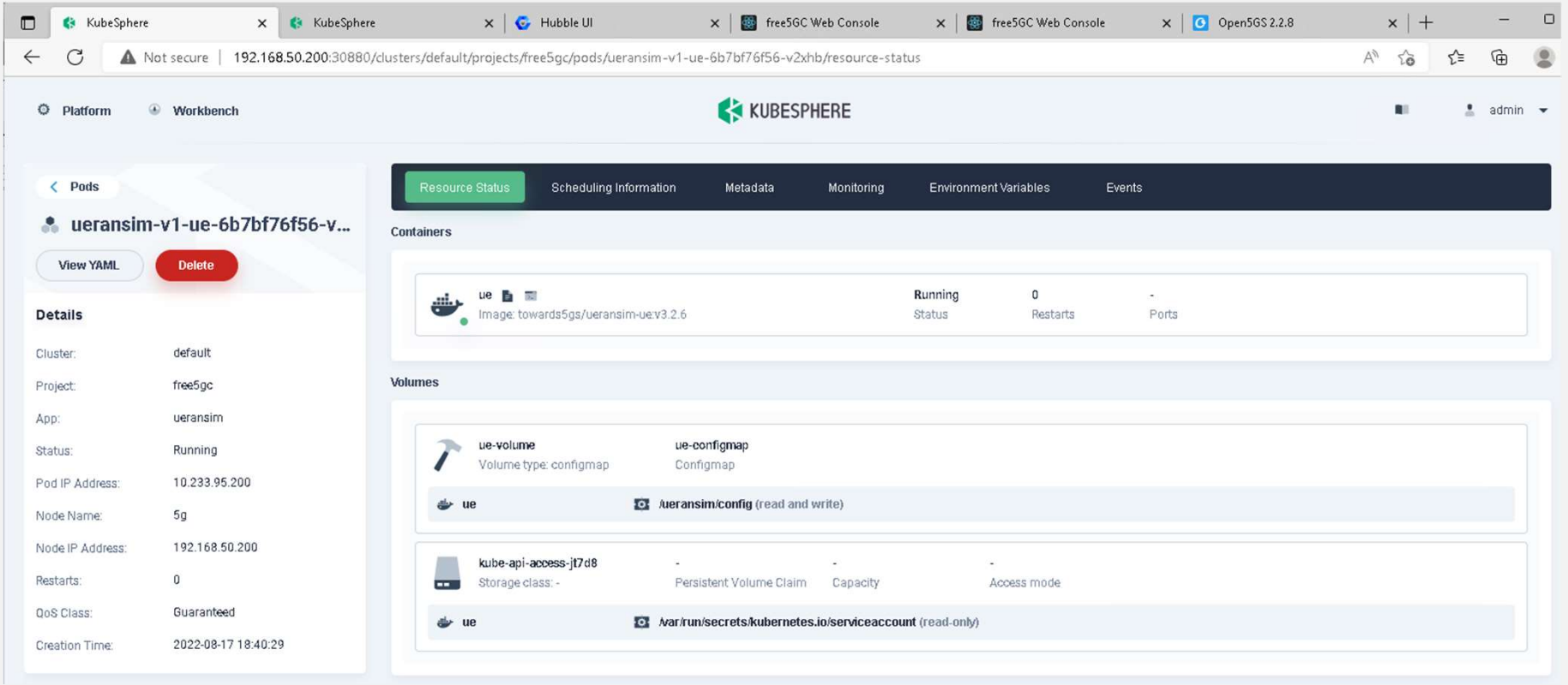
IV. TESTBED 3 (CLOUD NATIVE)

❖ Cloud Native @ KubeSphere



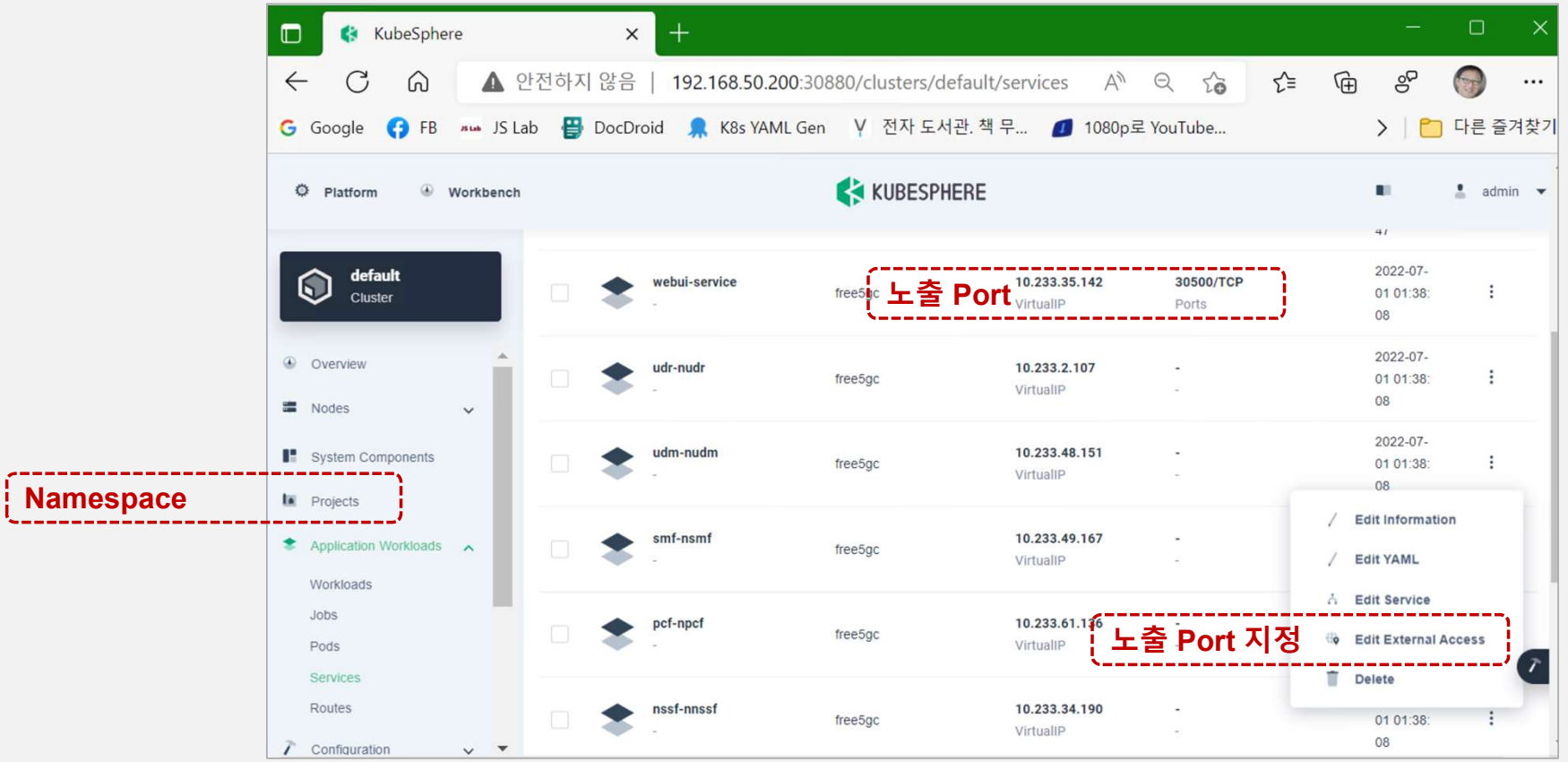
IV. TESTBED 3 (CLOUD NATIVE)

❖ Cloud Native @ KubeSphere



IV. TESTBED 3 (CLOUD NATIVE)

❖ 노출 포트 지정



IV. TESTBED 3 (CLOUD NATIVE)

❖ Deploying 5G core network (예: Free5GC @ Kubernetes and Helm)

```
root@5g:~# helm show values towards5gs/free5gc
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2021 Orange
# SPDX-License-Identifier: Apache-2.0
#
# This software is distributed under the Apache License 2.0,
# the text of which is available at todo
# or see the "LICENSE" file for more details.
#
# Author: Abderaouf KHICHANE, Ilhem FAJJARI, Ayoub BOUSSELMI
# Software description: An open-source project providing Helm charts to deploy 5G components
#(Core + RAN) on top of Kubernetes
#
# Default values for free5gc-chart.
# This is a YAML-formatted file.
# Declare variables to be passed into your templates.

global:
  name: free5gc
  userPlaneArchitecture: single  # possible values are "single" and "ulcl"
  nrf:
    service:
      name: nrf-nnrf
      type: ClusterIP
      port: "8000"
      nodePort: "30800"
  sbi:
    scheme: http
```

```
amf:
   n2if:  # NGAP
     ipAddress: 10.100.50.249
   service:
     ngap:
       enabled: false
       name: amf-n2
       port: 38412
       nodeport: 31412
       protocol: SCTP
       type: NodePort
 smf:
   n4if:
     ipAddress: 10.100.50.244
 #Global network parametes
 n2network:
   name: n2network
   masterIf: eth0
   subnetIP: 10.100.50.248
   cidr: 29
   gatewayIP: 10.100.50.254
   excludeIP: 10.100.50.254
 n3network:
   name: n3network
   masterIf: eth0
   subnetIP: 10.100.50.232
   cidr: 29
   gatewayIP: 10.100.50.238
   excludeIP: 10.100.50.238
 n4network:
   name: n4network
   masterIf: eth0
   subnetIP: 10.100.50.240
   cidr: 29
   gatewayIP: 10.100.50.246
   excludeIP: 10.100.50.246
```

```
   n6network:
     name: n6network
     masterIf: eth1
     subnetIP: 10.100.100.0
     cidr: 24
     gatewayIP: 10.100.100.1
     excludeIP: 10.100.100.254
   n9network:
     name: n9network
     masterIf: eth0
     subnetIP: 10.100.50.224
     cidr: 29
     gatewayIP: 10.100.50.230
     excludeIP: 10.100.50.230


 # These parameters can be used to
 enable/disable deployment of subcharts
 deployMongoDB: true
 deployAMF: true
 deployAUSF: true
 deployN3IWF: false
 deployNRF: true
 deployNSSF: true
 deployPCF: true
 deploySMF: true
 deployUDM: true
 deployUDR: true
 deployUPF: true
 deployWEBUI: true
```

```
# Disable the deployment of mongodb as an NRF
subchart
free5gc-nrf:
  db:
    enabled: false

# This section can be used to override the
default values in the MongoDB chart (remember
MongoDB is a subchart of the
free5gcControlplane chart since control plane
NFs rely on it.
mongodb:
  fullnameOverride: "mongodb"
  useStatefulSet: true
  auth:
    enabled: false
  persistence:
    size: 6Gi
    mountPath: /bitnami/mongodb/data/db/
  service:
    name: mongodb
    type: ClusterIP
    port: 27017
    nodePort: "30017"
```

Note: https://helm.sh/docs/intro/using_helm/

IV. TESTBED 3 (CLOUD NATIVE)

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm

- helm show values jslabrepo5gs/ueransim-gnb

```
root@jslab:~# helm show values jslabrepo5gs/ueransim-gnb
## @section Global parameters
## Global Docker image parameters
## Please, note that this will overr
global value
## Current available global Docker i

## @param global.imageRegistry Globa
## @param global.imagePullSecrets Gl
## @param global.storageClass Global
##
global:
  imageRegistry: ""
  ## E.g.
  ## imagePullSecrets:
  ##   - myRegistryKeySecretName
  ##
  imagePullSecrets: []
  storageClass: ""
```

```
## @section Common parameters

## @param kubeVersion Override Kubernetes version
##
kubeVersion: ""
## @param nameOverride String to
common.names.fullname
##
nameOverride: ""
## @param fullnameOverride Strin
common.names.fullname
##
fullnameOverride: ""
## @param commonLabels Labels to
objects
##
commonLabels: {}
## @param commonAnnotations Anno
deployed objects
##
commonAnnotations: {}
## @param clusterDomain Kubernet
name
##
clusterDomain: cluster.local
## @param extraDeploy Array of e
deploy with the release
##
extraDeploy: []
```

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

```
onfigured to use the
```

```
image:
  registry: docker.io
  repository: openverso/ueransim
  tag: 3.2.6
  ## Specify a imagePullPolicy
  ## Defaults to 'Always' if image tag is
'latest', else set to 'IfNotPresent'
  ## ref: http://kubernetes.io/docs/user-
guide/images/#pre-pulling-images
  ##
  pullPolicy: Always
  ## Optionally specify an array of
imagePullSecrets.
  ## Secrets must be manually created in the
namespace.
  ## ref:
https://kubernetes.io/docs/tasks/configure-pod-
container/pull-image-private-registry/
  ## e.g:
  ## pullSecrets:
  ##   - myRegistryKeySecretName
  ##
  pullSecrets: []
  ## Enable debug mode
  ##
  debug: false
```

```
name: ueransim-gnb
amf:
  # if set amf.ip takes
precedence over amf.hostname
  ip: ""
  hostname: open5gs-amf-ngap
interfaces:
  n2:
    dev: eth0
  n3:
    dev: eth0
  radio:
    dev: eth0
mcc: '999'
mnc: '70'
sst: 1
sd: "0x111111"
tac: '0001'

resources:
  limits: {}
  requests: {}
podSecurityContext:
  enabled: false
containerSecurityContext:
  enabled: false
podLabels: {}
podAnnotations: {}
affinity: {}
nodeSelector: {}
tolerations: []
```

```
ues:
  enabled: false
  count: 1
  initialMSISDN: '0000000001'
  key: 465B5CE8B199B49FAA5F0A2EE238A6BC
  op: E8ED289DEBA952E4283B54E88E6183CA
  opType: OPC
  apnList:
    - type: 'IPv4'
      apn: 'internet'
      slice:
        sst: 1
        sd: "0x111111"
      emergency: false
  resources:
    limits: {}
    requests: {}
  podSecurityContext:
    enabled: false
  containerSecurityContext:
    enabled: false
  podLabels: {}
  podAnnotations: {}
  affinity: {}
  nodeSelector: {}
  tolerations: []
```

IV. TESTBED 3 (CLOUD NATIVE)

❖ **K8s Operations** (as root)

- sudo kubectl get pods --all-namespaces

```
root@jslab:~# sudo kubectl get pods --all-namespaces
NAMESPACE                      NAME                                              READY   STATUS             RESTARTS       AGE
jslab5gs                       jslab5gs-v1-amf-58c966c965-9hnc9                  1/1     Running            0              22m
jslab5gs                       jslab5gs-v1-ausf-8486565658-qbxdm                 1/1     Running            0              22m
jslab5gs                       jslab5gs-v1-bsf-75854784b-clgcl                   1/1     Running            0              22m
jslab5gs                       jslab5gs-v1-hss-597ccffdd-w6h9b                   1/1     Running            5 (20m ago)    22m
jslab5gs                       jslab5gs-v1-mme-79b44bd76f-tb258                  1/1     Running            0              22m
jslab5gs                       jslab5gs-v1-mongodb-58c5f84cc9-4pnmr              1/1     Running            0              22m
jslab5gs                       jslab5gs-v1-nrf-698f64458b-dt8w6                  1/1     Running            0              22m
jslab5gs                       jslab5gs-v1-nssf-54cccb7c9d-5lj66                 1/1     Running            0              22m
jslab5gs                       jslab5gs-v1-open5gs-populate-bb874c8f-2b2r8       1/1     Running            0              22m
jslab5gs                       jslab5gs-v1-pcf-65956bf9bc-vrbb4                  1/1     Running            5 (20m ago)    22m
jslab5gs                       jslab5gs-v1-pcrf-647564bdb9-dsrqm                 1/1     Running            3 (20m ago)    22m
jslab5gs                       jslab5gs-v1-sgwc-ff6f6b596-cghsq                  1/1     Running            0              22m
jslab5gs                       jslab5gs-v1-sgwu-5797f549c6-hrkdd                 1/1     Running            0              22m
jslab5gs                       jslab5gs-v1-smf-c7bf5b64c-gl6mw                   1/1     Running            0              22m
jslab5gs                       jslab5gs-v1-udm-66b9c856b4-7h4sb                  1/1     Running            0              22m
jslab5gs                       jslab5gs-v1-udr-7c775f4fbc-fncg2                  1/1     Running            5 (20m ago)    22m
jslab5gs                       jslab5gs-v1-upf-bc79dd445-bvv9r                   1/1     Running            0              22m
jslab5gs                       jslab5gs-v1-webui-7cb68f88f9-dsprh                1/1     Running            0              22m
jslab5gs                       ueransim-gnb-6699d7bdb9-5lbfs                     0/1     CrashLoopBackOff   8 (91s ago)    17m
jslab5gs                       ueransim-ues-79679c9fc-prtkk                      1/1     Running            0              9m53s
kube-system                    calico-kube-controllers-69d878584c-72mvg          1/1     Running            2 (34m ago)    3h21m
kube-system                    calico-node-pjv8g                                 1/1     Running            2 (34m ago)    3h21m
kube-system                    coredns-b5648d655-2mn4x                           1/1     Running            2 (34m ago)    3h21m
kube-system                    coredns-b5648d655-qhnkd                           1/1     Running            2 (34m ago)    3h21m
kube-system                    kube-apiserver-jslab                              1/1     Running            2 (33m ago)    3h21m
kube-system                    kube-controller-manager-jslab                     1/1     Running            2 (34m ago)    3h21m
kube-system                    kube-multus-ds-6fw7t                              1/1     Running            2 (34m ago)    138m
kube-system                    kube-proxy-lsqtc                                  1/1     Running            2 (34m ago)    3h21m
kube-system                    kube-scheduler-jslab                              1/1     Running            2 (34m ago)    3h21m
kube-system                    nodelocaldns-69d69                                1/1     Running            2 (34m ago)    3h21m
kube-system                    openebs-localpv-provisioner-57bbf864d5-tsq46      1/1     Running            6 (34m ago)    3h21m
kube-system                    snapshot-controller-0                             1/1     Running            2 (34m ago)    3h19m
kubesphere-controls-system     default-http-backend-5bf68ff9b8-trg78             1/1     Running            2 (34m ago)    3h16m
kubesphere-controls-system     kubectl-admin-6dbcb94855-k966g                    1/1     Running            2 (33m ago)    3h7m
kubesphere-monitoring-system   alertmanager-main-0                               2/2     Running            4 (34m ago)    3h11m
kubesphere-monitoring-system   kube-state-metrics-687d66b747-g8xfv               3/3     Running            6 (34m ago)    3h12m
kubesphere-monitoring-system   node-exporter-tsgtg                               2/2     Running            4 (34m ago)    3h12m
kubesphere-monitoring-system   notification-manager-deployment-78664576cb-2b78s  2/2     Running            4 (33m ago)    3h9m
kubesphere-monitoring-system   notification-manager-operator-7d44854f54-nzgxd    2/2     Running            4 (34m ago)    3h10m
kubesphere-monitoring-system   prometheus-k8s-0                                  2/2     Running            4 (34m ago)    3h11m
kubesphere-monitoring-system   prometheus-operator-8955bbd98-x9fbh               2/2     Running            4 (34m ago)    3h12m
kubesphere-system              ks-apiserver-576fbd5df4-vpssv                     1/1     Running            2 (34m ago)    3h16m
kubesphere-system              ks-console-5c9fcbc67b-hzdn7                       1/1     Running            2 (34m ago)    3h16m
kubesphere-system              ks-controller-manager-f8dfd55c8-2t4v5             1/1     Running            2 (34m ago)    3h16m
kubesphere-system              ks-installer-85d6fb8c97-jznmk                     1/1     Running            2 (34m ago)    3h21m
root@jslab:~#
```

IV. TESTBED 3 (CLOUD NATIVE)

- kubectl exec -it -n jslab5gs jslab5gs-v1-amf-58c966c965-9hnc9 -- ip a
- kubectl exec -it -n jslab5gs jslab5gs-v1-smf-c7bf5b64c-gl6mw -- ip a

```
root@jslab:~# kubectl get pods -n jslab5gs
NAME                                      READY   STATUS
jslab5gs-v1-amf-58c966c965-9hnc9          1/1     Running
jslab5gs-v1-ausf-8486565658-qbxdm         1/1     Running
jslab5gs-v1-bsf-75854784b-clgcl           1/1     Running
jslab5gs-v1-hss-597ccffdd-w6h9b           1/1     Running
jslab5gs-v1-mme-79b44bd76f-tb258          1/1     Running
jslab5gs-v1-mongodb-58c5f84cc9-4pnmr      1/1     Running
jslab5gs-v1-nrf-698f64458b-dt8w6          1/1     Running
jslab5gs-v1-nssf-54cccb7c9d-5lj66         1/1     Running
jslab5gs-v1-open5gs-populate-bb874c8f-2b2r8   1/1     Running
jslab5gs-v1-pcf-65956bf9bc-vrbb4          1/1     Running
jslab5gs-v1-pcrf-647564bdb9-dsrqm         1/1     Running
jslab5gs-v1-sgwc-ff6f6b596-cghsq          1/1     Running
jslab5gs-v1-sgwu-5797f549c6-hrkdd         1/1     Running
jslab5gs-v1-smf-c7bf5b64c-gl6mw           1/1     Running
jslab5gs-v1-udm-66b9c856b4-7h4sb          1/1     Running
jslab5gs-v1-udr-7c775f4fbc-fncg2          1/1     Running
jslab5gs-v1-upf-bc79dd445-bvv9r           1/1     Running
jslab5gs-v1-webui-7cb68f88f9-dsprh        1/1     Running
ueransim-gnb-6699d7bdb9-5lbfs             0/1     CrashLoopBa
ueransim-ues-79679c9fc-prtkk              1/1     Running
```

```
root@jslab:~# kubectl exec -it -n jslab5gs jslab5gs-v1-amf-58c966c965-9hnc9 -- ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
2: tunl0@NONE: <NOARP> mtu 1480 qdisc noop state DOWN group default qlen 1000
    link/ipip 0.0.0.0 brd 0.0.0.0
4: eth0@if41: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1480 qdisc noqueue state UP group default
    link/ether 22:ee:24:f8:7f:94 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.233.114.128/32 scope global eth0
       valid_lft forever preferred_lft forever
```

```
      3 (26m ago)     28m
      0               28m
```

```
root@jslab:~# kubectl exec -it -n jslab5gs jslab5gs-v1-smf-c7bf5b64c-gl6mw -- ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
2: tunl0@NONE: <NOARP> mtu 1480 qdisc noop state DOWN group default qlen 1000
    link/ipip 0.0.0.0 brd 0.0.0.0
4: eth0@if37: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1480 qdisc noqueue state UP group default
    link/ether 8e:76:05:12:90:63 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.233.114.124/32 scope global eth0
       valid_lft forever preferred_lft forever
```

IV. TESTBED 3 (CLOUD NATIVE)

❖ Deploying 5G core network with open5GS, Kubernetes and Helm

1. helm repo add openverso https://gradiant.github.io/openverso-charts/
2. sudo kubectl create namespace jslabopenverso
3. helm repo update
4. helm repo list

KubeSphere Dashboard 확인
'project'

```
root@5g:~# helm repo add openverso https://gradiant.github.io/openverso-charts/
"openverso" has been added to your repositories
root@5g:~# sudo kubectl create namespace jslab
namespace/jslab created
root@5g:~# helm repo update
Hang tight while we grab the latest from your chart repositories...
...Unable to get an update from the "towards5gs" chart repository
(https://raw.githubusercontent.com/Orange-OpenSource/towards5gs-helm/main/repo/):
        Get "https://raw.githubusercontent.com/Orange-OpenSource/towards5gs-helm/main/repo/index.yaml":
dial tcp: lookup raw.githubusercontent.com on 127.0.0.53:53: read udp 127.0.0.1:52728->127.0.0.53:53:
i/o timeout
...Successfully got an update from the "openverso" chart repository
Update Complete. ⎈Happy Helming!⎈
root@5g:~# helm repo list
NAME            URL
towards5gs      https://raw.githubusercontent.com/Orange-OpenSource/towards5gs-helm/main/repo/
openverso       https://gradiant.github.io/openverso-charts/
```

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

Source: https://github.com/Gradiant/openverso-charts
Source: https://levelup.gitconnected.com/opensource-5g-core-with-service-mesh-bba4ded044fa (Reference for Service Mesh Test)

IV. TESTBED 3 (CLOUD NATIVE)

❖ Deploying 5G core network with open5GS, Kubernetes and Helm

5. helm search repo
6. sudo helm -n jslabopenverso install open5gs openverso/open5gs

- sudo helm -n jslabopenverso uninstall open5gs

```
root@5g:~# helm search repo
NAME                                    CHART VERSION   APP VERSION     DESCRIPTION
openverso/iperf3                        0.1.2           1.0.0           iPerf3 is a tool for active measurements of the...
openverso/oai-enb                       0.1.0           1.2.2           OpenAirInterface enodeb
openverso/oai-gnb                       0.3.1           2021.w32        description
openverso/open5gs                       0.5.0           2.4.4           Helm chart to deploy Open5gs services on Kubern...
openverso/srs-enb                       0.1.1           20.10.1         SRS enodeb
openverso/srs-epc                       0.1.0           20.10.1         SRS epc
openverso/srs-lte                       0.1.1           20.04.1         SRSLte enodeb + ue.
openverso/srs-ue                        0.1.1           20.10.1         SRS ue
openverso/ueransim                      0.2.1           3.2.6           ueransim for 5G RAN simulation
openverso/ueransim-gnb                  0.2.0           3.2.6           ueransim gNodeB for 5G RAN simulation
towards5gs/free5gc                      1.1.2           v3.1.1          A Helm chart to deploy Free5gc
towards5gs/free5gc-amf                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-ausf                 0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-n3iwf                0.2.1           v3.1.1          A Helm c
towards5gs/free5gc-nrf                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-nssf                 0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-pcf                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-smf                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-udm                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-udr                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-upf                  0.2.1           v3.1.1          A Helm c
towards5gs/free5gc-webui                0.1.2           v3.1.1          A Helm c
towards5gs/free5gcControlPlane          0.1.2           v3.0.5          DEPRECAT
towards5gs/free5gcN3iwf                 0.1.2           v3.0.5          DEPRECAT
towards5gs/free5gcUserPlane             0.1.2           v3.0.5          DEPRECAT
towards5gs/networks5g                   0.1.2           0.1.2           DEPRECAT
towards5gs/ueransim                     2.0.14          v3.2.6          A Helm chart to deploy UERANSIM
root@5g:~#
```

```
root@5g:~# helm search repo
NAME                                    CHART VERSION   APP VERSION     DESCRIPTION
openverso/iperf3                        0.1.2           1.0.0           iPerf3 is a tool for active measurements of the...
openverso/oai-enb                       0.1.0           1.2.2           OpenAirInterface enodeb
openverso/oai-gnb                       0.3.1           2021.w32        description
openverso/open5gs                       0.5.0           2.4.4           Helm chart to deploy Open5gs services on Kubern...
openverso/srs-enb                       0.1.1           20.10.1         SRS enodeb
openverso/srs-epc                       0.1.0           20.10.1         SRS epc
openverso/srs-lte                       0.1.1           20.04.1         SRSLte enodeb + ue.
openverso/srs-ue                        0.1.1           20.10.1         SRS ue
openverso/ueransim                      0.2.1           3.2.6           ueransim for 5G RAN simulation
openverso/ueransim-gnb                  0.2.0           3.2.6           ueransim gNodeB for 5G RAN simulation
```

IV. TESTBED 3 (CLOUD NATIVE)

❖ Deploying 5G core network with open5GS, Kubernetes and Helm

5. helm search repo
6. **sudo helm -n jslabopenverso install open5gs openverso/open5gs**
7. **sudo helm -n jslabopenverso install gnb openverso/ueransim-gnb**
8. **sudo helm -n jslabopenverso install ues openverso/ueransim-ues**

- sudo helm -n jslabopenverso install ueransim-ues jslabrepo5gs/ueransim-ues
- helm -n jslabopenverso uninstall open5gs
- helm -n jslabopenverso uninstall ues
- helm -n jslabopenverso uninstall ueransim-ues
- helm show values openverso/ueransim-gnb
- helm show values openverso/ueransim-ues
- **watch kubectl get pods -n jslabopenverso**

KubeSphere Dashboard 확인 'pod'

```
root@5g:~# sudo helm -n jslab install open5gs openverso/open5gs
NAME: open5gs
LAST DEPLOYED: Sun Jul 10 12:11:56 2022
NAMESPACE: jslab
STATUS: deployed
REVISION: 1
TEST SUITE: None
NOTES:
You have deployed open5gs 5G core services:
** 5G AMF Service **
Internal Access:
For services running at the same k8s namespace, AMF IP can be resolved at `open5gs-amf`.
You can also get the AMF clusterIP with:
```
kubectl get svc -n jslab open5gs-amf -o jsonpath='{.spec.clusterIP}')
```
External IP Access to this AMF service was not enabled (check amf.externalService.enabled).
```
** MME **
Internal Access:
For services running at the same k8s namespace, MME IP can be resolved at `open5gs-mme`.
You can also get the MME clusterIP with:
```
kubectl get svc -n jslab open5gs-mme -o jsonpath='{.spec.clusterIP}')
```
External IP Access to this MME service was not enabled (check mme.externalService.enabled).
```
** WEBUI **
Access Open5gs web ui at:
  http://open5gs-jslab.ingress.lab5g.gradiant.org
With user: "admin" and password "1423"
```

Source: https://helm.sh/ko/

IV. TESTBED 3 (CLOUD NATIVE)

❖ Kubernetes Operations

- kubectl get svc -A

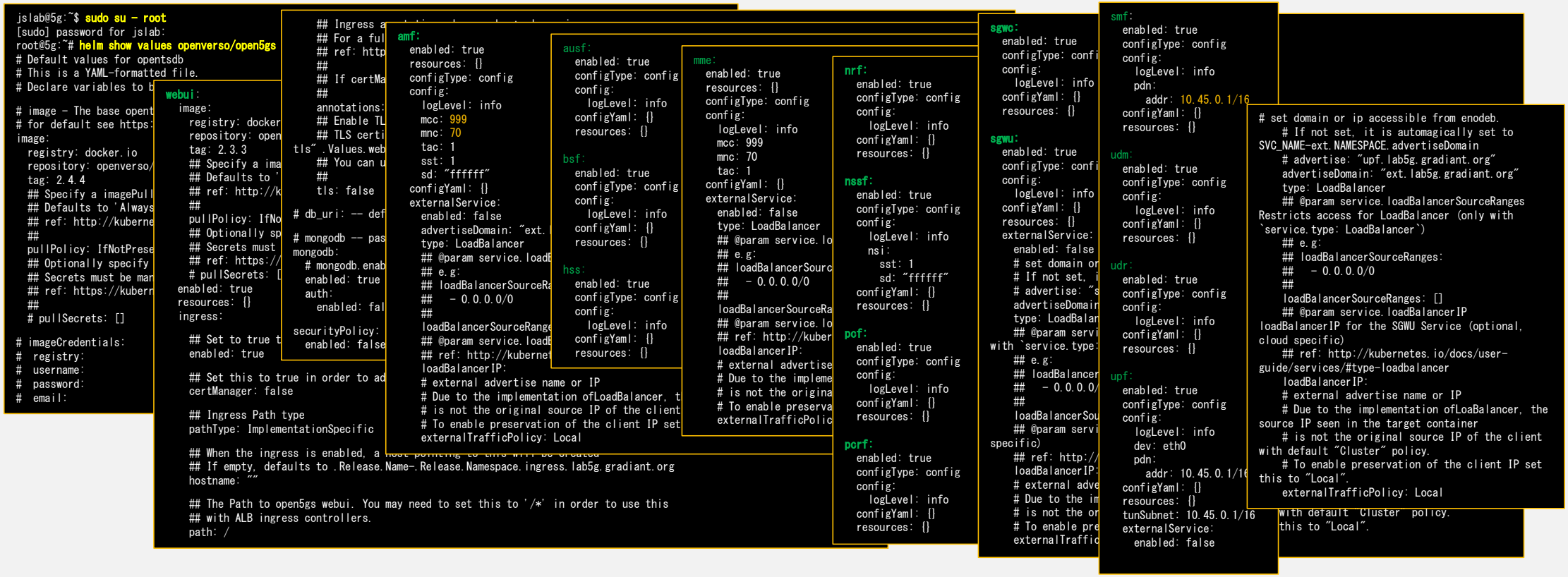
KubeSphere Dashboard 확인
'service'

```
root@node1:~/multus-cni# kubectl get svc -A
NAMESPACE                      NAME                        TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)                                  AGE
default                        deathstar                   ClusterIP   10.233.21.159   <none>        80/TCP                                   13d
default                        kubernetes                  ClusterIP   10.233.0.1      <none>        443/TCP                                  13d
jslab                          gnb-ueransim-gnb            ClusterIP   None            <none>        4997/UDP,2152/UDP                        6d21h
jslab                          open5gs-amf                 ClusterIP   10.233.29.253   <none>        7777/TCP,38412/SCTP                      7d1h
jslab                          open5gs-ausf                ClusterIP   10.233.51.236   <none>        7777/TCP                                 7d1h
jslab                          open5gs-bsf                 ClusterIP   10.233.33.243   <none>        7777/TCP                                 7d1h
jslab                          open5gs-hss                 ClusterIP   10.233.5.68     <none>        3868/SCTP                                7d1h
jslab                          open5gs-mme                 ClusterIP   10.233.19.242   <none>        36412/SCTP,3868/SCTP,2123/UDP            7d1h
jslab                          open5gs-mongodb             ClusterIP   10.233.29.173   <none>        27017/TCP                                7d1h
jslab                          open5gs-nrf                 ClusterIP   10.233.62.190   <none>        7777/TCP                                 7d1h
jslab                          open5gs-nssf                ClusterIP   10.233.60.110   <none>        7777/TCP                                 7d1h
jslab                          open5gs-pcf                 ClusterIP   10.233.32.80    <none>        7777/TCP                                 7d1h
jslab                          open5gs-pcrf                ClusterIP   10.233.45.169   <none>        3868/SCTP                                7d1h
jslab                          open5gs-sgwc                ClusterIP   10.233.18.209   <none>        2123/UDP,8805/UDP                        7d1h
jslab                          open5gs-sgwu                ClusterIP   10.233.46.237   <none>        2152/UDP,8805/UDP                        7d1h
jslab                          open5gs-smf                 ClusterIP   10.233.36.49    <none>        2123/UDP,8805/UDP,3868/SCTP,7777/TCP     7d1h
jslab                          open5gs-udm                 ClusterIP   10.233.6.211    <none>        7777/TCP                                 7d1h
jslab                          open5gs-udr                 ClusterIP   10.233.40.1     <none>        7777/TCP                                 7d1h
jslab                          open5gs-upf                 ClusterIP   10.233.43.230   <none>        2152/UDP,8805/UDP                        7d1h
jslab                          open5gs-webui               ClusterIP   10.233.42.148   <none>        3000/TCP                                 7d1h
jslab                          ueransim-gnb                ClusterIP   None            <none>        4997/UDP,2152/UDP                        6d21h
jslab5gc                       amf-namf                    ClusterIP   10.233.35.85    <none>        80/TCP                                   7m5s
jslab5gc                       ausf-nausf                  ClusterIP   10.233.63.94    <none>        80/TCP                                   7m5s
jslab5gc                       gnb-service                 ClusterIP   10.233.27.76    <none>        4997/UDP                                 63s
jslab5gc                       mongodb                     ClusterIP   10.233.7.86     <none>        27017/TCP                                7m5s
jslab5gc                       nrf-nnrf                    ClusterIP   10.233.43.245   <none>        8000/TCP                                 7m5s
jslab5gc                       nssf-nnssf                  ClusterIP   10.233.9.116    <none>        80/TCP                                   7m5s
jslab5gc                       pcf-npcf                    ClusterIP   10.233.37.62    <none>        80/TCP                                   7m5s
jslab5gc                       smf-nsmf                    ClusterIP   10.233.14.19    <none>        80/TCP                                   7m5s
jslab5gc                       udm-nudm                    ClusterIP   10.233.47.99    <none>        80/TCP                                   7m5s
jslab5gc                       udr-nudr                    ClusterIP   10.233.20.3     <none>        80/TCP                                   7m5s
jslab5gc                       webui-service               NodePort    10.233.20.18    <none>        5000:30500/TCP                           7m5s
```

IV. TESTBED 3 (CLOUD NATIVE)

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm (참고)

- helm show values openverso/open5gs



IV. TESTBED 3 (CLOUD NATIVE)

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm (참고)

- helm show values openverso/ueransim-gnb

```
root@5g:~# helm show values openverso/ueransim-gnb
## @section Global parameters
## Global Docker image parameters
## Please, note that this will override the image parameters, including dependencies, configured to use the global value
## Current available global Docker image parameters: imageRegistry, imagePullSecrets and storageClass

## @param global.imageRegistry Global Docker image registry
## @param global.imagePullSecrets Global Docker registry se
## @param global.storageClass Global StorageClass for Persi
##
global:
  imageRegistry:
  ## E.g.
  ## imagePullSecrets:
  ##   - myRegistryKeySecretName
  ##
  imagePullSecrets: []
  storageClass:

## @section Common parameters

## @param kubeVersion Override Kubernetes version
##
kubeVersion:
## @param nameOverride String to partially override common.
##
nameOverride:
## @param fullnameOverride String to fully override common.
##
fullnameOverride:
## @param commonLabels Labels to add to all deployed objects
```

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

```
##
commonLabels: {}
## @param commonAnnotations Annotations to add to all deployed objects
##
commonAnnotations: {}
## @param clusterDomain Kubernetes cluster domain name
##
clusterDomain: cluster.local
## @param extraDeploy Array of extra objects to deploy with the release
##
extraDeploy: []

image:
  registry: docker.io
  repository: openverso/ueransim
  tag: 3.2.6
  ## Specify a imagePullPolicy
  ## Defaults to 'Always' if image tag is 'latest', else set to 'IfNotPresent'
  ## ref: http://kubernetes.io/docs/user-guide/images/#pre-pull images
  ##
  pullPolicy: Always
  ## Optionally specify an array of imagePullSecrets.
  ## Secrets must be manually created in the namespace.
  ## ref: https://kubernetes.io/docs/tasks/
```

```
configure-pod-container/pull-image-private-registry/
  ## e.g:
  ## pullSecrets:
  ##   - myRegistryKeySecretName
  ##
  pullSecrets: []
  ## Enable debug mode
  ##
  debug: false

name: ueransim-gnb
amf:
  # if set amf.ip takes precedence over amf.hostname
  ip:
  hostname: open5gs-amf
interfaces:
  n2:
    dev: eth0
  n3:
    dev: eth0
  radio:
    dev: eth0
mcc: '999'
mnc: '70'
sst: 1
sd: "0xffffff"
tac: '0001'
```

```
resources:
  limits: {}
  requests: {}
podSecurityContext:
  enabled: false
containerSecurityContext:
  enabled: false
podLabels: {}
podAnnotations: {}
affinity: {}
nodeSelector: {}
tolerations: []

ues:
  enabled: false
  count: 1
  initialMSISDN: '0000000001'
  key: 465B5CE8B199B49FAA5F0A2EE238A6BC
  op: E8ED289DEBA952E4283B54E88E6183CA
  opType: OPC
  apn: internet
  resources:
    limits: {}
    requests: {}
  podSecurityContext:
    enabled: false
  containerSecurityContext:
    enabled: false
  podLabels: {}
  podAnnotations: {}
  affinity: {}
  nodeSelector: {}
  tolerations: []

50.238
```

IV. TESTBED 3 (CLOUD NATIVE)

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm (참고)

- helm show values openverso/ueransim

```
root@5g:~# helm show values towards5gs/ueransim
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2021 Orange
# SPDX-License-Identifier: Apache-2.0
#
# This software is distributed und
# the text of which is available a
# or see the "LICENSE" file for mo
#
# Author: Abderaouf KHICHANE, Ilhe
# Software description: An open-so
#
# Default values for ueransim-char
# This is a YAML-formatted file.
# Declare variables to be passed i

global:
  multiCluster: false
  #Global network parametes
  n2network:
    name: n2network
    masterIf: eth0
    subnetIP: 10.100.50.248
    cidr: 29
    gatewayIP: 10.100.50.254
    excludeIP: 10.100.50.254
  n3network:
    name: n3network
    masterIf: eth0
    subnetIP: 10.100.50.232
    cidr: 29
    gatewayIP: 10.100.50.238
    excludeIP: 10.100.50.238
```

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

```
projectName: ueransim

gnb:
  enabled: true
  name: gnb
  replicaCount: 1
  image:
    name: towards5gs/ueransim-gnb
    pullPolicy: IfNotPresent
  configmap:
    name: gnb-configmap
  volume:
    name: gnb-volume
    mount: /ueransim/config
  service:
    name: gnb-service
    type: ClusterIP
    port: 4997
    protocol: UDP

  n2if:  # NGAP
    ipAddress: 10.100.50.250
  n3if:  # GTP-U
    ipAddress: 10.100.50.236

amf:
  n2if:  # NGAP
    ipAddress: 10.100.50.249
    port: 38412
  service:
    ngap:
      enabled: false  # if true set gnb.amf.n2if.ipAddress to the
name of AMF NGAP service or the IP of the cluster hosting the AMF
```

```
podAnnotations: {}
  # additional annotations
imagePullSecrets: []
podSecurityContext: {}
resources:
  limits:
    cpu: 250m
    memory: 256Mi
  requests:
    cpu: 250m
    memory: 256Mi
nodeSelector: {}
tolerations: []
affinity: {}

configuration: |-
  mcc: '208' # Mobile Country Code value
  mnc: '93'  # Mobile Network Code value (2 or
  nci: '0x000000010'  # NR Cell Identity (36-bi
  idLength: 32        # NR gNB ID length in bit
  tac: 1     # Tracking Area Code
  # List of supported S-NSSAIs by this gNB
  slices:
    - sst: 0x1
      sd: 0x010203
  # Indicates whether or not SCTP stream number
should be ignored.
  ignoreStreamIds: true
```

```
ue:
  enabled: true
  name: ue
  replicaCount: 1
  image:
    name: towards5gs/ueransim-ue
    pullPolicy: IfNotPresent
  configmap:
    name: ue-configmap
  volume:
    name: ue-volume
    mount: /ueransim/config
  command: "./nr-ue -c ../config/ue
config.yaml"  # This is the command
will be launched in the UE containe
  # A script that will be run after
UE creation. It may be used to
periodically generate traffic
  script: ""
  # script: |-
  #   ping .....

  podAnnotations: {}
    # additional annotations
  imagePullSecrets: []
  podSecurityContext: {}
  securityContext:
    capabilities:
          add: ["NET_ADMIN"]
  resources:
    limits:
      cpu: 120m
      memory: 128Mi
    requests:
      cpu: 120m
      memory: 128Mi
  nodeSelector: {}
  tolerations: []
  affinity: {}
```

```
configuration: |-
    supi: "imsi-208930000000003"  # IMSI number
    mcc: '208' # Mobile Country Code value
    mnc: '93' # Mobile Network Code value (2 or 3 digits)
    key: "8baf473f2f8fd09487cccbd7097c6862" # Operator code
(OP or OPC) of the UE
    op: "8e27b6af0e692e750f32667a3b14605d" # This value
specifies the OP type and it can be either 'OP' or 'OPC'
    opType: "OPC" # This value specifies the OP type and it
can be either 'OP' or 'OPC'
    amf: '8000' # Authentication Management Field (AMF) value
    imei: '356938035643803' # IMEI number of
    imeiSv: '4370816125816151'
    # UAC Access Identities Configuration
    uacAic:
      mps: false
      mcs: false
    # UAC Access Control Class
    uacAcc:
      normalClass: 0
      class11: false
      class12: false
      class13: false
      class14: false
      class15: false
    sessions:
      - type: "IPv4"
        apn: "internet"
        slice:
          sst: 0x01
          sd: 0x010203
    # Configured NSSAI for this UE by HPLMN
    configured-nssai:
      - sst: 0x01
        sd: 0x010203
    # Default Configured NSSAI for this UE
    default-nssai:
      - sst: 1
        sd: 1
```

```
  # Supported encryption and integrity
algorithms by this UE
    integrity:
      IA1: true
      IA2: true
      IA3: true
    ciphering:
      EA1: true
      EA2: true
      EA3: true
    # Integrity protection maximum data
rate for user plane
    integrityMaxRate:
      uplink: 'full'
      downlink: 'full'

  test:
    connectivity:
      name: ue-connectivity-test
      image: bitnami/kubectl:1.22.0
      configmap:
        name: connectivity-test-
configmap
      volume:
        name: connectivity-test-volume
        mount: /scripts
      ttlseconds: 50
```

IV. TESTBED 3 (CLOUD NATIVE)

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm (참고)

- **gnb@ueransim:** helm show values openverso/ueransim

```
root@5g:~# helm show values towards5gs/ueransim
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2021 Orange
# SPDX-License-Identifier: Apache-2.0
#
# This software is distributed under the Apache License 2.0,
# the text of which is available at todo
# or see the "LICENSE" file for more details.
#
# Author: Abderaouf KHICHANE, Ilhem FAJJARI, Ayoub BOUSSELMI
# Software description: An open-source project providing Helm charts to deploy 5G c
#
# Default values for ueransim-chart.
# This is a YAML-formatted file.
# Declare variables to be passed into your templates.

global:
  multiCluster: false
  #Global network parametes
  n2network:
    name: n2network
    masterIf: eth0
    subnetIP: 10.100.50.248
    cidr: 29
    gatewayIP: 10.100.50.254
    excludeIP: 10.100.50.254
  n3network:
    name: n3network
    masterIf: eth0
    subnetIP: 10.100.50.232
    cidr: 29
    gatewayIP: 10.100.50.238
    excludeIP: 10.100.50.238
```

```
projectName: ueransim

gnb:
  enabled: true
  name: gnb
  replicaCount: 1
  image:
    name: towards5gs/ueransim-gnb
    pullPolicy: IfNotPresent
  configmap:
    name: gnb-configmap
  volume:
    name: gnb-volume
    mount: /ueransim/config
  service:
    name: gnb-service
    type: ClusterIP
    port: 4997
    protocol: UDP

  n2if:  # NGAP
    ipAddress: 10.100.50.250
  n3if:  # GTP-U
    ipAddress: 10.100.50.236

  amf:
    n2if:  # NGAP
      ipAddress: 10.100.50.249
      port: 38412
    service:
      ngap:
        enabled: false  # if true set gnb.amf.n2if.ipAddress to the name of AMF
NGAP service or the IP of the cluster hosting the AMF
```

```
  podAnnotations: {}
    # additional annotations
  imagePullSecrets: []
  podSecurityContext: {}
  resources:
    limits:
      cpu: 250m
      memory: 256Mi
    requests:
      cpu: 250m
      memory: 256Mi
  nodeSelector: {}
  tolerations: []
  affinity: {}

  configuration: |-
    mcc: '208' # Mobile Country Code value
    mnc: '93'  # Mobile Network Code value (2 or 3 digits)
    nci: '0x000000010'  # NR Cell Identity (36-bit)
    idLength: 32        # NR gNB ID length in bits [22...32]
    tac: 1     # Tracking Area Code
    # List of supported S-NSSAIs by this gNB
    slices:
      - sst: 0x1
        sd: 0x010203
    # Indicates whether or not SCTP stream number errors should be
ignored.
    ignoreStreamIds: true
```

IV. TESTBED 3 (CLOUD NATIVE)

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm (참고)

- **ue@ueransim:** helm show values openverso/ueransim

```
root@5g:~# helm show values towards5gs/ueransim
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2
# SPDX-License-Identifier: Apache-2.0
#
# This software is distributed under the
# the text of which is available at todo
# or see the "LICENSE" file for more deta
#
# Author: Abderaouf KHICHANE, Ilhem FAJJA
# Software description: An open-source pr
#
# Default values for ueransim-chart.
# This is a YAML-formatted file.
# Declare variables to be passed into you

global:
  multiCluster: false
  #Global network parametes
  n2network:
    name: n2network
    masterIf: eth0
    subnetIP: 10.100.50.248
    cidr: 29
    gatewayIP: 10.100.50.254
    excludeIP: 10.100.50.254
  n3network:
    name: n3network
    masterIf: eth0
    subnetIP: 10.100.50.232
    cidr: 29
    gatewayIP: 10.100.50.238
    excludeIP: 10.100.50.238
```

```
ue:
  enabled: true
  name: ue
  replicaCount: 1
  image:
    name: towards5gs/ueransim-ue
    pullPolicy: IfNotPresent
  configmap:
    name: ue-configmap
  volume:
    name: ue-volume
    mount: /ueransim/config
  command: "./nr-ue -c ../config/ue-config.yaml"  # Thi
command that will be launched in the UE container
  # A script that will be run after the UE creation. It
used to periodically generate traffic
  script: ""
  # script: |-
  #   ping .....

  podAnnotations: {}
    # additional annotations
  imagePullSecrets: []
  podSecurityContext: {}
  securityContext:
    capabilities:
            add: ["NET_ADMIN"]
  resources:
    limits:
      cpu: 120m
      memory: 128Mi
    requests:
      cpu: 120m
      memory: 128Mi
```

```
 nodeSelector: {}
  tolerations: []
  affinity: {}
 configuration: |-
    supi: "imsi-208930000000003"  # IMSI number
    mcc: '208' # Mobile Country Code value
    mnc: '93' # Mobile Network Code value (2 or 3 digits)
    key: "8baf473f2f8fd09487cccbd7097c6862" # Operator co
of the UE
    op: "8e27b6af0e692e750f32667a3b14605d" # This value s
type and it can be either 'OP' or 'OPC'
    opType: "OPC" # This value specifies the OP type and
either 'OP' or 'OPC'
    amf: '8000' # Authentication Management Field (AMF) v
    imei: '356938035643803' # IMEI number of the device
    imeiSv: '4370816125816151'
    # UAC Access Identities Configuration
    uacAic:
      mps: false
      mcs: false
    # UAC Access Control Class
    uacAcc:
      normalClass: 0
      class11: false
      class12: false
      class13: false
      class14: false
      class15: false
    sessions:
      - type: "IPv4"
        apn: "internet"
        slice:
          sst: 0x01
          sd: 0x010203
```

imsi-208930000000003

```
# Configured NSSAI for this UE by HPLMN
   configured-nssai:
     - sst: 0x01
       sd: 0x010203
   # Default Configured NSSAI for this UE
   default-nssai:
     - sst: 1
       sd: 1
# Supported encryption and integrity algorithms by this UE
   integrity:
     IA1: true
     IA2: true
     IA3: true
   ciphering:
     EA1: true
     EA2: true
     EA3: true
   # Integrity protection maximum data rate for user plane
   integrityMaxRate:
     uplink: 'full'
     downlink: 'full'

 test:
   connectivity:
     name: ue-connectivity-test
     image: bitnami/kubectl:1.22.0
     configmap:
       name: connectivity-test-configmap
     volume:
       name: connectivity-test-volume
       mount: /scripts
     ttlseconds: 50
```

V. 5G Edge LB Virtual Lab

V. 5G EDGE LB VIRTUAL LAB

❖ LoxiLB Virtual Lab

- **LoxiLB의 버추얼 랩은 사용자가 웹 환경에서 인터랙티브하게 LoxiLB를 체험할 수 있는 환경을 제공**
  - https://killercoda.com/netlox
- **시나리오 25개: TCP/UDP, NAT64/66, SCTP, UL/CL, etc**
  - IPv4 Basic TCP Load Balancing Test
  - IPv4 Basic TCP Load Balancing Test with WRR(Weighted Round Robin) Algorithm
  - Load Balancing Test over Clustering with BGP and HA (Full NAT Mode)
  - SCTP Load Balancing Test
  - SCTP Load Balancing Test with Full-NAT Mode
  - SCTP Load Balancing Test with VxLAN Overlay
  - TCP Load Balancing Test in 5G N3 Interface as LBO(Local Break Out)
  - SCTP Load Balancing Test in 5G N3 Interface as LBO(Local Break Out)

Source: https://killercoda.com/netlox

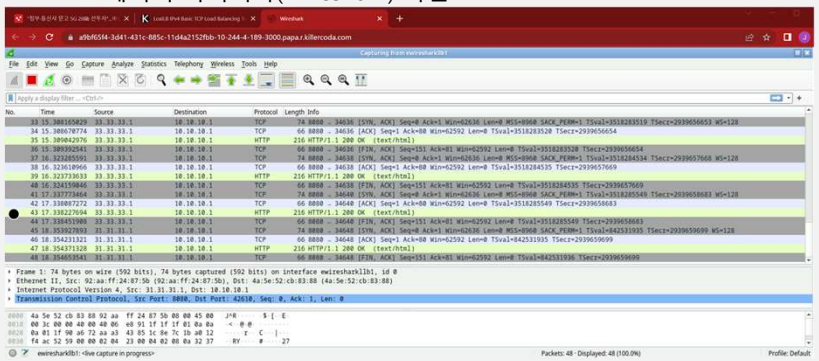
V. 5G EDGE LB VIRTUAL LAB

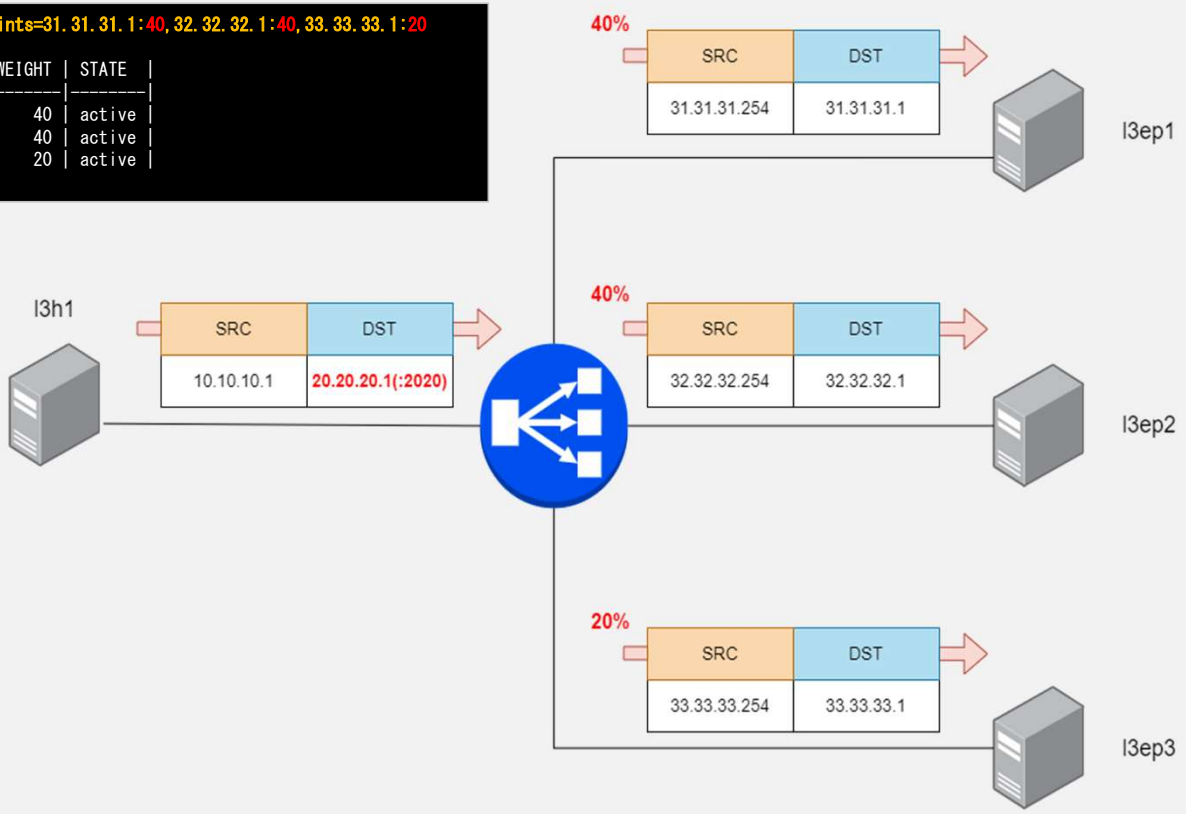
❖ IPv4 Basic TCP Load Balancing Test with WRR(Weighted Round Robin) Algorithm

- loxicmd create lb 20.20.20.1 --select=priority --tcp=2020:8080 --endpoints=31.31.31.1:40,32.32.32.1:40,33.33.33.1:20

```
root@97e71197b1df:/# loxicmd create lb 20.20.20.1 --select=priority --tcp=2020:8080 --endpoints=31.31.31.1:40,32.32.32.1:40,33.33.33.1:20
root@97e71197b1df:/# loxicmd get lb -o wide
| EXTERNAL IP | PORT | PROTOCOL | BLOCK |  SELECT  |  MODE   | ENDPOINT IP | TARGET PORT | WEIGHT | STATE  |
|-------------|------|----------|-------|----------|---------|-------------|-------------|--------|--------|
| 20.20.20.1  | 2020 | tcp      |     0 | priority | default | 31.31.31.1  |        8080 |     40 | active |
|             |      |          |       |          |         | 32.32.32.1  |        8080 |     40 | active |
|             |      |          |       |          |         | 33.33.33.1  |        8080 |     20 | active |
root@97e71197b1df:/#
```

WRR 트레픽의 와이어샥(Wireshark) 확인





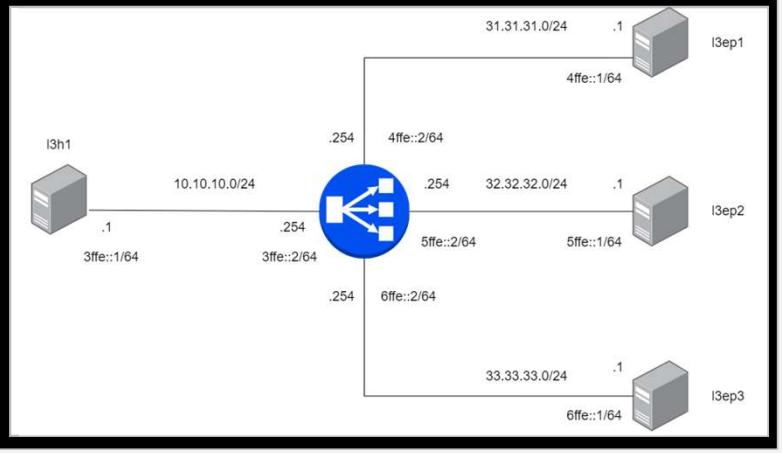
Source: https://killercoda.com/netlox

V. 5G EDGE LB VIRTUAL LAB

❖ IPv4 Basic TCP Load Balancing Test with WRR(Weighted Round Robin) Algorithm

○ Achieving LoxiLB IPv4 Basic TCP Load Balancing Test with WRR algorithm

```
ubuntu $ docker ps
CONTAINER ID   IMAGE                                COMMAND                  CREATED              STATUS              PORTS                    NAMES
3412edc42bfc   lscr.io/linuxserver/wireshark:latest   "/init"                  About a minute ago   Up About a minute                            wireshark
d8b4fb335337   eyes852/ubuntu-iperf-test:0.5        "bash"                   2 minutes ago        Up 2 minutes                                 l3ep3
38e47d6607c4   eyes852/ubuntu-iperf-test:0.5        "bash"                   2 minutes ago        Up 2 minutes                                 l3ep2
2bb62e32a99b   eyes852/ubuntu-iperf-test:0.5        "bash"                   2 minutes ago        Up 2 minutes                                 l3ep1
536c2bca92ea   eyes852/ubuntu-iperf-test:0.5        "bash"                   2 minutes ago        Up 2 minutes                                 l3h1
97e71197b1df   ghcr.io/loxilb-io/loxilb:latest      "/root/loxilb-io/lox…"   2 minutes ago        Up 2 minutes        11111/tcp, 22222/tcp     llb1
ubuntu $ docker exec -it llb1 loxicmd help
A longer description that spans multiple lines and likely contains
        examples and usage of using your application. For example:

        Cobra is a CLI library for Go that empowers applications.
        This application is a tool to generate the needed files
        to quickly create a Cobra application.

Usage:
  loxicmd [command]

Available Commands:
  apply       Apply configuration
  completion  Generate the autocompletion script for the specified shell
  create      Create a Load balance features in the LoxiLB.
  delete      Delete a Load balance features in the LoxiLB.
  get         A brief description of your command
  help        Help about any command
  save        saves current configuration

Flags:
  -s, --apiserver string   Set API server IP address (default "127.0.0.1")
  -h, --help               help for loxicmd
  -o, --output string      Set output layer (ex.) wide, json)
  -p, --port int16         Set API server port number (default 11111)
      --protocol string    Set API server http/https (default "http")
  -t, --timeout int16      Set timeout (default 5)

Use "loxicmd [command] --help" for more information about a command.
ubuntu $
```



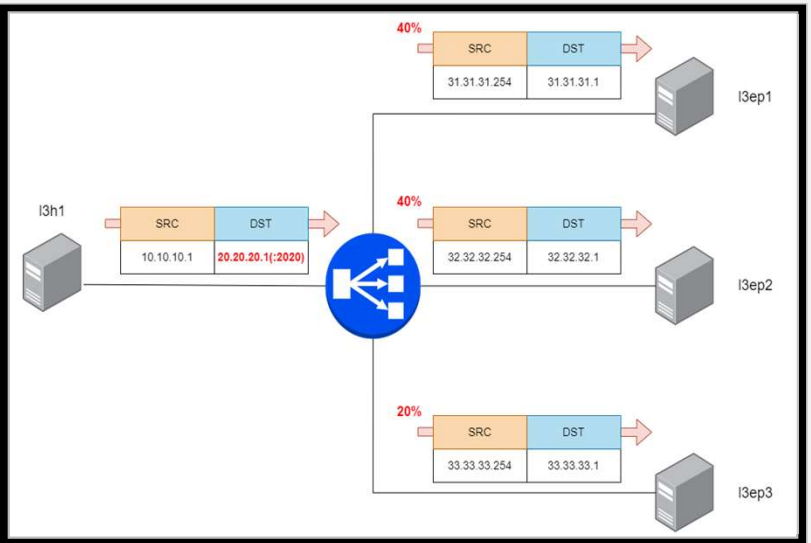
Source: https://killercoda.com/netlox/scenario/loxilb-wrrtcplb

V. 5G EDGE LB VIRTUAL LAB

❖ IPv4 Basic TCP Load Balancing Test with WRR(Weighted Round Robin) Algorithm

○ Check Topology for WRR

```
ubuntu $ ip netns exec l3ep1 ifconfig eth0
ubuntu $ ip netns exec l3ep2 ifconfig eth0
ubuntu $ ip netns exec l3ep3 ifconfig eth0
ubuntu $ ip netns exec l3h1 ifconfig eth0
ubuntu $ ip netns exec llb1 route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
0.0.0.0         172.17.0.1      0.0.0.0         UG    0      0        0 eth0
10.10.10.0      0.0.0.0         255.255.255.0   U     0      0        0 ellb1l3h1
31.31.31.0      0.0.0.0         255.255.255.0   U     0      0        0 ellb1l3ep1
32.32.32.0      0.0.0.0         255.255.255.0   U     0      0        0 ellb1l3ep2
33.33.33.0      0.0.0.0         255.255.255.0   U     0      0        0 ellb1l3ep3
172.17.0.0      0.0.0.0         255.255.0.0     U     0      0        0 eth0
ubuntu $ ip netns exec llb1 ping 31.31.31.1
ubuntu $ ip netns exec llb1 ping 32.32.32.1
ubuntu $ ip netns exec llb1 ping 33.33.33.1
ubuntu $ ip netns exec llb1 ping 10.10.10.1
ubuntu $ cd ~/
ubuntu $ dir
common.sh  config-mirror.sh  config.sh  filesystem  rmconfig-mirror.sh  rmconfig.sh  server1.js  server2.js  server3.js  start.sh  validation.sh
ubuntu $ sudo /bin/bash ./config.sh
########################################
Configuring LoxiLB Basic TCP Policy
########################################
ProtoPortpair: map[tcp:[2020:8080]]
Debug: response.StatusCode: 200
ubuntu $ docker exec -it llb1 bash
root@8b74b5ddc4d2:/#loxicmd create lb 20.20.20.1 --select=priority --tcp=2020:8080 --endpoints=31.31.31.1:40,32.32.32.1:40,33.33.33.1:20
```



Source: https://killercoda.com/netlox/scenario/loxilb-wrrtcplb

V. 5G EDGE LB VIRTUAL LAB

❖ IPv4 Basic TCP Load Balancing Test with WRR(Weighted Round Robin) Algorithm

○ Configure LoxiLB Rules and Check configuration

```
root@97e71197b1df:/# loxicmd get lb -o wide
| EXTERNAL IP | PORT | PROTOCOL | BLOCK |  SELECT  |  MODE   | ENDPOINT IP | TARGET PORT | WEIGHT | STATE  |
|-------------|------|----------|-------|----------|---------|-------------|-------------|--------|--------|
| 20.20.20.1  | 2020 | tcp      |     0 | priority | default | 31.31.31.1  |        8080 |     40 | active |
|             |      |          |       |          |         | 32.32.32.1  |        8080 |     40 | active |
|             |      |          |       |          |         | 33.33.33.1  |        8080 |     20 | active |
root@97e71197b1df:/#
```

```
ubuntu $ cd ~/
ubuntu $ sudo /bin/bash ./validation.sh
SCENARIO-wrrtcplb1
server1 UP
server2 UP
server3 UP
server1
server1
server1
server1
server1
server1
server1
server2
server2
server2
server2
server2
server2
server2
server3
server3
server3
server1
./validation.sh: line 54: 25902 Killed                  $hexec l3ep1
node ./server1.js
./validation.sh: line 54: 25903 Killed                  $hexec l3ep2
node ./server2.js
./validation.sh: line 54: 25904 Killed                  $hexec l3ep3
node ./server3.js
SCENARIO-wrrtcplb2 [OK]
```

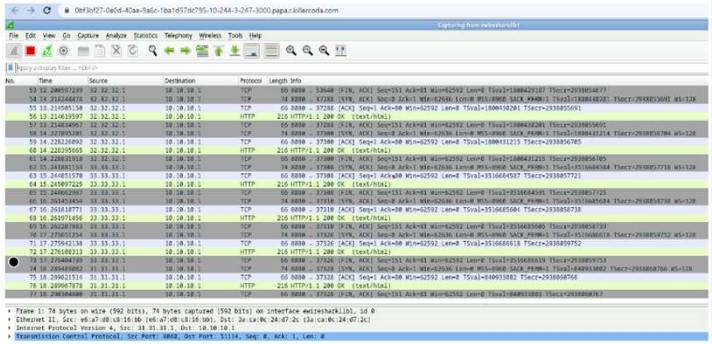
```
source ./common.sh
connect_docker_hosts_default_ns llb1 wireshark

./config-mirror.sh 1 ellb1l3ep1 ellb1wireshark
./config-mirror.sh 2 ellb1l3ep2 ellb1wireshark
./config-mirror.sh 3 ellb1l3ep3 ellb1wireshark
```

```
./config-mirror.sh 1 ellb1l3ep1 ellb1wireshark
./config-mirror.sh 2 ellb1l3ep2 ellb1wireshark
./config-mirror.sh 3 ellb1l3ep3 ellb1wireshark
```

`1` is unique id for mirror object.

Access Wireshark for Analytics ACCESS WIRESHARK and select `ewiresharkllb1` as capturing port.

You can check as like following figure:



(2) Delete Mirror Object

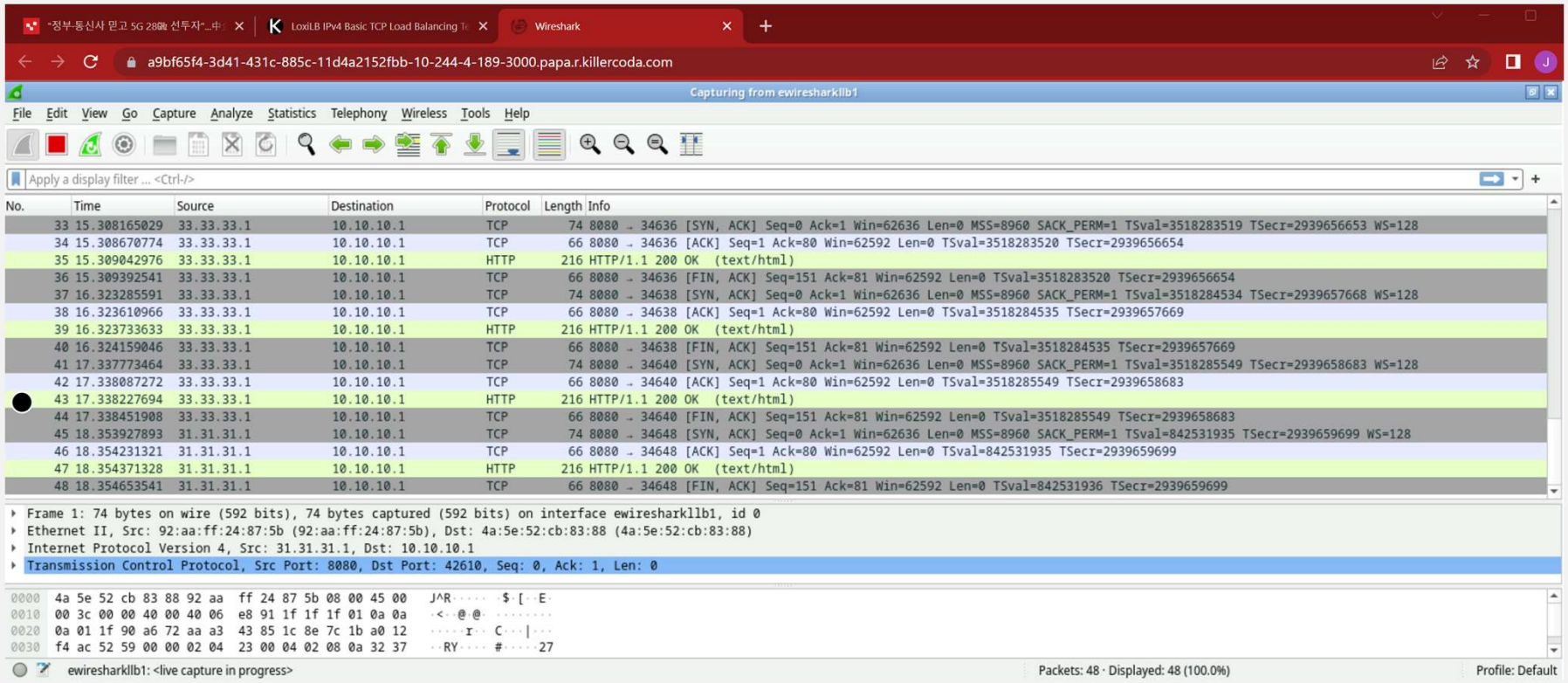
```
./rmconfig-mirror.sh 1
./rmconfig-mirror.sh 2
./rmconfig-mirror.sh 3
```

Source: https://killercoda.com/netlox/scenario/loxilb-wrrtcplb

V. 5G EDGE LB VIRTUAL LAB

❖ IPv4 Basic TCP Load Balancing Test with WRR(Weighted Round Robin) Algorithm

- Validate LoxiLB Rules
- Access Wireshark for Analytics ACCESS WIRESHARK and select ewiresharkllb1 as capturing port.

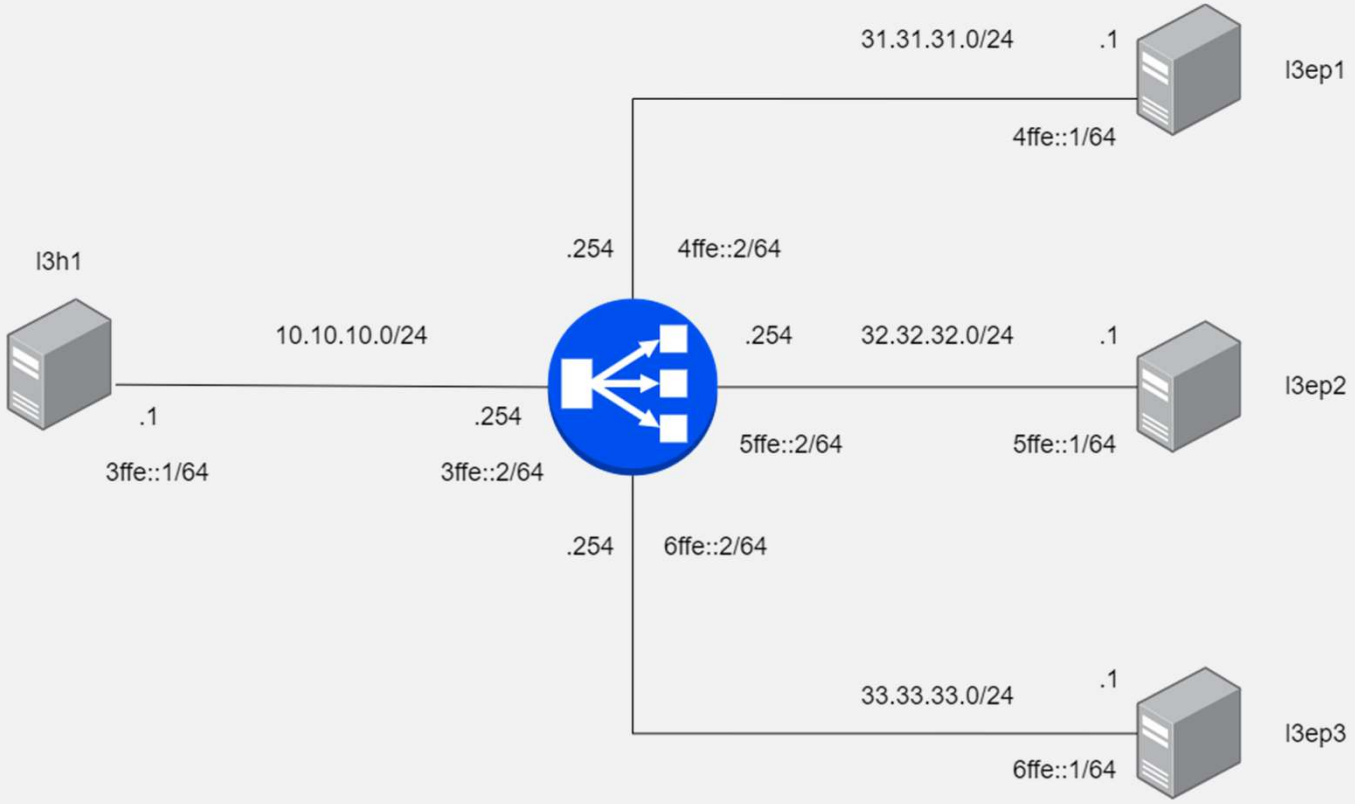


Source: https://killercoda.com/netlox/scenario/loxilb-wrrtcplb

V. 5G EDGE LB VIRTUAL LAB

❖ IPv4 Basic TCP Load Balancing Test with WRR(Weighted Round Robin) Algorithm

- Achieving LoxiLB IPv4 Basic TCP Load Balancing Test with WRR algorithm

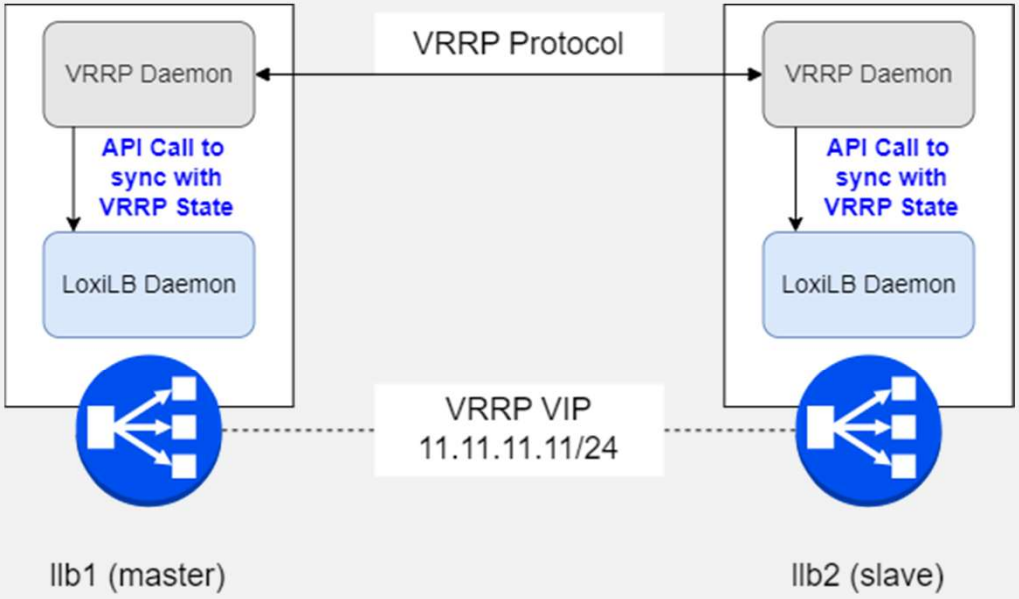


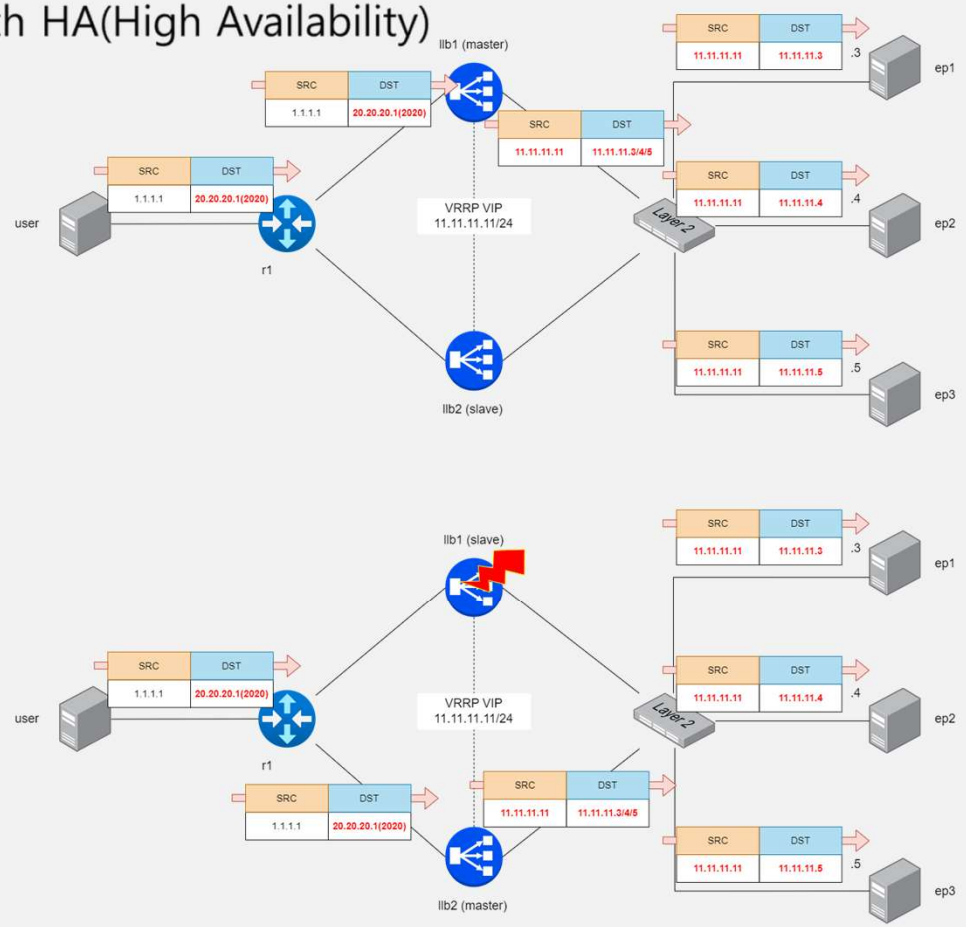
Source: https://killercoda.com/netlox

V. 5G EDGE LB VIRTUAL LAB

❖ Load Balancing Test with HA(High Availability)

- Learn How To test LoxiLB TCP Load Balancing Test with HA(High Availability)



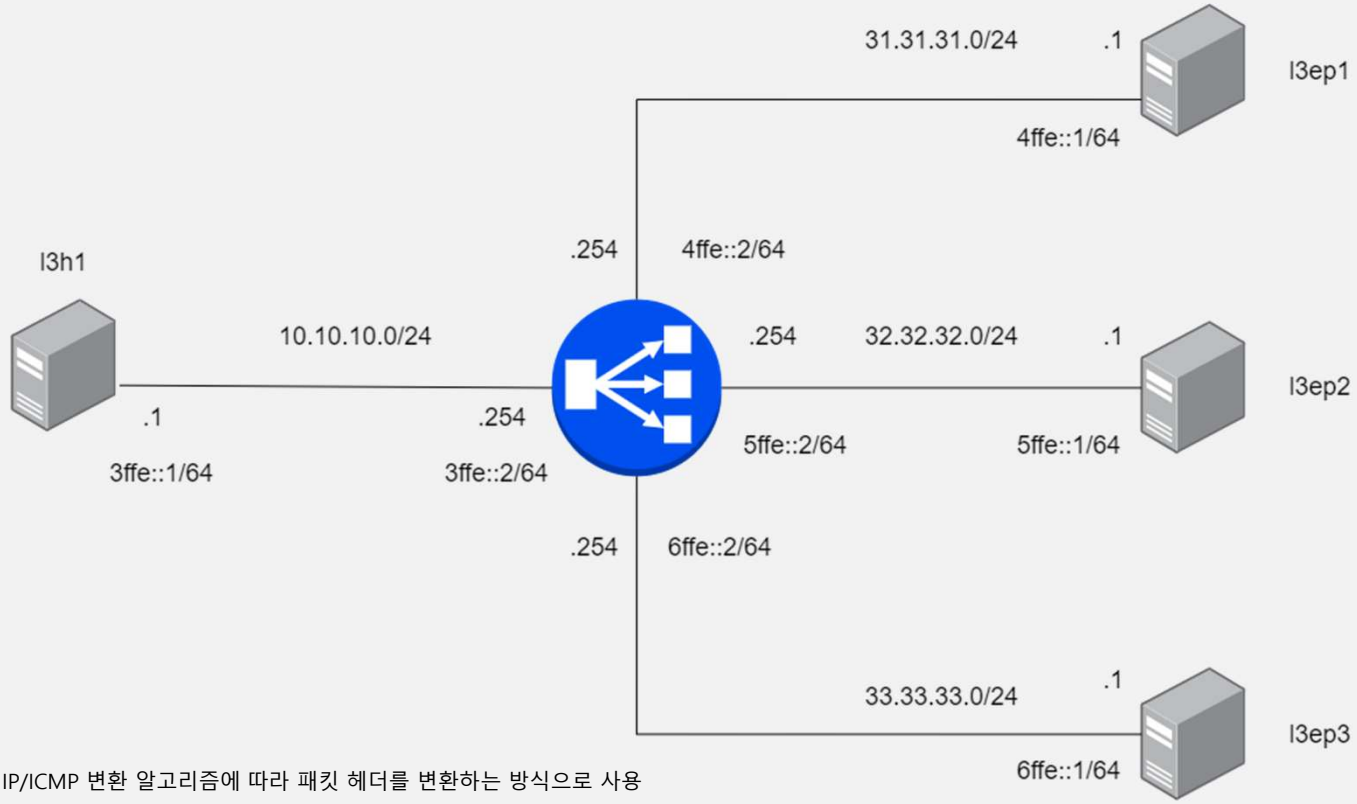


Source: https://killercoda.com/netlox

V. 5G EDGE LB VIRTUAL LAB

❖ LoxiLB NAT64 Load Balancing Test

- Learn How To test LoxiLB NAT64 Load Balancing Timeout Test



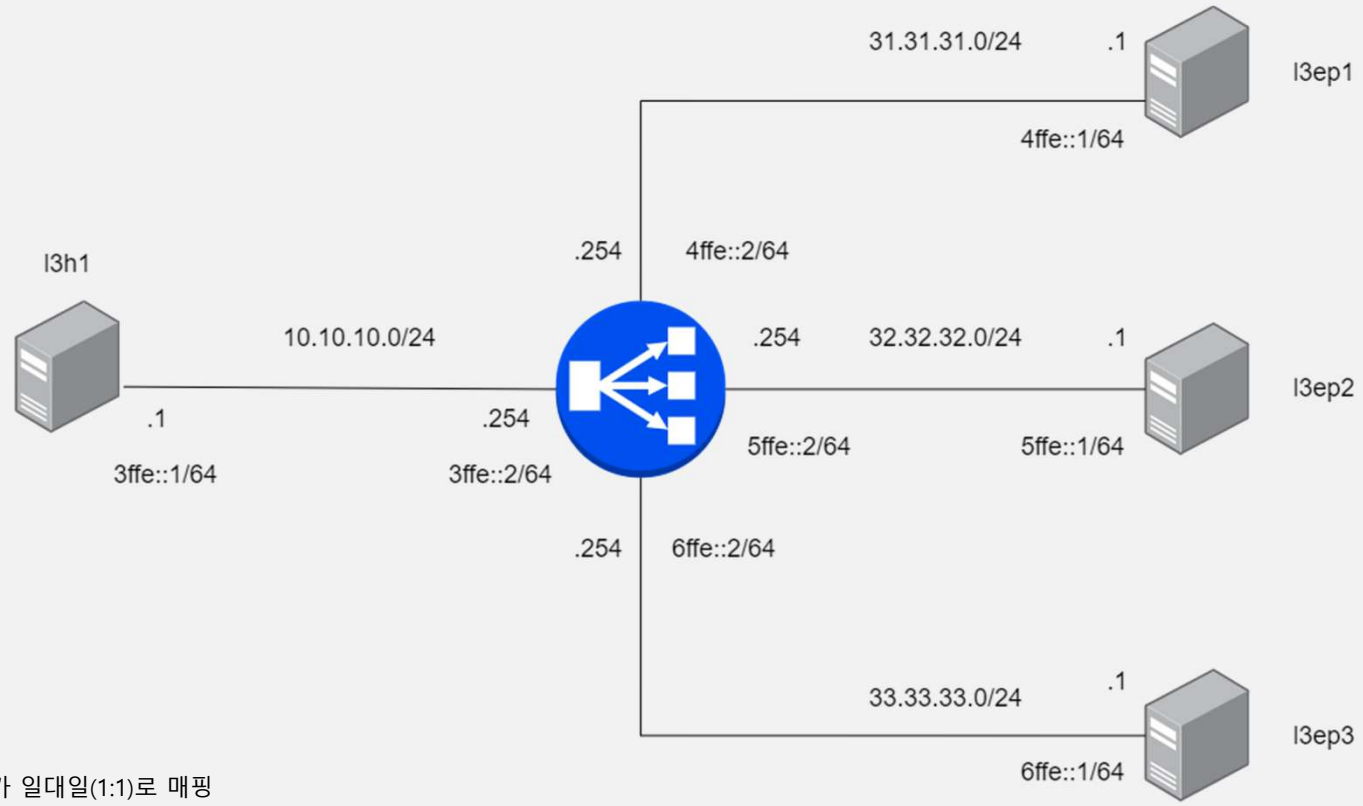
NAT64는 IPv6 패킷을 IPv4 패킷으로 변환하는 데 사용되는 변환 메커니즘이며, IP/ICMP 변환 알고리즘에 따라 패킷 헤더를 변환하는 방식으로 사용

Source: https://killercoda.com/netlox

V. 5G EDGE LB VIRTUAL LAB

❖ NAT66 Load Balancing Test

- Learn How To test LoxiLB NAT66 Load Balancing Timeout Test



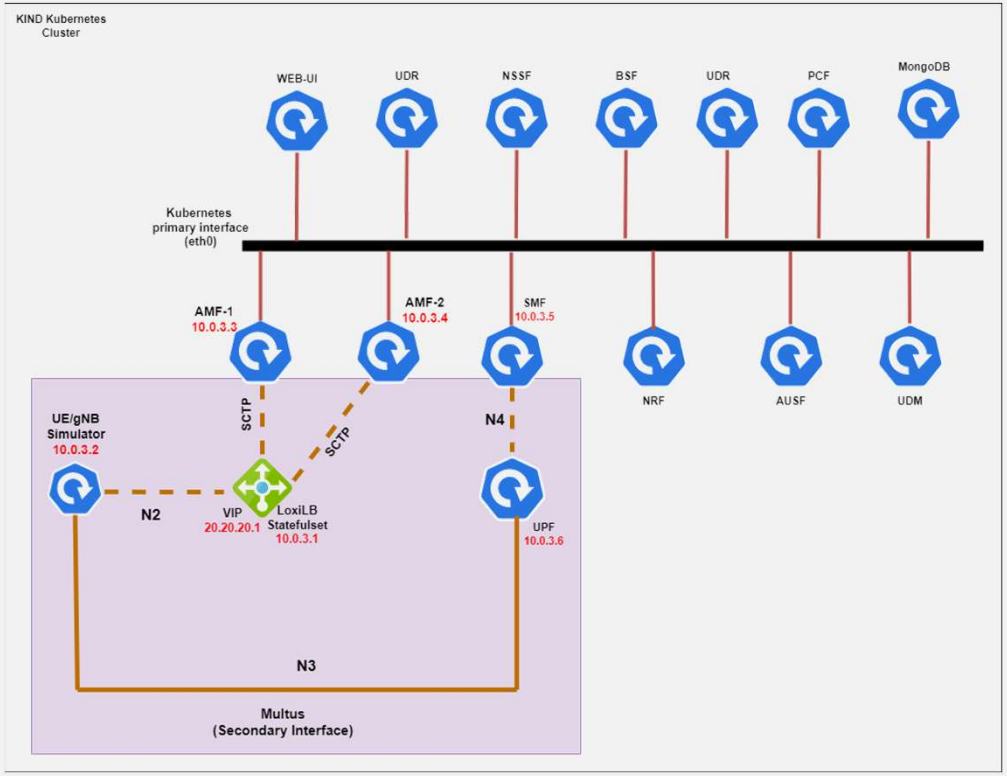
NAT66은 일반적으로 알고 있는 NAT와는 달리 외부 주소와 내부 주소가 일대일(1:1)로 매핑

Source: https://killercoda.com/netlox

V. 5G EDGE LB VIRTUAL LAB

❖ SCTP Load Balancing Test

- Learn How To test LoxiLB SCTP Load Balancing Timeout Tes



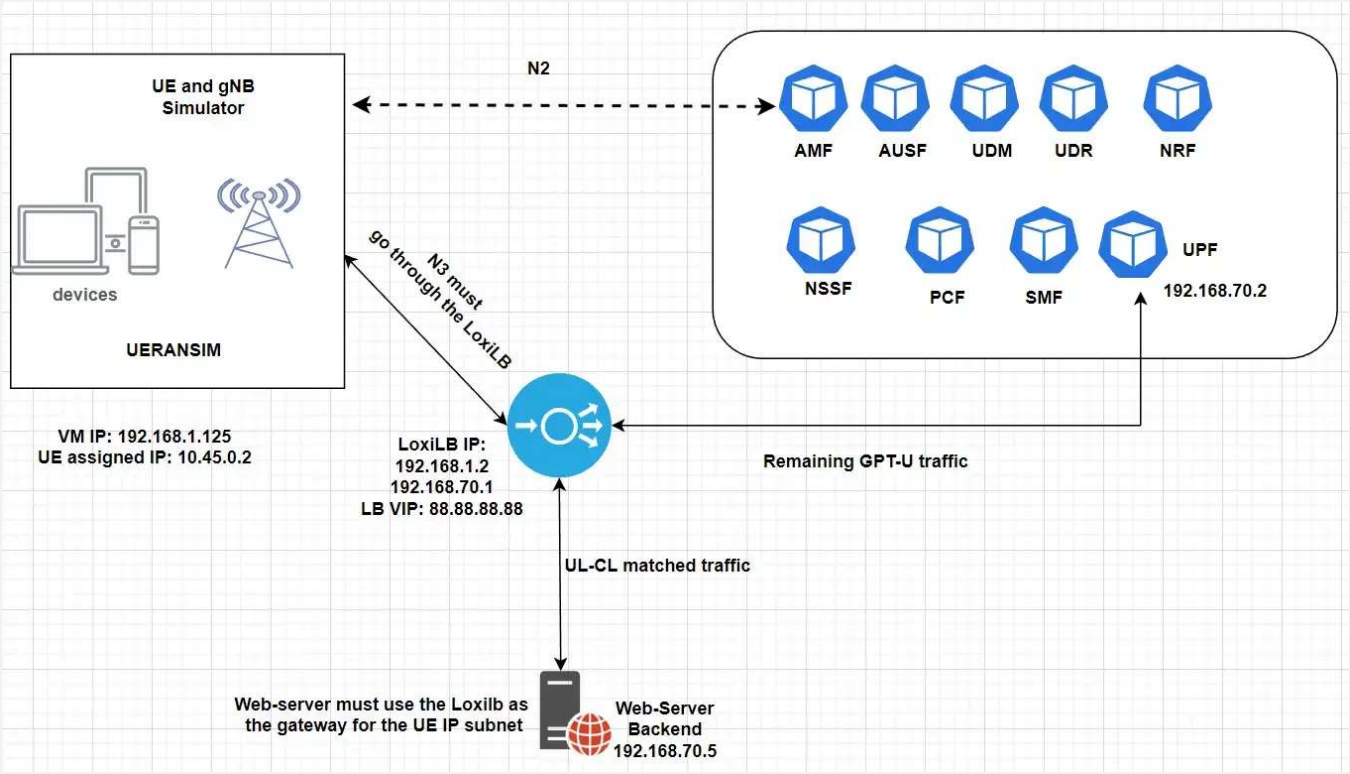
Source: https://killercoda.com/netlox

Source: https://futuredon.medium.com/5g-sctp-loadbalancer-using-loxilb-b525198a9103

V. 5G EDGE LB VIRTUAL LAB

❖ SCTP Load Balancing Test in 5G N3 Interface as LBO(Local Break Out)

- Learn How To test LoxiLB SCTP Load Balancing Test in 5G N3 Interface as LBO(Local Break Out)



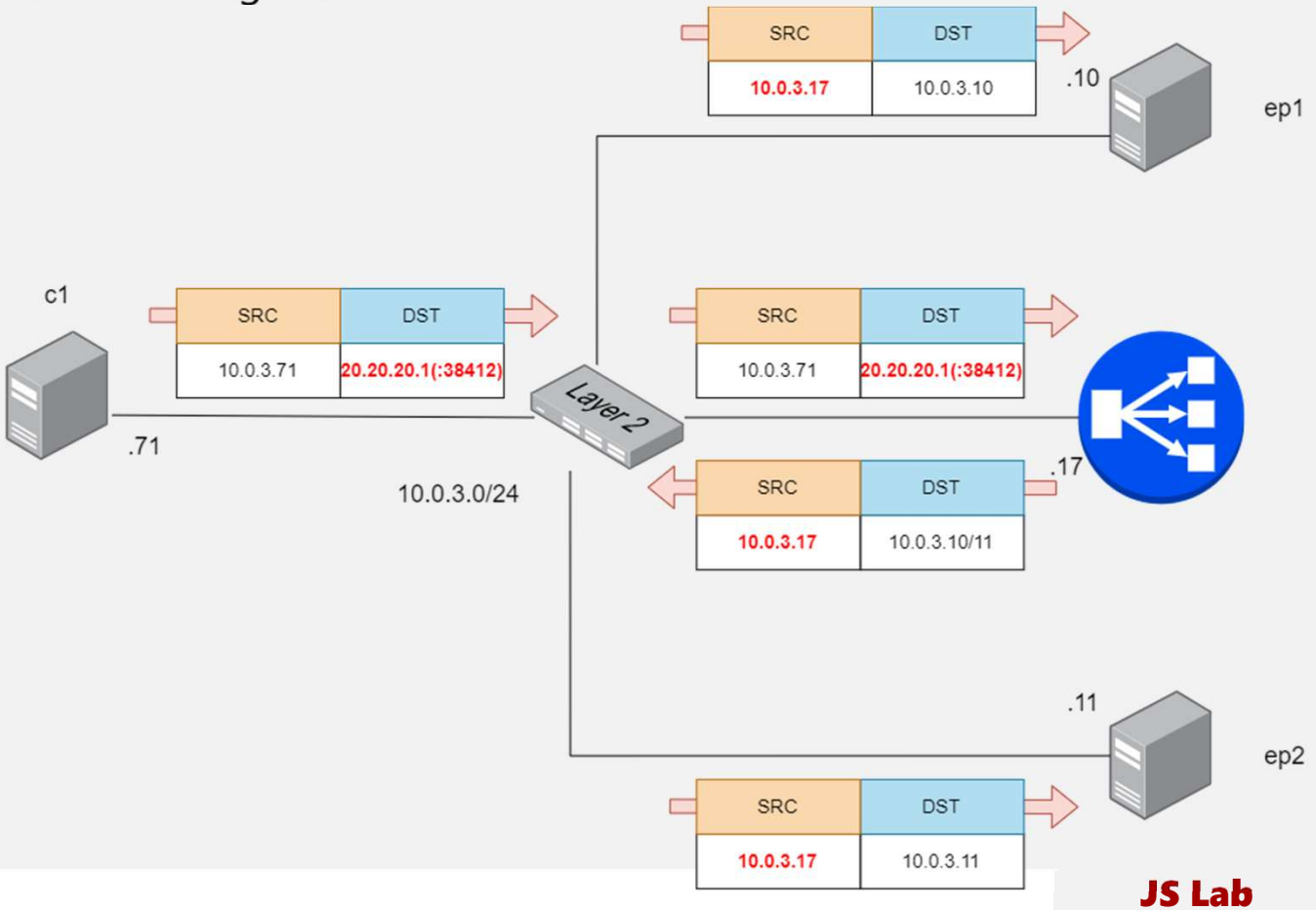
Source: https://killercoda.com/netlox

Source: https://futuredon.medium.com/5g-uplink-classifier-using-loxilb-7593a4d66f4c

V. 5G EDGE LB VIRTUAL LAB

❖ SCTP Load Balancing Test with Full-NAT Mode

- Learn How To test LoxiLB SCTP Load Balancing Test with Full-NAT Mode

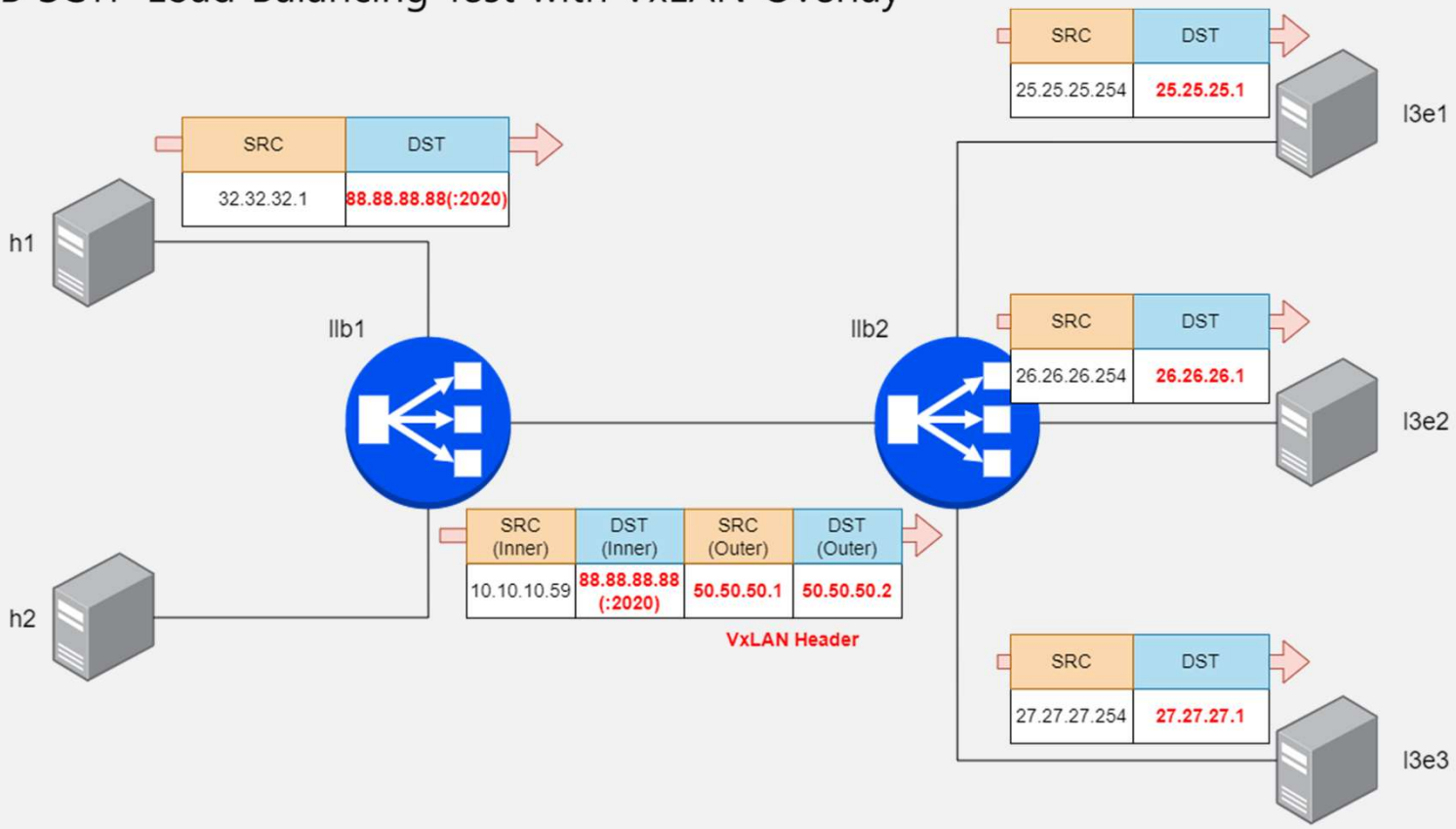


Source: https://killercoda.com/netlox

V. 5G EDGE LB VIRTUAL LAB

❖ SCTP Load Balancing Test with VxLAN Overlay

- Learn How To test LoxiLB SCTP Load Balancing Test with VxLAN Overlay

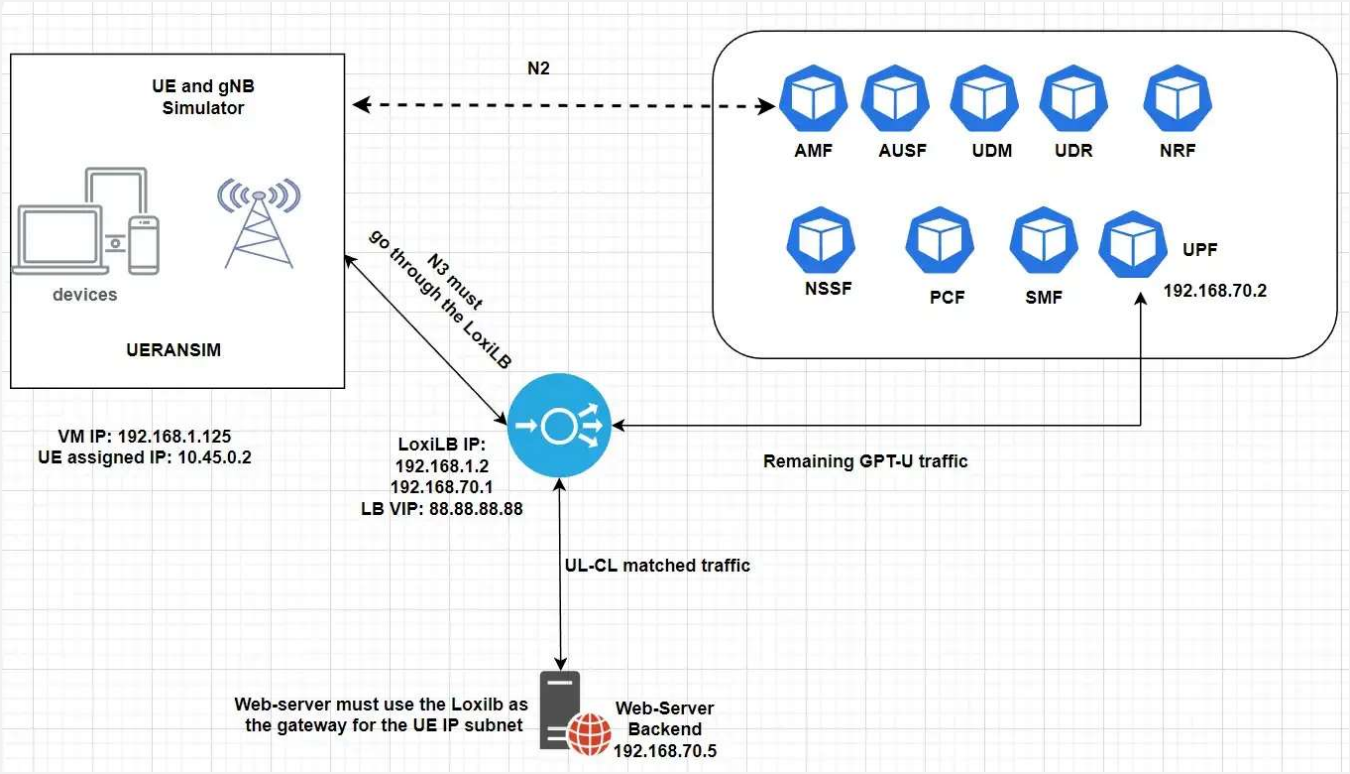


Source: https://killercoda.com/netlox

V. 5G EDGE LB VIRTUAL LAB

❖ TCP Load Balancing Test in 5G N3 Interface as LBO(Local Break Out)

- Learn How To test LoxiLB TCP Load Balancing Test in 5G N3 Interface as LBO(Local Break Out)



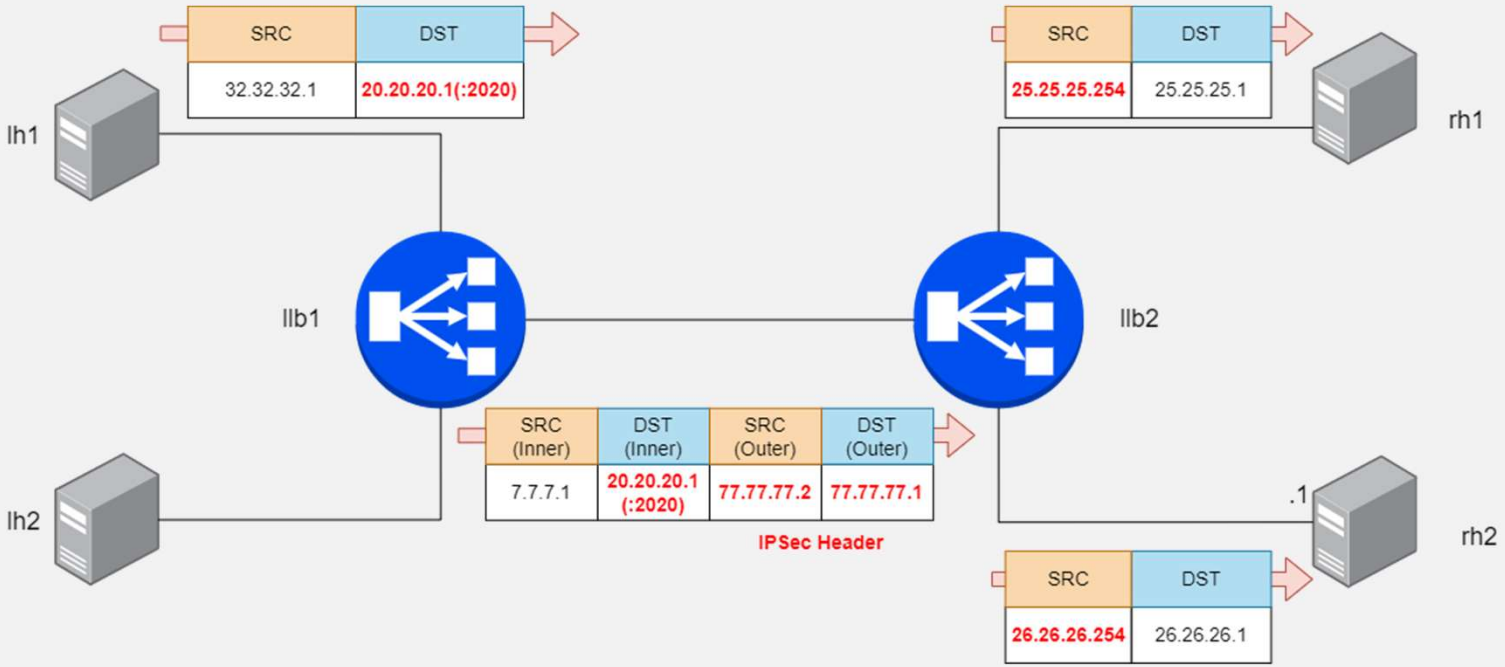
Source: https://killercoda.com/netlox/scenario/loxilb-3node-1client-lb

Source: https://futuredon.medium.com/5g-uplink-classifier-using-loxilb-7593a4d66f4c

V. 5G EDGE LB VIRTUAL LAB

❖ TCP Load Balancing Test with IPSec

- Learn How To test LoxiLB TCP Load Balancing Test with IPSec

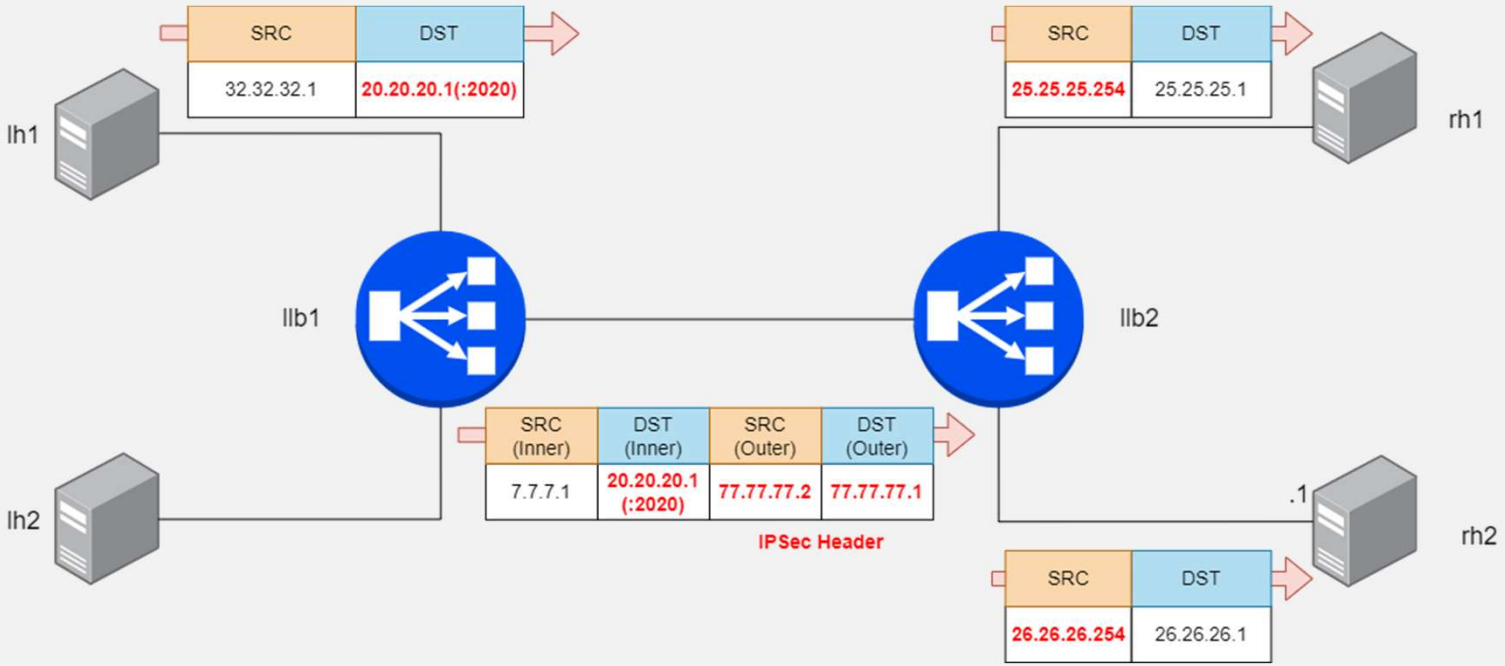


Source: https://killercoda.com/netlox

V. 5G EDGE LB VIRTUAL LAB

❖ TCP Load Balancing Test with IPSec and Strongswan

- Learn How To test LoxiLB TCP Load Balancing Test with IPSec and Strongswan



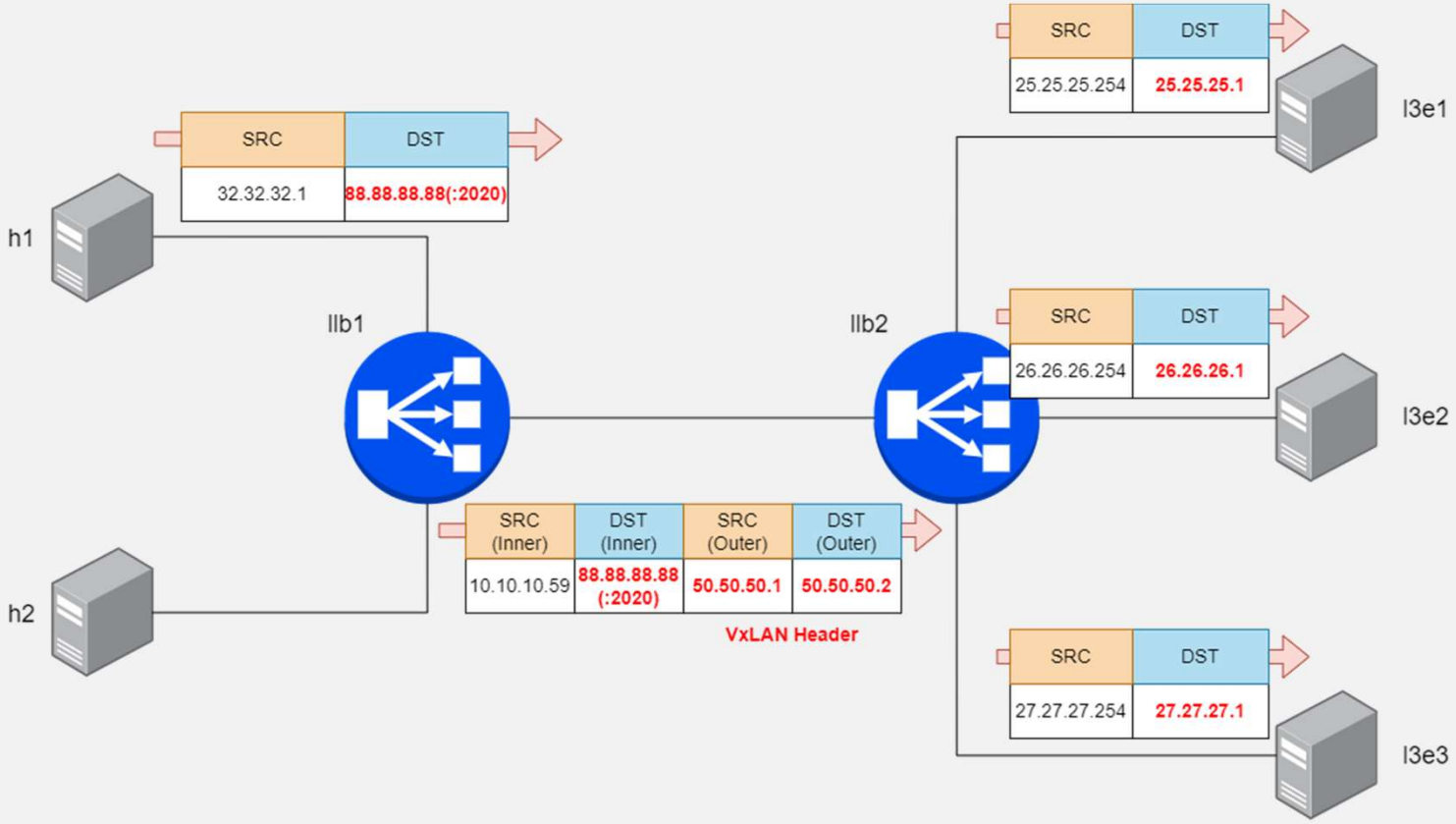
strongSwan: Open-source, modular and portable IPsec-based VPN solution

Source: https://killercoda.com/netlox

V. 5G EDGE LB VIRTUAL LAB

❖ LoxiLB TCP Load Balancing Test with VxLAN Overlay

- Achieving LoxiLB TCP Load Balancing Test with VxLAN Overlay



Source: https://killercoda.com/netlox

V. 5G EDGE LB VIRTUAL LAB

❖ LoxiLB 3 Endpoints 1 Client Test

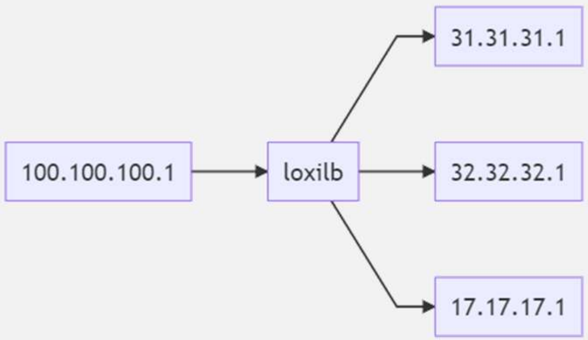
- How to configure LoxiLB: How to setup it and How to use loxi CLI.
- How to do a troubleshoot.
- How to test performance.

```
ubuntu $ echo waiting for init-background-script to finish
waiting for init-background-script to finish
ubuntu $ echo ====== It will tabke 5 - 10 minutes ======
====== It will tabke 5 - 10 minutes ======
ubuntu $ while [ ! -f /tmp/background0 ]; do sleep 1; done
ubuntu $ echo Hello and welcome to this LoxiLB scenario!
Hello and welcome to this LoxiLB scenario!
ubuntu $
```

```
ubuntu $ ip netns exec l3e1 ifconfig eth0
ubuntu $ ip netns exec l3e2 ifconfig eth0
ubuntu $ ip netns exec l3e3 ifconfig eth0
ubuntu $ ip netns exec l3c1 ifconfig eth0
ubuntu $ ip netns exec loxilb route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
0.0.0.0         172.17.0.1      0.0.0.0         UG    0      0        0 eth0
17.17.17.0      0.0.0.0         255.255.255.0   U     0      0        0 enp3
31.31.31.0      0.0.0.0         255.255.255.0   U     0      0        0 enp1
32.32.32.0      0.0.0.0         255.255.255.0   U     0      0        0 enp2
100.100.100.0   0.0.0.0         255.255.255.0   U     0      0        0 enp4
172.17.0.0      0.0.0.0         255.255.0.0     U     0      0        0 eth0
ubuntu $ ip netns exec loxilb ping 31.31.31.1
ubuntu $ ip netns exec loxilb ping 32.32.32.1
ubuntu $ ip netns exec loxilb ping 17.17.17.1
ubuntu $ ip netns exec loxilb ping 100.100.100.1
ubuntu $ ip netns
l3c1
l3e3
l3e2
l3e1
loxilb (id: 0)
```

네임스페이스는 lo 인터페이스만 가지고 있으며 다른 네임스페이스와 통신할 수 없는 영역

```
root@3398fc6113e0:/# loxicmd get port
| INDEX | PORTNAME  |        MAC        | LINK/STATE |             L3INFO              |    L2INFO     |
|-------|-----------|-------------------|------------|---------------------------------|---------------|
|     1 | lo        | 00:00:00:00:00:00 | true/true  | Routed: true IPv4 :             | IsPVID: true  |
|       |           |                   |            | [127.0.0.1/8 - Primary]  IPv6   | VID : 3801    |
|       |           |                   |            | : []                            |               |
|     2 | vlan3801  | aa:bb:cc:dd:ee:ff | true/true  | Routed: false                   | IsPVID: false |
|       |           |                   |            | IPv4 : []                       | VID : 3801    |
|       |           |                   |            | IPv6 : []                       |               |
|     3 | llb0      | d2:ed:85:74:ba:db | true/true  | Routed: false                   | IsPVID: true  |
|       |           |                   |            | IPv4 : []                       | VID : 3803    |
|       |           |                   |            | IPv6 : []                       |               |
|     4 | vlan3803  | aa:bb:cc:dd:ee:ff | true/true  | Routed: false                   | IsPVID: false |
|       |           |                   |            | IPv4 : []                       | VID : 3803    |
|       |           |                   |            | IPv6 : []                       |               |
|     5 | eth0      | 02:42:ac:11:00:02 | true/true  | Routed: true IPv4 :             | IsPVID: true  |
|       |           |                   |            | [172.17.0.2/16 - Primary]       | VID : 3805    |
|       |           |                   |            | IPv6 : []                       |               |
|     6 | vlan3805  | aa:bb:cc:dd:ee:ff | true/true  | Routed: false                   | IsPVID: false |
|       |           |                   |            | IPv4 : []                       | VID : 3805    |
|       |           |                   |            | IPv6 : []                       |               |
|     7 | enp1      | 9e:c9:54:8b:c7:0c | true/true  | Routed: true IPv4 :             | IsPVID: true  |
|       |           |                   |            | [31.31.31.254/24 - Primary]     | VID : 3807    |
|       |           |                   |            | IPv6 : []                       |               |
|     8 | vlan3807  | aa:bb:cc:dd:ee:ff | true/true  | Routed: false                   | IsPVID: false |
|       |           |                   |            | IPv4 : []                       | VID : 3807    |
|       |           |                   |            | IPv6 : []                       |               |
|     9 | enp2      | 3e:d4:bc:31:35:75 | true/true  | Routed: true IPv4 :             | IsPVID: true  |
|       |           |                   |            | [32.32.32.254/24 - Primary]     | VID : 3809    |
|       |           |                   |            | IPv6 : []                       |               |
|    10 | vlan3809  | aa:bb:cc:dd:ee:ff | true/true  | Routed: false                   | IsPVID: false |
|       |           |                   |            | IPv4 : []                       | VID : 3809    |
|       |           |                   |            | IPv6 : []                       |               |
|    11 | enp3      | a6:63:01:10:1b:b7 | true/true  | Routed: true IPv4 :             | IsPVID: true  |
|       |           |                   |            | [17.17.17.254/24 - Primary]     | VID : 3811    |
                                                                                    | IsPVID: false |
                                                                                    | VID : 3811    |
                                                                                    | IsPVID: true  |
                                                                                    | VID : 3813    |
                                                                                    | IsPVID: false |
                                                                                    | VID : 3813    |
```




```
ubuntu $ docker exec -it loxilb bash
root@3398fc6113e0:/# loxicmd create lb 20.20.20.1 --tcp=2020:5001 --endpoints=31.31.31.1:1,32.32.32.1:1,17.17.17.1:1
ProtoPortpair: map[tcp:[2020:5001]]
Debug: response.StatusCode: 200
root@3398fc6113e0:/# loxicmd get lb -o wide
| EXTERNAL IP | PORT | PROTOCOL | BLOCK | SELECT |  MODE   | ENDPOINT IP | TARGET PORT | WEIGHT | STATE  |
|-------------|------|----------|-------|--------|---------|-------------|-------------|--------|--------|
| 20.20.20.1  | 2020 | tcp      |     0 | rr     | default | 17.17.17.1  |        5001 |      1 | active |
|             |      |          |       |        |         | 31.31.31.1  |        5001 |      1 | active |
|             |      |          |       |        |         | 32.32.32.1  |        5001 |      1 | active |
root@3398fc6113e0:/#
```

Source: https://killercoda.com/netlox/scenario/loxilb-3node-1client-lb

V. 5G EDGE LB VIRTUAL LAB

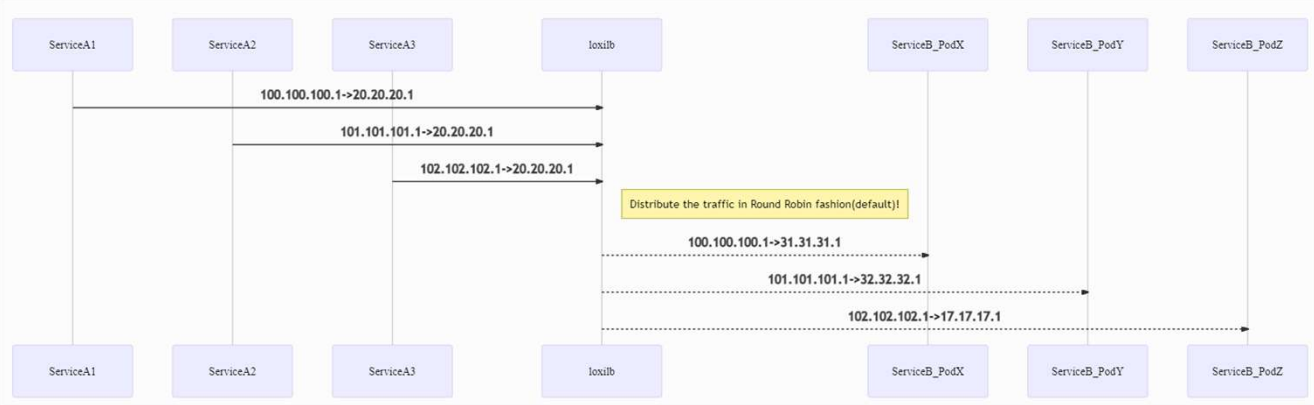
❖ Send traffics and check result

- Install WSK HTTP Traffic generator benchmark tool:
- wrk -t8 -c400 -d30s http://20.20.20.1:2020/

```
sudo apt-get install build-essential libssl-dev git -y
git clone https://github.com/wg/wrk.git wrk
cd wrk
sudo make
sudo cp wrk /usr/local/bin

cd ~/
go build server.go

sudo ip netns exec l3e1 bash          Tab1
./server

sudo ip netns exec l3e2 bash          Tab2
./server

sudo ip netns exec l3e3 bash          Tab3
./server

sudo ip netns exec l3c1 bash          Tab4
wrk -t8 -c400 -d30s http://20.20.20.1:2020/
```

```
Editor   Tab 1   Tab 2   Tab 3   Tab 4
ubuntu $ sudo ip netns exec l3c1 bash
ubuntu $ wrk -t8 -c400 -d30s http://20.20.20.1:2020/
Running 30s test @ http://20.20.20.1:2020/
  8 threads and 400 connections
  Thread Stats   Avg      Stdev     Max   +/- Stdev
    Latency    33.20ms   61.77ms 948.35ms   92.93%
    Req/Sec     2.99k   752.59     9.12k    74.78%
  710906 requests in 30.10s, 50.85MB read
Requests/sec:  23618.50
Transfer/sec:      1.69MB
ubuntu $
```

-t8: Thread 8개가 실행되어
-c400: HTTP Connection 400개를 서버에 연결하고 (각 Thread 별로 50개의 Connection 연결)
-d30s: 30초동안 지속적으로 트래픽 발생

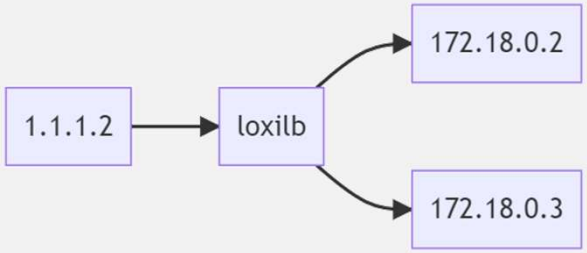


Source: https://killercoda.com/netlox/scenario/loxilb-3node-1client-lb

V. 5G EDGE LB VIRTUAL LAB

❖ Learn How To Configure LoxiLB and CCM to integrate with Kubernetes

- How to configure LoxiLB: How to setup it and How to use loxi CLI.
- How to configure Loxi-CCM to intergrate with Kubernetes.
- How to deploy kubernetes LoadBalancer service.




```
ubuntu $ ip netns exec loxilb ping 1.1.1.2
ubuntu $ ip netns exec loxilb ping 172.18.0.2
ubuntu $ ip netns exec loxilb ping 172.18.0.3

ubuntu $ docker ps
CONTAINER ID   IMAGE                  COMMAND                  CREATED          STATUS          PORTS                       NAMES
868bcaeedceb   kindest/node:v1.24.0   "/usr/local/bin/entr…"   10 minutes ago   Up 10 minutes                               k8s-playground-worker
cf6fe033b710   kindest/node:v1.24.0   "/usr/local/bin/entr…"   10 minutes ago   Up 10 minutes   127.0.0.1:35077->6443/tcp   k8s-playground-control-plane

ubuntu $ docker exec -it k8s-playground-control-plane ip route add 1.1.1.0/24 via 172.18.0.254 dev eth0
ubuntu $ docker exec -it k8s-playground-worker ip route add 1.1.1.0/24 via 172.18.0.254 dev eth0
ubuntu $ cd ~
ubuntu $ dir
filesystem  iproute2  kind-config.yaml  kubectl  loxilb-io  loxilb_cli_install.sh  loxilb_install.sh  server.go
ubuntu $ ./loxilb_install.sh
```

Compile & Build LoxiLB from source code

Source: https://killercoda.com/netlox/scenario/loxilb-ccm

V. 5G EDGE LB VIRTUAL LAB

❖ Learn How To Configure LoxiLB and CCM to integrate with Kubernetes

- Compile & Build LoxiLB Command from source code

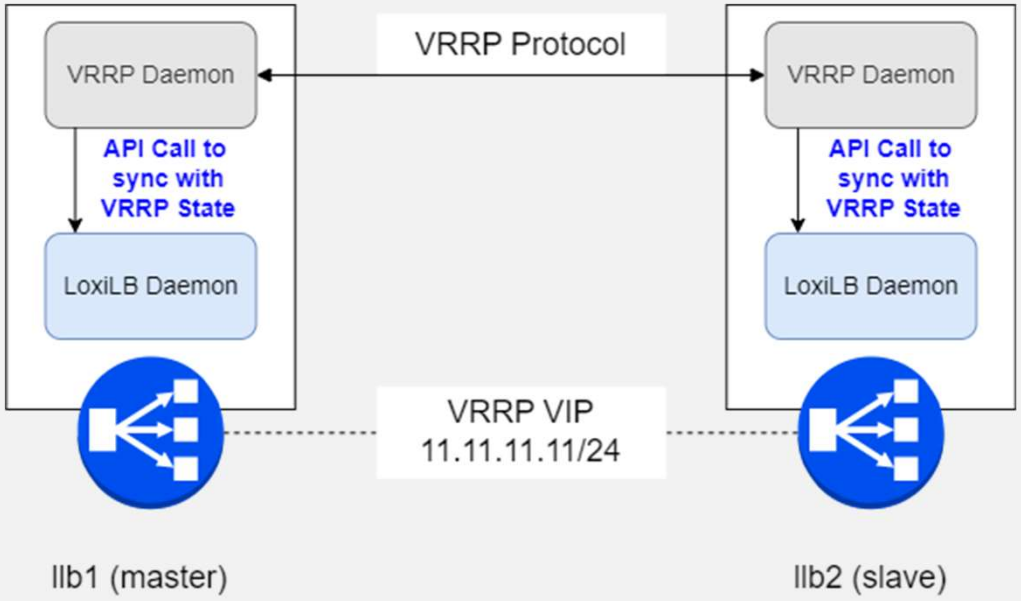
```
cd ~
./loxilb_cli_install.sh
```

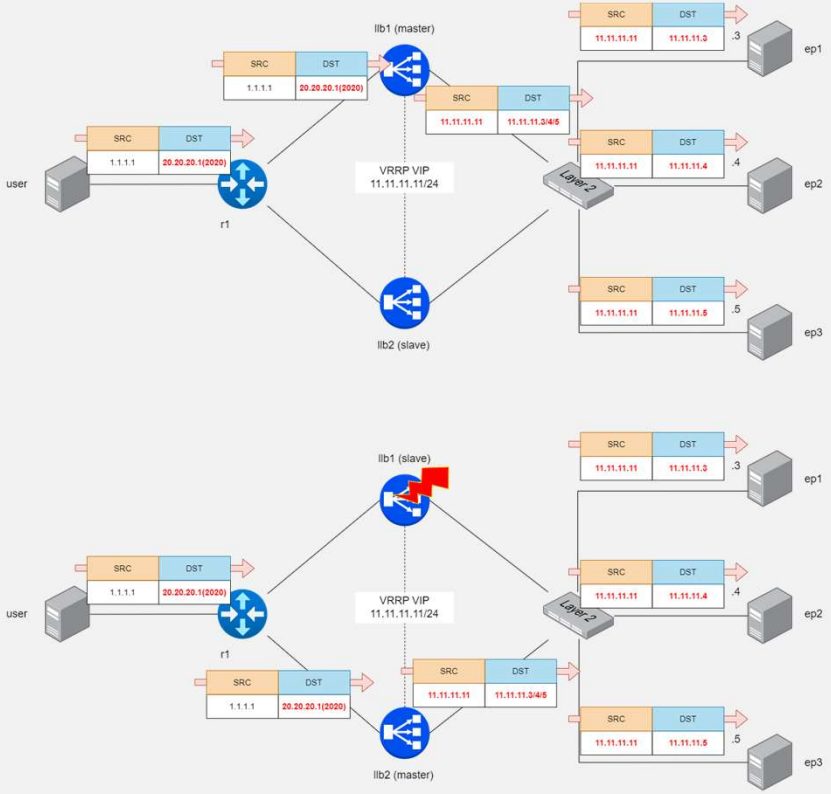
Source: https://killercoda.com/netlox/scenario/loxilb-ccm

V. 5G EDGE LB VIRTUAL LAB

❖ LoxiLB Load Balancing Test over Clustering with BGP and HA (Full NAT Mode)

- **Achieving LoxiLB Load Balancing Test over Clustering with BGP and HA (FULL NAT Mode)**



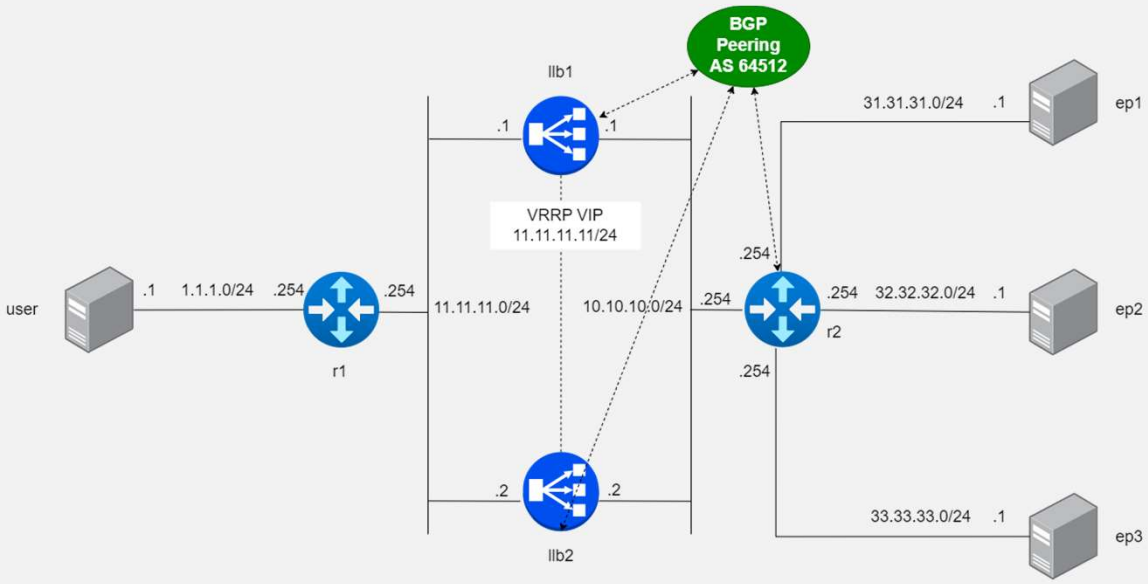


Source: https://killercoda.com/netlox/scenario/loxilb-cluster1

V. 5G EDGE LB VIRTUAL LAB

❖ LoxiLB Load Balancing Test over Clustering with BGP and HA (Full NAT Mode)

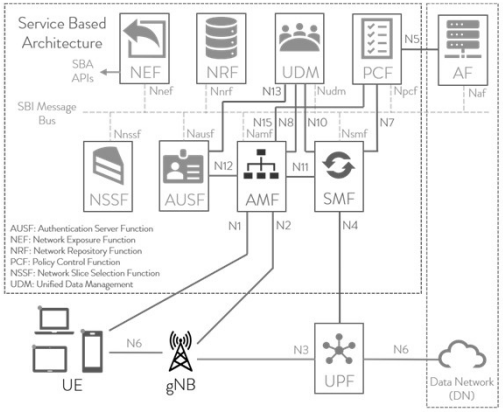
- Achieving LoxiLB Load Balancing Test over Clustering with BGP and HA (FULL NAT Mode)




```
ip netns exec ep1 ifconfig eth0
ip netns exec ep2 ifconfig eth0
ip netns exec ep3 ifconfig eth0
ip netns exec r1 route -n
ip netns exec r2 route -n
ip netns exec llb1 route -n
ip netns exec llb2 route -n
ip netns exec user ifconfig eth0

ip netns exec llb1 ping 11.11.11.254 -c 5
ip netns exec llb1 ping 10.10.10.254 -c 5
ip netns exec llb2 ping 11.11.11.254 -c 5
ip netns exec llb2 ping 10.10.10.254 -c 5
ip netns exec r1 ping 1.1.1.1 -c 5
ip netns exec r2 ping 31.31.31.1 -c 5
ip netns exec r2 ping 32.32.32.1 -c 5
ip netns exec r2 ping 33.33.33.1 -c 5

cd ~/
sudo /bin/bash ./config.sh
```

Source: https://killercoda.com/netlox/scenario/loxilb-cluster1

부록 1. Kubernetes 설치



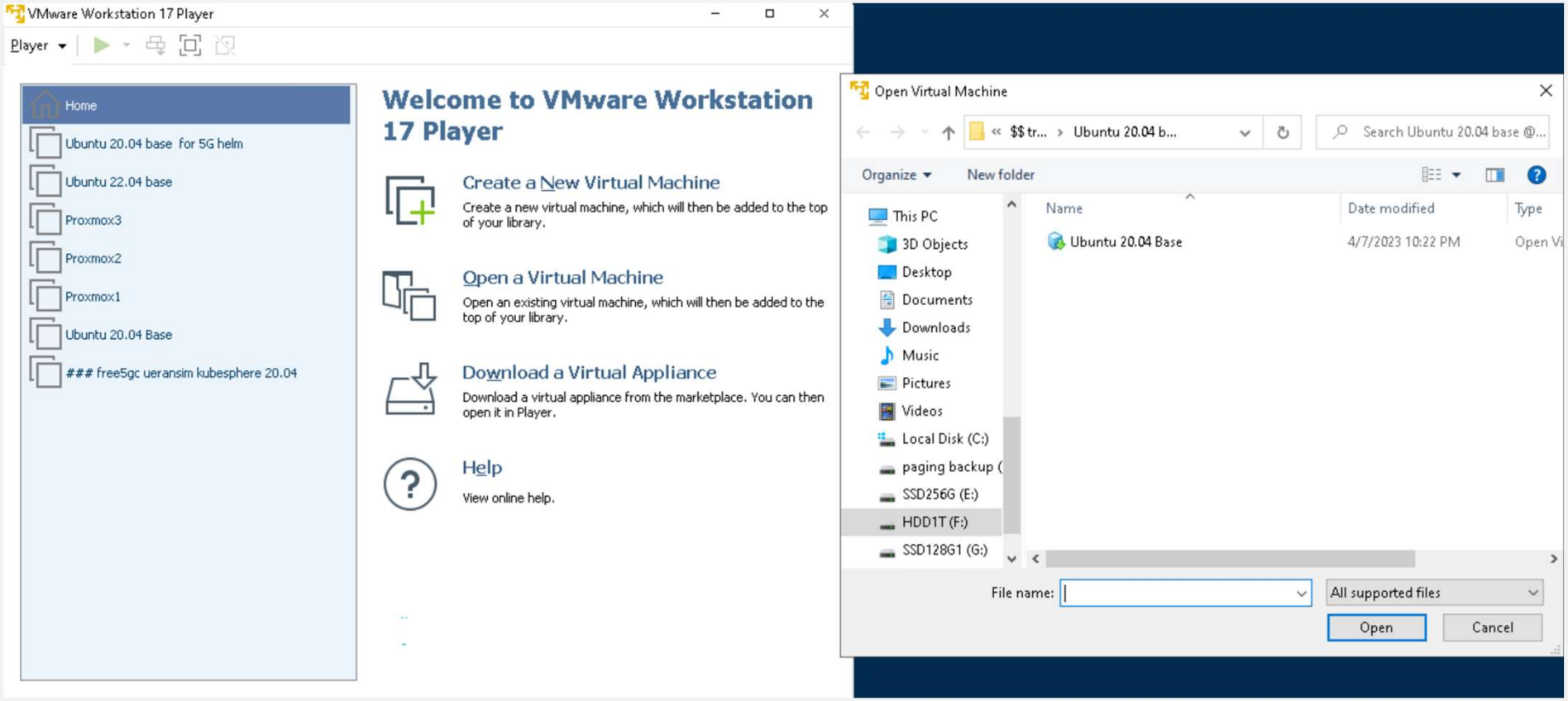
부록 1. KUBERNETES 설치

❖ 개요 - Kubernetes 구축 솔루션

- **Self-managed solutions:**
  - Minikube: Single node, Windows and MacOS with virtualization
  - MicroK8s: It was just for a Single node, Linux (Now for multimode)
  - K3s: lightweight Kubernetes (512 MB RAM, 200 MB disk), SQLite (Instead of Etcd)
  - Kind: Kubernetes-in-Docker (Windows, Mac, and Linux)
  - Desktop Docker: Docker for Mac/Windows now ships with a bundled Kubernetes offering
  - K3d: K3s-in-Docker (similar to Kind).
  - Kubeadm: The official CNCF tool for provisioning Kubernetes clusters
  - Kubespray: Composition of Ansible playbooks, inventory, provisioning tools
- **Enterprise solutions:**
  - OpenShift: Red Hat (IBM), hybrid cloud, enterprise container platform
  - KubeSphere
  - Rancher: Rancher, multi-cluster orchestration platform
- **Cloud-based solutions:**
  - Amazon EKS: Amazon Elastic Container Service (EKS) for Kubernetes
  - Google Cloud: Kubernetes Engine
  - MS Azure: Azure Kubernetes Service (AKS)
  - IBM Cloud: IBM Cloud Kubernetes service

부록 1. KUBERNETES 설치

❖ Open a Virtual Machine



Source: https://kubesphere.io/docs/v3.3/quick-start/all-in-one-on-linux/

부록 1. KUBERNETES 설치

❖ Hardware recommendations

OS	Minimum Requirements
Ubuntu 16.04, 18.04, 20.04, 22.04	2 CPU cores, 4 GB memory, and 40 GB disk space
Debian Buster, Stretch	2 CPU cores, 4 GB memory, and 40 GB disk space
CentOS 7.x	2 CPU cores, 4 GB memory, and 40 GB disk space
Red Hat Enterprise Linux 7	2 CPU cores, 4 GB memory, and 40 GB disk space
SUSE Linux Enterprise Server 15/openSUSE Leap 15.2	2 CPU cores, 4 GB memory, and 40 GB disk space

Source: https://kubesphere.io/docs/v3.3/quick-start/all-in-one-on-linux/

부록 1. KUBERNETES 설치

❖ Container runtimes

- sudo apt install docker.io

Supported Container Runtime	Version
Docker	19.3.8 +
containerd	Latest
CRI-O (experimental, not fully tested)	Latest
iSula (experimental, not fully tested)	Latest

Source: https://kubesphere.io/docs/v3.3/quick-start/all-in-one-on-linux/

부록 1. KUBERNETES 설치

❖ Network and DNS requirements

- etc/resolv.conf의 DNS 주소를 사용할 수 있는지 확인 (클러스터에서 DNS 문제가 발생할 수 있음.)
- 네트워크 구성에서 방화벽 규칙 또는 보안 그룹을 사용하는 경우 인프라 구성 요소가 특정 포트를 통해 서로 통신할 수 있는지 확인 (방화벽을 해제하는 것을 권장)
- 지원되는 CNI 플러그인: Calico 및 Flannel. 다른 플러그인(예: Cilium 및 Kube-OVN)도 작동할 수 있지만 완전히 테스트되지 않았음

Source: https://kubesphere.io/docs/v3.3/quick-start/all-in-one-on-linux/

부록 1. KUBERNETES 설치

❖ Dependency requirements

- sudo apt install docker.io
- sudo apt install conntrack
- sudo apt install socat
- sudo apt install ipset

Dependency	Kubernetes Version ≥ 1.18	Kubernetes Version < 1.18
socat	Required	Optional but recommended
conntrack	Required	Optional but recommended
ebtables	Optional but recommended	Optional but recommended
ipset	Optional but recommended	Optional but recommended

Source: https://kubesphere.io/docs/v3.3/quick-start/all-in-one-on-linux/

부록 1. KUBERNETES 설치

❖ 사내 운영망 환경 시험 시 필요한 'Ubuntu Server 16.04/18.04' 설정

- 호스트 이름 변경 -

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

- Root 활성화 -

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

- Root 계정 생성 -

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

- SSH Well-known Port 변경 -

```
sudo nano /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 @ Remote -

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

- 고정 IP 주소 설정-

```
sudo nano /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)
```

- Remote for sshd @ Putty -

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

부록 1. KUBERNETES 설치

❖ Download KubeKey / Get Started with Installation

- sudo curl -sfL https://get-kk.kubesphere.io | VERSION=v3.0.7 sh -
- dir
- chmod +x kk
- ### ./kk create cluster [--with-kubernetes version] [--with-kubesphere version]
- sudo ./kk create cluster --with-kubernetes v1.22.12 --with-kubesphere v3.3.2

```
jslab@jslab:~$ sudo curl -sfL https://get-kk.kubesphere.io | VERSION=v3.0.7 sh -

Downloading kubekey v3.0.7 from https://github.com/kubesphere/kubekey/releases/download/v3.0.7/kubekey-v3.0.7-linux-amd64.tar.gz ...

Kubekey v3.0.7 Download Complete!
jslab@jslab:~$
jslab@jslab:~$ dir
kk  kubekey  kubekey-v3.0.7-linux-amd64.tar.gz
jslab@jslab:~$
jslab@jslab:~$ chmod +x kk
jslab@jslab:~$
jslab@jslab:~$ sudo ./kk create cluster --with-kubernetes v1.22.12 --with-kubesphere v3.3.2
```

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

Source: https://kubesphere.io/docs/v3.3/quick-start/all-in-one-on-linux/

부록 1. KUBERNETES 설치

❖ Install KubeSphere

- curl -sfL https://get-kk.kubesphere.io | VERSION=v1.2.1 sh -
- chmod +x kk
- All in one
  - ./kk create cluster [--with-kubernetes version] [--with-kubesphere version]
- **All in one** (Sample)
  - **sudo ./kk create cluster --with-kubernetes v1.22.12 --with-kubesphere v3.3.2**

```
jslab@jslab:~$ sudo ./kk create cluster --with-kubernetes v1.22.12 --with-kubesphere v3.3.2

+-------+------+------+---------+----------+-------+-------+---------+-----------+--------+----------+---------------------+------------+------------+-----------------+-------------+
| name  | sudo | curl | openssl | ebtables | socat | ipset | ipvsadm | conntrack | chrony | docker   | containerd          | nfs client | ceph client | glusterfs client | time        |
+-------+------+------+---------+----------+-------+-------+---------+-----------+--------+----------+---------------------+------------+------------+-----------------+-------------+
| jslab | y    | y    | y       | y        | y     | y     |         | y         |        | 20.10.21 | 1.6.12-0ubuntu1~22.04.1 |            |            |                 | UTC 16:35:43 |
+-------+------+------+---------+----------+-------+-------+---------+-----------+--------+----------+---------------------+------------+------------+-----------------+-------------+

This is a simple check of your environment.
Before installation, ensure that your machines meet all requirements specified at
https://github.com/kubesphere/kubekey#requirements-and-recommendations

Continue this installation? [yes/no]: yes
```

Source: https://kubesphere.io/docs/v3.3/quick-start/all-in-one-on-linux/

부록 1. KUBERNETES 설치

❖ Welcome to KubeSphere!

- http://192.168.42.100:30880 (admin/P@88w0rd)

```
#################################################
###              Welcome to KubeSphere!       ###
#################################################

Console: http://192.168.42.100:30880
Account: admin
Password: P@88w0rd
NOTES：
  1. After you log into the console, please check the
     monitoring status of service components in
     "Cluster Management". If any service is not
     ready, please wait patiently until all components
     are up and running.
  2. Please change the default password after login.

#################################################
https://kubesphere.io             2023-04-06 16:52:21
#################################################
16:52:25 UTC success: [jslab]
16:52:25 UTC Pipeline[CreateClusterPipeline] execute successfully
Installation is complete.

Please check the result using the command:

        kubectl logs -n kubesphere-system $(kubectl get pod -n kubesphere-system -l 'app in (ks-install, ks-installer)' -o
jsonpath='{.items[0].metadata.name}') -f

jslab@jslab:~$
```

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

부록 1. KUBERNETES 설치

❖ sudo docker ps

```
jslab@jslab:~$ sudo docker ps
[sudo] password for jslab:
CONTAINER ID   IMAGE                                        COMMAND                  CREATED         STATUS         PORTS     NAMES
a05fe0011771   kubesphere/notification-tenant-sidecar        "/tenant-sidecar"        10 minutes ago  Up 10 minutes            k8s_tenant_notification-manager-deployment-78664576cb-5rzlj_kubesphere-monitoring-system_157e3065-cae1-4d8d-b718-c263d644ba6e_0
8f16c89285d3   kubesphere/notification-manager              "/notification-manag…"   10 minutes ago  Up 10 minutes            k8s_notification-manager_notification-manager-deployment-78664576cb-5rzlj_kubesphere-monitoring-system_157e3065-cae1-4d8d-b718-c263d644ba6e_0
a83e237d63b7   7c63de88523a                                 "/bin/prometheus-con…"   10 minutes ago  Up 10 minutes            k8s_config-reloader_prometheus-k8s-0_kubesphere-monitoring-system_ee89a45c-f61d-4f0e-a771-b3a7d72d3dd7_0
f39b46ee450c   prom/prometheus                              "/bin/prometheus --w…"   10 minutes ago  Up 10 minutes            k8s_prometheus_prometheus-k8s-0_kubesphere-monitoring-system_ee89a45c-f61d-4f0e-a771-b3a7d72d3dd7_0
b892986d0ae6   kubesphere/kubectl                           "entrypoint.sh"          11 minutes ago  Up 11 minutes            k8s_kubectl_kubectl-admin-6dbcb94855-tdp76_kubesphere-controls-system_486a6989-d758-49d3-aee4-b044623ebac4_0
c3e97c9b3f69   kubesphere/pause:3.5                         "/pause"                 11 minutes ago  Up 11 minutes            k8s_POD_notification-manager-deployment-78664576cb-5rzlj_kubesphere-monitoring-system_157e3065-cae1-4d8d-b718-c263d644ba6e_0
c6bca84f9bf9   kubesphere/notification-manager-operator      "/notification-manag…"   11 minutes ago  Up 11 minutes            k8s_notification-manager-operator_notification-manager-operator-7d44854f54-jhsnv_kubesphere-monitoring-system_bb3a4b74-c07f-4a8f-9210-6bd843711a4e_0
b156fa2f643a   kubesphere/prometheus-config-reloader        "/bin/prometheus-con…"   12 minutes ago  Up 12 minutes            k8s_config-reloader_alertmanager-main-0_kubesphere-monitoring-system_525cca8c-c070-4638-a627-fa9add3d5396_0
7c330f2a22fb   kubesphere/ks-apiserver                      "ks-apiserver --logt…"   12 minutes ago  Up 12 minutes            k8s_ks-apiserver_ks-apiserver-576fbd5df4-vbmpd_kubesphere-system_36002958-913b-439a-a7c3-578fdc48ba3e_0
e6d2af027dd1   kubesphere/pause:3.5                         "/pause"                 13 minutes ago  Up 13 minutes            k8s_POD_kubectl-admin-6dbcb94855-tdp76_kubesphere-controls-system_486a6989-d758-49d3-aee4-b044623ebac4_0
660cb24b6967   kubesphere/ks-controller-manager             "controller-manager …"   13 minutes ago  Up 13 minutes            k8s_ks-controller-manager_ks-controller-manager-f8dfd55c8-fn8c8_kubesphere-system_52342f81-e1c5-4bd6-9402-561cf1c9873a_0
7eaa7920be4e   29589495df8d                                 "/usr/local/bin/kube…"   13 minutes ago  Up 13 minutes            k8s_kube-rbac-proxy-self_kube-state-metrics-687d66b747-6rpb8_kubesphere-monitoring-system_05827a75-382d-4b90-9d6b-d74aec83fcec_0
40f3c2673946   kubesphere/kube-rbac-proxy                   "/usr/local/bin/kube…"   13 minutes ago  Up 13 minutes            k8s_kube-rbac-proxy-main_kube-state-metrics-687d66b747-6rpb8_kubesphere-monitoring-system_05827a75-382d-4b90-9d6b-d74aec83fcec_0
3f0789ee4183   kubesphere/kube-rbac-proxy                   "/usr/local/bin/kube…"   13 minutes ago  Up 13 minutes            k8s_kube-rbac-proxy_node-exporter-dw8lr_kubesphere-monitoring-system_1c92ab61-e1c4-4d4d-8f10-74f9586279bc_0
f19c76113031   kubesphere/kube-rbac-proxy                   "/usr/local/bin/kube…"   13 minutes ago  Up 13 minutes            k8s_kube-rbac-proxy_notification-manager-operator-7d44854f54-jhsnv_kubesphere-monitoring-system_bb3a4b74-c07f-4a8f-9210-6bd843711a4e_0
eb2fcf6f8fd4   kubesphere/pause:3.5                         "/pause"                 14 minutes ago  Up 14 minutes            k8s_POD_prometheus-k8s-0_kubesphere-monitoring-system_ee89a45c-f61d-4f0e-a771-b3a7d72d3dd7_0
8f5ff7da5503   prom/alertmanager                            "/bin/alertmanager --…"  14 minutes ago  Up 14 minutes            k8s_alertmanager_alertmanager-main-0_kubesphere-monitoring-system_525cca8c-c070-4638-a627-fa9add3d5396_0
4ab33d303c92   kubesphere/pause:3.5                         "/pause"                 14 minutes ago  Up 14 minutes            k8s_POD_ks-apiserver-576fbd5df4-vbmpd_kubesphere-system_36002958-913b-439a-a7c3-578fdc48ba3e_0
4c7ebe210ebb   kubesphere/pause:3.5                         "/pause"                 14 minutes ago  Up 14 minutes            k8s_POD_ks-controller-manager-f8dfd55c8-fn8c8_kubesphere-system_52342f81-e1c5-4bd6-9402-561cf1c9873a_0
fec5e598c0be   kubesphere/kube-rbac-proxy                   "/usr/local/bin/kube…"   15 minutes ago  Up 15 minutes            k8s_kube-rbac-proxy_prometheus-operator-8955bbd98-srvph_kubesphere-monitoring-system_34aa1551-bd52-4dc1-a9fc-b161caee8980_0
a62bd604c5b7   kubesphere/kube-state-metrics                "/kube-state-metrics…"   15 minutes ago  Up 15 minutes            k8s_kube-state-metrics_kube-state-metrics-687d66b747-6rpb8_kubesphere-monitoring-system_05827a75-382d-4b90-9d6b-d74aec83fcec_0
30108943ca0c   prom/node-exporter                           "/bin/node_exporter …"   15 minutes ago  Up 15 minutes            k8s_node-exporter_node-exporter-dw8lr_kubesphere-monitoring-system_1c92ab61-e1c4-4d4d-8f10-74f9586279bc_0
1002eaeeb20c   kubesphere/pause:3.5                         "/pause"                 16 minutes ago  Up 16 minutes            k8s_POD_notification-manager-operator-7d44854f54-jhsnv_kubesphere-monitoring-system_bb3a4b74-c07f-4a8f-9210-6bd843711a4e_0
11e3c0c1a192   kubesphere/pause:3.5                         "/pause"                 16 minutes ago  Up 16 minutes            k8s_POD_alertmanager-main-0_kubesphere-monitoring-system_525cca8c-c070-4638-a627-fa9add3d5396_0
37a08ba43931   kubesphere/prometheus-operator               "/bin/operator --kub…"   16 minutes ago  Up 16 minutes            k8s_prometheus-operator_prometheus-operator-8955bbd98-srvph_kubesphere-monitoring-system_34aa1551-bd52-4dc1-a9fc-b161caee8980_0
63104e1a6104   kubesphere/pause:3.5                         "/pause"                 16 minutes ago  Up 16 minutes            k8s_POD_kube-state-metrics-687d66b747-6rpb8_kubesphere-monitoring-system_05827a75-382d-4b90-9d6b-d74aec83fcec_0
6013c88398bf   kubesphere/pause:3.5                         "/pause"                 16 minutes ago  Up 16 minutes            k8s_POD_node-exporter-dw8lr_kubesphere-monitoring-system_1c92ab61-e1c4-4d4d-8f10-74f9586279bc_0
ec162886b809   kubesphere/pause:3.5                         "/pause"                 16 minutes ago  Up 16 minutes            k8s_POD_prometheus-operator-8955bbd98-srvph_kubesphere-monitoring-system_34aa1551-bd52-4dc1-a9fc-b161caee8980_0
fc5db4f3dffb   mirrorgooglecontainers/defaultbackend-amd64  "/server"                18 minutes ago  Up 18 minutes            k8s_default-http-backend_default-http-backend-5bf68ff9b8-cxgpp_kubesphere-controls-system_dc102db7-c887-4cd3-a161-f5f4ebfdb6db_0
7d69c4e0863d   kubesphere/ks-console                        "docker-entrypoint.s…"   18 minutes ago  Up 18 minutes            k8s_ks-console_ks-console-5c9fcbc67b-9bdjc_kubesphere-system_8d8f42ce-eddb-445d-8668-15030e229772_0
209ca5783847   kubesphere/pause:3.5                         "/pause"                 19 minutes ago  Up 19 minutes            k8s_POD_ks-console-5c9fcbc67b-9bdjc_kubesphere-system_8d8f42ce-eddb-445d-8668-15030e229772_0
8501a97f183f   kubesphere/pause:3.5                         "/pause"                 19 minutes ago  Up 19 minutes            k8s_POD_default-http-backend-5bf68ff9b8-cxgpp_kubesphere-controls-system_dc102db7-c887-4cd3-a161-f5f4ebfdb6db_0
9e5745c096d2   csiplugin/snapshot-controller                "/snapshot-controlle…"   21 minutes ago  Up 21 minutes            k8s_snapshot-controller_snapshot-controller-0_kube-system_35d67d20-2258-4a44-b510-812fa90ff830_0
8d0d2e135d57   kubesphere/pause:3.5                         "/pause"                 21 minutes ago  Up 21 minutes            k8s_POD_snapshot-controller-0_kube-system_35d67d20-2258-4a44-b510-812fa90ff830_0
e934ae199edc   openebs/provisioner-localpv                  "/usr/local/bin/prov…"   21 minutes ago  Up 21 minutes            k8s_openebs-provisioner-hostpath_openebs-localpv-provisioner-57bbf864d5-mhmjs_kube-system_0d74ef2f-fcb3-461f-8a3d-1c0939dae594_0
59b421329132   kubesphere/ks-installer                      "/shell-operator sta…"   22 minutes ago  Up 22 minutes            k8s_installer_ks-installer-85d6fb8c97-jj7n5_kubesphere-system_4bdea3ba-27e9-4204-a852-a1f795206217_0
7bb75826353a   ec95788d0f72                                 "/usr/bin/kube-contr…"   22 minutes ago  Up 22 minutes            k8s_calico-kube-controllers_calico-kube-controllers-69d878584c-r519c_kube-system_9a4afa59-7907-445a-8f4c-edf482e05af8_0
dc171912210c   296a6d5035e2                                 "/coredns -conf /etc…"   22 minutes ago  Up 22 minutes            k8s_coredns_coredns-b5648d655-tjzn5_kube-system_e801644c-02a8-47a9-9dc0-e535673ab499_0
503540e36ca8   296a6d5035e2                                 "/coredns -conf /etc…"   22 minutes ago  Up 22 minutes            k8s_coredns_coredns-b5648d655-7rxcn_kube-system_28338401-3bb1-43eb-965b-70b3ae655c0f_0
5377f64dc64d   kubesphere/pause:3.5                         "/pause"                 22 minutes ago  Up 22 minutes            k8s_POD_calico-kube-controllers-69d878584c-r519c_kube-system_9a4afa59-7907-445a-8f4c-edf482e05af8_0
b47ce96003d0   kubesphere/pause:3.5                         "/pause"                 22 minutes ago  Up 22 minutes            k8s_POD_openebs-localpv-provisioner-57bbf864d5-mhmjs_kube-system_0d74ef2f-fcb3-461f-8a3d-1c0939dae594_0
6b9bf98e2517   kubesphere/pause:3.5                         "/pause"                 22 minutes ago  Up 22 minutes            k8s_POD_coredns-b5648d655-tjzn5_kube-system_e801644c-02a8-47a9-9dc0-e535673ab499_0
55887a9a6040   kubesphere/pause:3.5                         "/pause"                 22 minutes ago  Up 22 minutes            k8s_POD_coredns-b5648d655-7rxcn_kube-system_28338401-3bb1-43eb-965b-70b3ae655c0f_0
3701adc08fe0   kubesphere/pause:3.5                         "/pause"                 22 minutes ago  Up 22 minutes            k8s_POD_ks-installer-85d6fb8c97-jj7n5_kubesphere-system_4bdea3ba-27e9-4204-a852-a1f795206217_0
6461ae328e87   a3447b26d32c                                 "start_runit"            22 minutes ago  Up 22 minutes            k8s_calico-node_calico-node-w6294_kube-system_3fc07479-7d0c-436e-934e-2292412 5a545_0
765f6b01023d   5340ba194ec9                                 "/node-cache -locali…"   22 minutes ago  Up 22 minutes            k8s_node-cache_nodelocaldns-jp87q_kube-system_8bc72427-926f-4151-8a92-79ab15f1e35d_0
1749bd366c5f   kubesphere/pause:3.5                         "/pause"                 22 minutes ago  Up 22 minutes            k8s_POD_nodelocaldns-jp87q_kube-system_8bc72427-926f-4151-8a92-79ab15f1e35d_0
646e4ca4e831   761817698b62                                 "/usr/local/bin/kube…"   22 minutes ago  Up 22 minutes            k8s_kube-proxy_kube-proxy-2cb27_kube-system_9b9a0fbe-c82e-4eee-95ab-34d37ff642b1_0
43f607ac5bbc   kubesphere/pause:3.5                         "/pause"                 22 minutes ago  Up 22 minutes            k8s_POD_kube-proxy-2cb27_kube-system_9b9a0fbe-c82e-4eee-95ab-34d37ff642b1_0
bfc2a27c2fda   kubesphere/pause:3.5                         "/pause"                 22 minutes ago  Up 22 minutes            k8s_POD_calico-node-w6294_kube-system_3fc07479-7d0c-436e-934e-2292412 5a545_0
dd7d50e2637c   f5ef4d6e36ee                                 "kube-controller-man…"   23 minutes ago  Up 23 minutes            k8s_kube-controller_kube-controller-manager-jslab_kube-system_898d827bd77c9d67f14c4461cff3d731_0
8828bf0e562c   5ee90014579c                                 "kube-scheduler --au…"   23 minutes ago  Up 23 minutes            k8s_kube-scheduler_kube-scheduler-jslab_kube-system_98c5c78d9268cc3e7e256dd8b9671226_0
3af41cf1abac   d922296a8b85                                 "kube-apiserver --ad…"   23 minutes ago  Up 23 minutes            k8s_kube-apiserver_kube-apiserver-jslab_kube-system_ae9af56aa432607153b2572b9ad2f05b_0
2ba3dcd06291   kubesphere/pause:3.5                         "/pause"                 23 minutes ago  Up 23 minutes            k8s_POD_kube-scheduler-jslab_kube-system_98c5c78d9268cc3e7e256dd8b9671226_0
ab73c3b58326   kubesphere/pause:3.5                         "/pause"                 23 minutes ago  Up 23 minutes            k8s_POD_kube-controller-manager-jslab_kube-system_898d827bd77c9d67f14c4461cff3d731_0
77eedb3770cb   kubesphere/pause:3.5                         "/pause"                 23 minutes ago  Up 23 minutes            k8s_POD_kube-apiserver-jslab_kube-system_ae9af56aa432607153b2572b9ad2f05b_0
jslab@jslab:~$
```

부록 1. KUBERNETES 설치

- ❖ Docker Operations
  - sudo docker info
- ❖ K8s Operations
  - sudo kubectl get all --all-namespaces
  - sudo kubectl get svc --all-namespaces
- ❖ Linux Operations
  - sudo apt install net-tools
  - sudo netstat -tulpn | grep LISTEN

```
jslab@jslab:~$ sudo docker info
Client:
 Context:    default
 Debug Mode: false

Server:
 Containers: 59
  Running: 56
  Paused: 0
  Stopped: 3
 Images: 31
 Server Version: 20.10.21
 Storage Driver: overlay2
  Backing Filesystem: extfs
  Supports d_type: true
  Native Overlay Diff: true
  userxattr: false
 Logging Driver: json-file
 Cgroup Driver: systemd
 Cgroup Version: 2
 Plugins:
  Volume: local
  Network: bridge host ipvlan macvlan null overlay
  Log: awslogs fluentd gcplogs gelf journald json-file local logentries splunk syslog
 Swarm: inactive
 Runtimes: io.containerd.runc.v2 io.containerd.runtime.v1.linux runc
 Default Runtime: runc
 Init Binary: docker-init
 containerd version:
 runc version:
 init version:
 Security Options:
  apparmor
  seccomp
   Profile: default
  cgroupns
 Kernel Version: 5.15.0-69-generic
 Operating System: Ubuntu 22.04.2 LTS
 OSType: linux
 Architecture: x86_64
 CPUs: 4
 Total Memory: 7.73GiB
 Name: jslab
 ID: 7HN3:CSPR:EUUE:3CCZ:OVXQ:JOZY:QXLO:JL5Z:KELY:I5F3:5PFP:6SBU
 Docker Root Dir: /var/lib/docker
 Debug Mode: false
 Registry: https://index.docker.io/v1/
 Labels:
 Experimental: false
 Insecure Registries:
  127.0.0.0/8
 Live Restore Enabled: false

jslab@jslab:~$
```

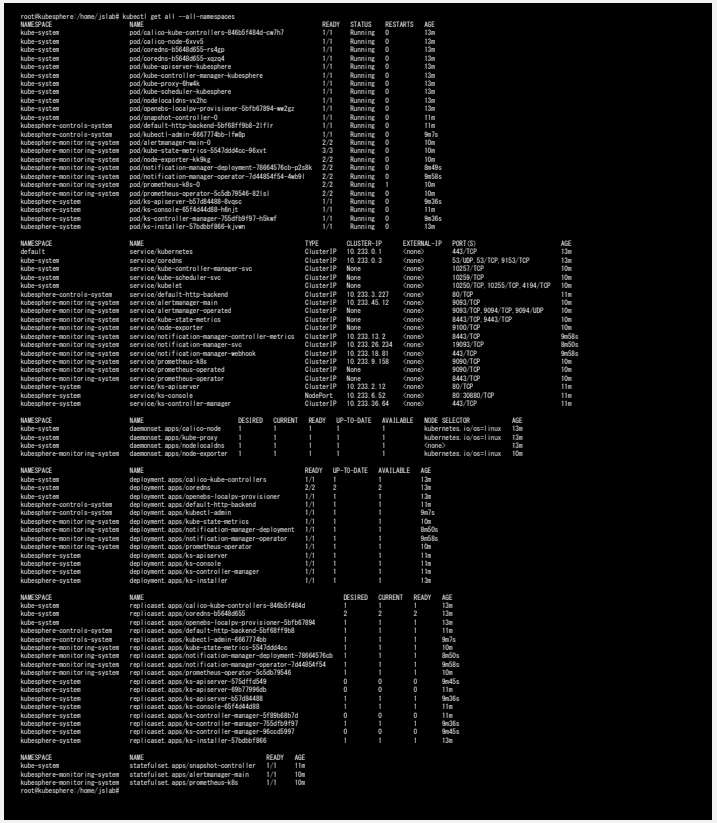
부록 1. KUBERNETES 설치

- ❖ Docker Operations
  - docker info
- ❖ **K8s Operations** (as root)
  - **kubectl get svc --all-namespaces**
  - kubectl get all --all-namespaces
- ❖ Linux Operations
  - sudo netstat -tulpn | grep LISTEN

```
jslab@jslab:~$ sudo kubectl get svc --all-namespaces
NAMESPACE                      NAME                                         TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)                      AGE
default                        kubernetes                                   ClusterIP   10.233.0.1      <none>        443/TCP                      26m
kube-system                    coredns                                      ClusterIP   10.233.0.3      <none>        53/UDP,53/TCP,9153/TCP       26m
kube-system                    kube-controller-manager-svc                  ClusterIP   None            <none>        10257/TCP                    20m
kube-system                    kube-scheduler-svc                           ClusterIP   None            <none>        10259/TCP                    20m
kube-system                    kubelet                                      ClusterIP   None            <none>        10250/TCP,10255/TCP,4194/TCP 19m
kubesphere-controls-system     default-http-backend                         ClusterIP   10.233.60.145   <none>        80/TCP                       22m
kubesphere-monitoring-system   alertmanager-main                            ClusterIP   10.233.57.29    <none>        9093/TCP,8080/TCP            20m
kubesphere-monitoring-system   alertmanager-operated                        ClusterIP   None            <none>        9093/TCP,9094/TCP,9094/UDP   19m
kubesphere-monitoring-system   kube-state-metrics                           ClusterIP   None            <none>        8443/TCP,9443/TCP            20m
kubesphere-monitoring-system   node-exporter                                ClusterIP   None            <none>        9100/TCP                     20m
kubesphere-monitoring-system   notification-manager-controller-metrics      ClusterIP   10.233.61.232   <none>        8443/TCP                     19m
kubesphere-monitoring-system   notification-manager-svc                     ClusterIP   10.233.14.235   <none>        19093/TCP                    15m
kubesphere-monitoring-system   notification-manager-webhook                 ClusterIP   10.233.35.43    <none>        443/TCP                      19m
kubesphere-monitoring-system   prometheus-k8s                               ClusterIP   10.233.41.75    <none>        9090/TCP,8080/TCP            20m
kubesphere-monitoring-system   prometheus-operated                          ClusterIP   None            <none>        9090/TCP                     19m
kubesphere-monitoring-system   prometheus-operator                          ClusterIP   None            <none>        8443/TCP                     20m
kubesphere-system              ks-apiserver                                 ClusterIP   10.233.2.176    <none>        80/TCP                       22m
kubesphere-system              ks-console                                   NodePort    10.233.13.233   <none>        80:30880/TCP                 22m
kubesphere-system              ks-controller-manager                        ClusterIP   10.233.8.6      <none>        443/TCP
```

부록 1. KUBERNETES 설치

- ❖ Docker Operations
  - docker info
- ❖ **K8s Operations**
  - kubectl get svc --all-namespaces
  - **kubectl get all --all-namespaces**
  - kubectl get nodes
  - kubectl get svc
  - kubectl get svc --all-namespaces
  - kubectl get pods
  - kubectl get pods --all-namespaces
- ❖ Linux Operations
  - sudo netstat -tulpn | grep LISTEN



```
root@kubesphere:/home/jslab# kubectl get all --all-namespaces
NAMESPACE                      NAME                                                  READY   STATUS    RESTARTS   AGE
kube-system                    pod/calico-kube-controllers-846b5f484d-cw7h7          1/1     Running   0          13m
kube-system                    pod/calico-node-6xvv5                                 1/1     Running   0          13m
kube-system                    pod/coredns-b5648d655-rs4gp                           1/1     Running   0          13m
kube-system                    pod/coredns-b5648d655-xqzq4                           1/1     Running   0          13m
kube-system                    pod/kube-apiserver-kubesphere                         1/1     Running   0          13m
kube-system                    pod/kube-controller-manager-kubesphere                1/1     Running   0          13m
kube-system                    pod/kube-proxy-8tw4k                                  1/1     Running   0          13m
kube-system                    pod/kube-scheduler-kubesphere                         1/1     Running   0          13m
kube-system                    pod/nodelocaldns-vv2hc                                1/1     Running   0          13m
kube-system                    pod/openebs-localpv-provisioner-5bfb67894-ww2gz       1/1     Running   0          13m
kube-system                    pod/snapshot-controller-0                             1/1     Running   0          11m
kubesphere-controls-system     pod/default-http-backend-5bf68ff9b8-2ifir             1/1     Running   0          11m
kubesphere-controls-system     pod/kubectl-admin-666774bb-lfwbp                      1/1     Running   0          9m7s
kubesphere-monitoring-system   pod/alertmanager-main-0                               2/2     Running   0          10m
kubesphere-monitoring-system   pod/kube-state-metrics-5547dd4cc-86xvt                3/3     Running   0          10m
kubesphere-monitoring-system   pod/node-exporter-kk9kg                               2/2     Running   0          10m
kubesphere-monitoring-system   pod/notification-manager-deployment-78664576cb-p2s8k  2/2     Running   0          8m49s
kubesphere-monitoring-system   pod/notification-manager-operator-7d4485df54-4wb9l    2/2     Running   0          9m58s
kubesphere-monitoring-system   pod/prometheus-k8s-0                                  2/2     Running   1          10m
kubesphere-monitoring-system   pod/prometheus-operator-5c5db79546-82lsl              2/2     Running   0          10m
kubesphere-system              pod/ks-apiserver-857d84488-8vqqc                      1/1     Running   0          9m36s
kubesphere-system              pod/ks-console-65f4d44d88-h6njt                       1/1     Running   0          11m
kubesphere-system              pod/ks-controller-manager-755df9df97-n5kwf            1/1     Running   0          9m35s
kubesphere-system              pod/ks-installer-57bdbf866-kjvm                       1/1     Running   0          13m

NAMESPACE                      NAME                                                  TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)                                 AGE
default                        service/kubernetes                                    ClusterIP   10.233.0.1      <none>        443/TCP                                 13m
kube-system                    service/coredns                                       ClusterIP   10.233.0.3      <none>        53/UDP,53/TCP,9153/TCP                  13m
kube-system                    service/kube-controller-manager-svc                   ClusterIP   None            <none>        10257/TCP                               10m
kube-system                    service/kube-scheduler-svc                            ClusterIP   None            <none>        10259/TCP                               10m
kube-system                    service/kubelet                                       ClusterIP   None            <none>        10250/TCP,10255/TCP,4194/TCP            10m
kubesphere-controls-system     service/default-http-backend                          ClusterIP   10.233.3.227    <none>        80/TCP                                  11m
kubesphere-monitoring-system   service/alertmanager-main                             ClusterIP   10.233.45.12    <none>        9093/TCP                                10m
kubesphere-monitoring-system   service/alertmanager-operated                         ClusterIP   None            <none>        9093/TCP,9094/TCP,9094/UDP              10m
kubesphere-monitoring-system   service/kube-state-metrics                            ClusterIP   None            <none>        8443/TCP,9443/TCP                       10m
kubesphere-monitoring-system   service/node-exporter                                 ClusterIP   None            <none>        9100/TCP                                10m
kubesphere-monitoring-system   service/notification-manager-controller-metrics       ClusterIP   10.233.13.2     <none>        8443/TCP                                9m58s
kubesphere-monitoring-system   service/notification-manager-svc                      ClusterIP   10.233.26.234   <none>        19093/TCP                               9m58s
kubesphere-monitoring-system   service/notification-manager-webhook                  ClusterIP   10.233.18.81    <none>        443/TCP                                 9m58s
kubesphere-monitoring-system   service/prometheus-k8s                                ClusterIP   10.233.9.158    <none>        9090/TCP                                10m
kubesphere-monitoring-system   service/prometheus-operated                           ClusterIP   None            <none>        9090/TCP                                10m
kubesphere-monitoring-system   service/prometheus-operator                           ClusterIP   None            <none>        8443/TCP                                10m
kubesphere-system              service/ks-apiserver                                  ClusterIP   10.233.2.12     <none>        80/TCP                                  11m
kubesphere-system              service/ks-console                                    NodePort    10.233.6.52     <none>        80:30880/TCP                            11m
kubesphere-system              service/ks-controller-manager                         ClusterIP   10.233.36.64    <none>        443/TCP                                 11m

NAMESPACE                      NAME                                  DESIRED   CURRENT   READY   UP-TO-DATE   AVAILABLE   NODE SELECTOR            AGE
kube-system                    daemonset.apps/calico-node            1         1         1       1            1           kubernetes.io/os=linux   13m
kube-system                    daemonset.apps/kube-proxy             1         1         1       1            1           kubernetes.io/os=linux   13m
kube-system                    daemonset.apps/nodelocaldns           1         1         1       1            1           <none>                   13m
kubesphere-monitoring-system   daemonset.apps/node-exporter          1         1         1       1            1           kubernetes.io/os=linux   10m

NAMESPACE                      NAME                                                  READY   UP-TO-DATE   AVAILABLE   AGE
kube-system                    deployment.apps/calico-kube-controllers               1/1     1            1           13m
kube-system                    deployment.apps/coredns                               2/2     2            2           13m
kube-system                    deployment.apps/openebs-localpv-provisioner           1/1     1            1           13m
kubesphere-controls-system     deployment.apps/default-http-backend                  1/1     1            1           11m
kubesphere-controls-system     deployment.apps/kubectl-admin                         1/1     1            1           9m7s
kubesphere-monitoring-system   deployment.apps/kube-state-metrics                    1/1     1            1           10m
kubesphere-monitoring-system   deployment.apps/notification-manager-deployment       1/1     1            1           8m50s
kubesphere-monitoring-system   deployment.apps/notification-manager-operator         1/1     1            1           9m58s
kubesphere-monitoring-system   deployment.apps/prometheus-operator                   1/1     1            1           10m
kubesphere-system              deployment.apps/ks-apiserver                          1/1     1            1           11m
kubesphere-system              deployment.apps/ks-console                            1/1     1            1           11m
kubesphere-system              deployment.apps/ks-controller-manager                 1/1     1            1           11m
kubesphere-system              deployment.apps/ks-installer                          1/1     1            1           13m

NAMESPACE                      NAME                                                  DESIRED   CURRENT   READY   AGE
kube-system                    replicaset.apps/calico-kube-controllers-846b5f484d    1         1         1       13m
kube-system                    replicaset.apps/coredns-b5648d655                     2         2         2       13m
kube-system                    replicaset.apps/openebs-localpv-provisioner-5bfb67894 1         1         1       13m
kubesphere-controls-system     replicaset.apps/default-http-backend-5bf68ff9b8       1         1         1       11m
kubesphere-controls-system     replicaset.apps/kubectl-admin-666774bb                1         1         1       9m7s
kubesphere-monitoring-system   replicaset.apps/kube-state-metrics-5547dd4cc          1         1         1       10m
kubesphere-monitoring-system   replicaset.apps/notification-manager-deployment-78664576cb 1      1         1       8m50s
kubesphere-monitoring-system   replicaset.apps/notification-manager-operator-7d4485df54 1        1         1       9m58s
kubesphere-monitoring-system   replicaset.apps/prometheus-operator-5c5db79546        1         1         1       10m
kubesphere-system              replicaset.apps/ks-apiserver-575df1fd49               0         0         0       9m45s
kubesphere-system              replicaset.apps/ks-apiserver-6867f996db               0         0         0       11m
kubesphere-system              replicaset.apps/ks-apiserver-857d84488                1         1         1       9m36s
kubesphere-system              replicaset.apps/ks-console-65f4d44d88                 1         1         1       11m
kubesphere-system              replicaset.apps/ks-controller-manager-5f88b68b7d      0         0         0       11m
kubesphere-system              replicaset.apps/ks-controller-manager-755df9f97       1         1         1       9m35s
kubesphere-system              replicaset.apps/ks-controller-manager-96ccd5997       0         0         0       9m45s
kubesphere-system              replicaset.apps/ks-installer-57bdbf866                1         1         1       13m

NAMESPACE                      NAME                                  READY   AGE
kube-system                    statefulset.apps/snapshot-controller  1/1     11m
kubesphere-monitoring-system   statefulset.apps/alertmanager-main    1/1     10m
kubesphere-monitoring-system   statefulset.apps/prometheus-k8s       1/1     10m
root@kubesphere:/home/jslab#
```

부록 1. KUBERNETES 설치

- ❖ Docker Operations
  - docker info
- ❖ K8s Operations
  - kubectl get all --all-namespaces
  - kubectl get svc --all-namespaces
- ❖ Linux Operations
  - sudo apt install net-tools
  - sudo netstat -tulpn | grep LISTEN

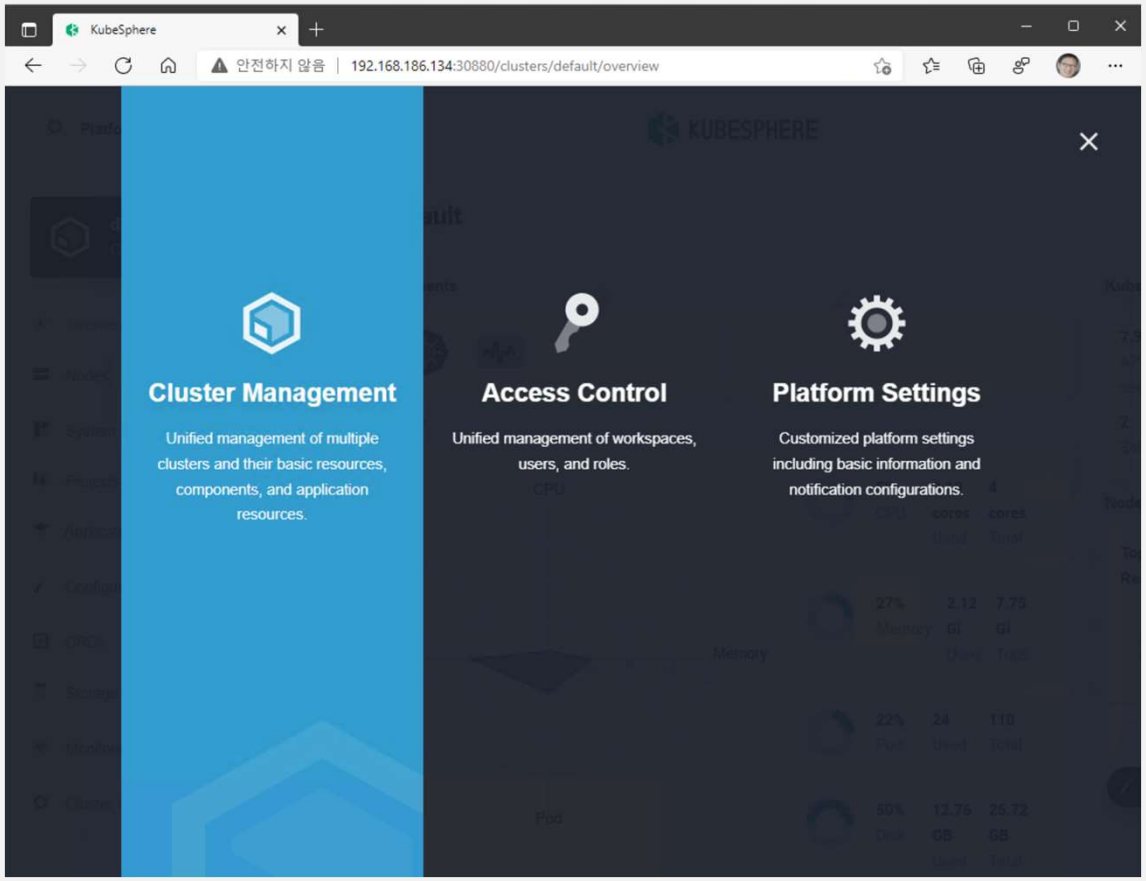
```
jslab@jslab:~$ sudo netstat -tulpn | grep LISTEN
[sudo] password for jslab:
tcp        0      0 127.0.0.53:53           0.0.0.0:*               LISTEN      883/systemd-resolve
tcp        0      0 127.0.0.1:2379          0.0.0.0:*               LISTEN      915/etcd
tcp        0      0 169.254.25.10:53        0.0.0.0:*               LISTEN      3094/node-cache
tcp        0      0 127.0.0.1:10249         0.0.0.0:*               LISTEN      2902/kube-proxy
tcp        0      0 127.0.0.1:10248         0.0.0.0:*               LISTEN      919/kubelet
tcp        0      0 192.168.42.100:2379     0.0.0.0:*               LISTEN      915/etcd
tcp        0      0 192.168.42.100:2380     0.0.0.0:*               LISTEN      915/etcd
tcp        0      0 169.254.25.10:9254      0.0.0.0:*               LISTEN      3094/node-cache
tcp        0      0 127.0.0.1:35957         0.0.0.0:*               LISTEN      919/kubelet
tcp        0      0 192.168.42.100:9100     0.0.0.0:*               LISTEN      2743/kube-rbac-prox
tcp        0      0 127.0.0.1:9100          0.0.0.0:*               LISTEN      2682/node_exporter
tcp        0      0 127.0.0.1:9099          0.0.0.0:*               LISTEN      6935/calico-node
tcp        0      0 0.0.0.0:22              0.0.0.0:*               LISTEN      985/sshd: /usr/sbin
tcp        0      0 127.0.0.1:42163         0.0.0.0:*               LISTEN      935/containerd
tcp        0      0 127.0.0.1:6010          0.0.0.0:*               LISTEN      21162/sshd: jslab@p
tcp6       0      0 :::10259                :::*                    LISTEN      2101/kube-scheduler
tcp6       0      0 :::10256                :::*                    LISTEN      2902/kube-proxy
tcp6       0      0 :::10257                :::*                    LISTEN      2058/kube-controlle
tcp6       0      0 :::10250                :::*                    LISTEN      919/kubelet
tcp6       0      0 :::6443                 :::*                    LISTEN      2053/kube-apiserver
tcp6       0      0 :::22                   :::*                    LISTEN      985/sshd: /usr/sbin
tcp6       0      0 :::9353                 :::*                    LISTEN      3094/node-cache
tcp6       0      0 :::9253                 :::*                    LISTEN      3094/node-cache
tcp6       0      0 ::1:6010                :::*                    LISTEN      21162/sshd: jslab@p
jslab@jslab:~$
```

부록 1. KUBERNETES 설치

❖ Console

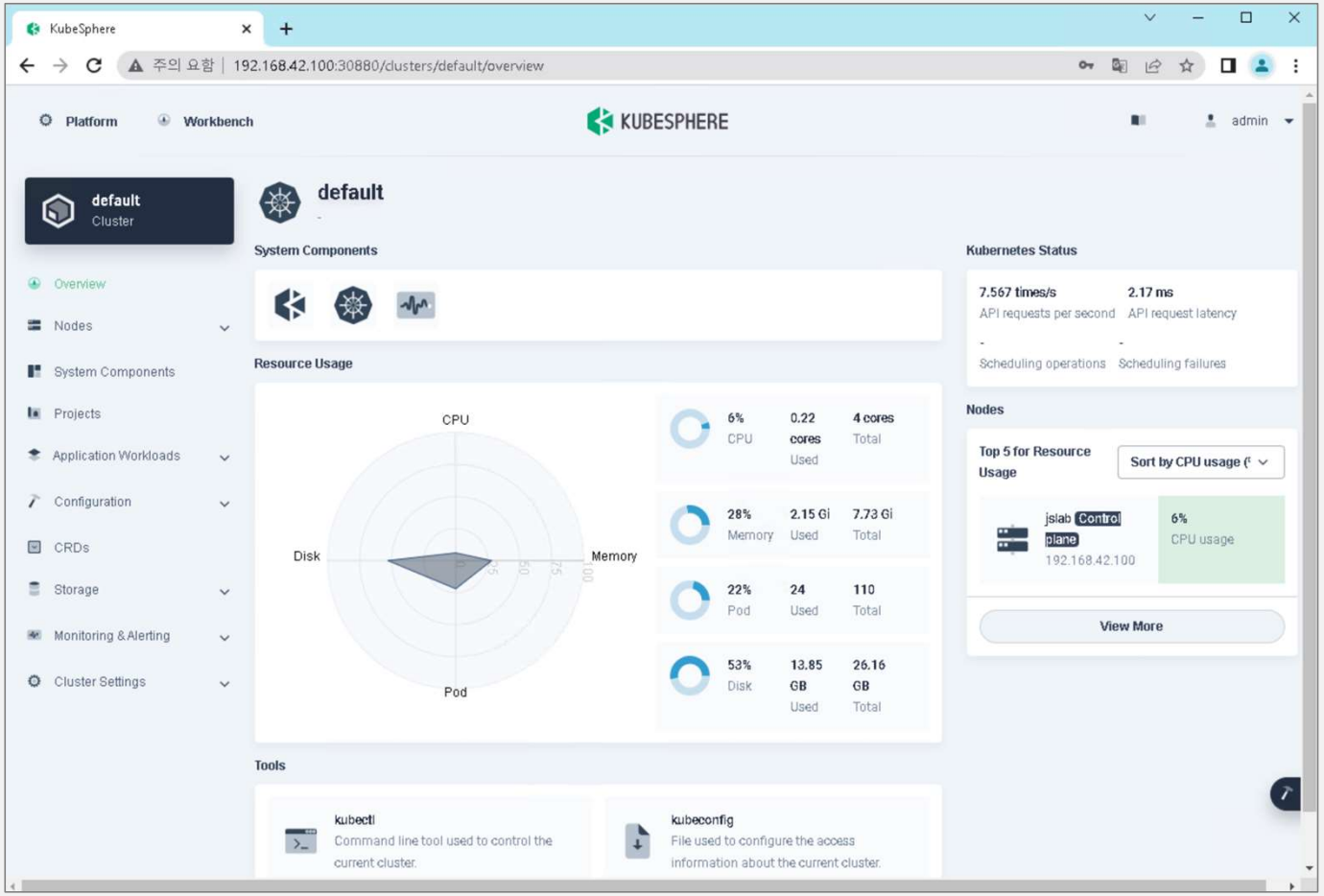
- http://192.168.0.101:30880

```
Console: http://192.168.0.101:30880
Account: admin
Password: P@88w0rd    —> JSLab123
```



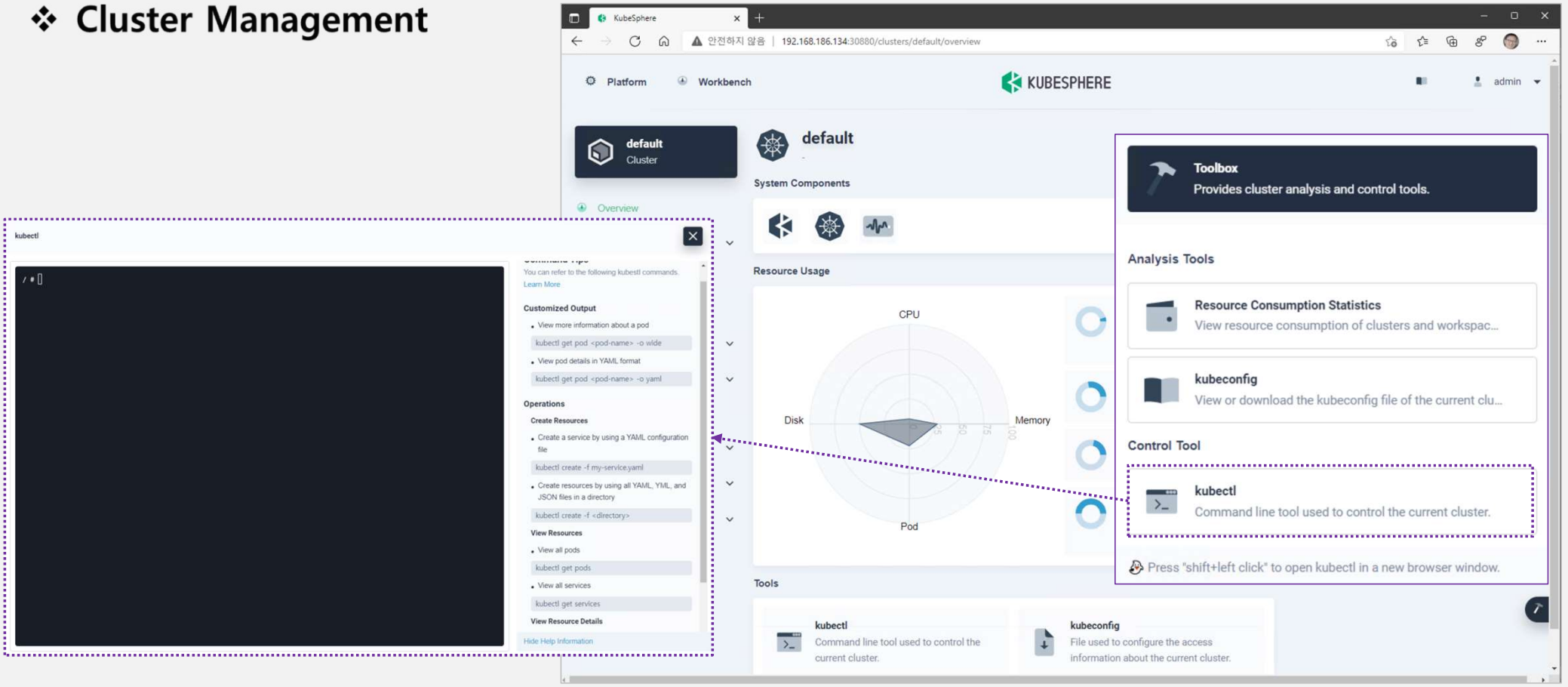
부록 1. KUBERNETES 설치

❖ Cluster Management



부록 1. KUBERNETES 설치

❖ Cluster Management

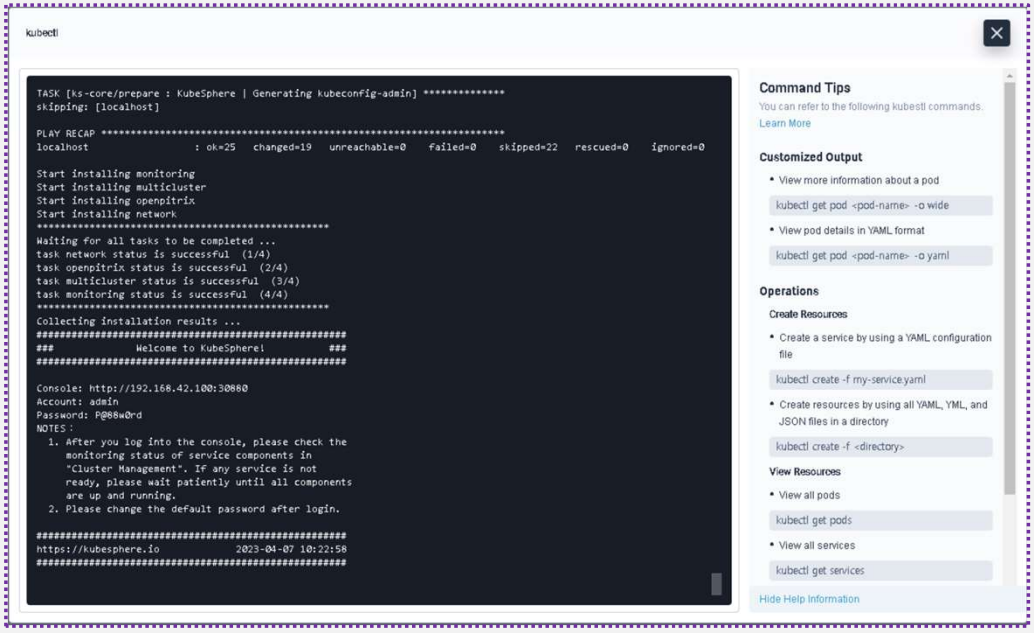


부록 1. KUBERNETES 설치

❖ Verify the Installation

- kubectl logs -n kubesphere-system $(kubectl get pod -n kubesphere-system -l 'app in (ks-install, ks-installer)' -o jsonpath='{.items[0].metadata.name}') -f

```
kubectl logs -n kubesphere-system $(kubectl get pod -n kubesphere-system -l 'app in (ks-install, ks-installer)' -o
jsonpath='{.items[0].metadata.name}') -f
```

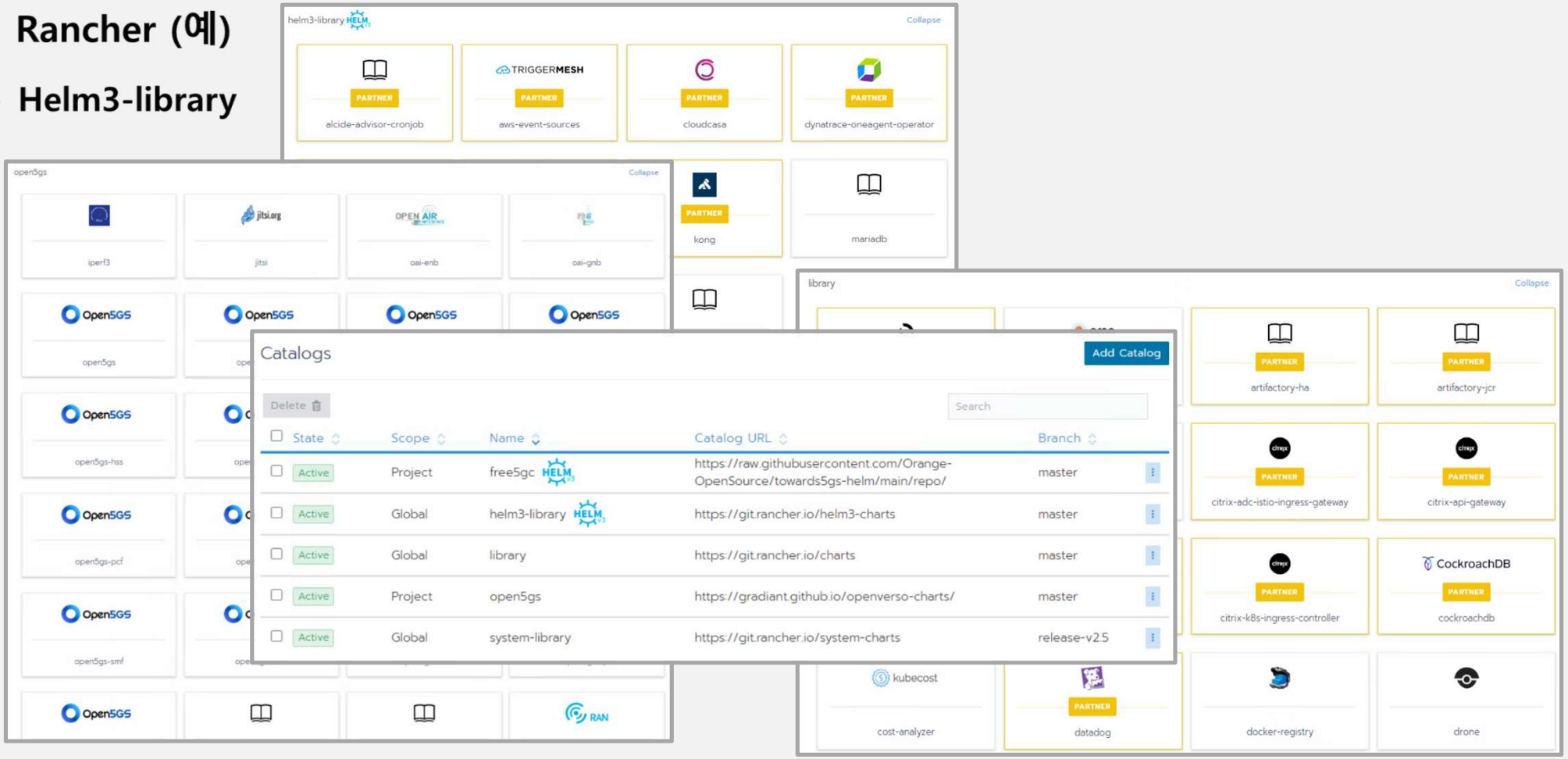


부록 2. Helm Operations

부록 2. HELM OPERATIONS

❖ Rancher (예)

- Helm3-library



부록 2. HELM OPERATIONS

❖ Install Helm

1. sudo su - root
2. sudo snap install helm3

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

```
jslab@jslab:~$ sudo snap install helm3
[sudo] password for jslab:
helm3 3.3.4 from dt9394 (terraform-snap) installed
jslab@jslab:~$
```

❖ Helm operations

1. helm search: 차트 찾기
2. helm install: 패키지 설치
3. helm show values stable/mariadb: 설치 전 차트 커스터마이징

Source: https://helm.sh/ko/
Source: https://medium.com/rahasak/deploying-5g-core-network-with-free5gc-kubernets-and-helm-charts-29741cea3922

부록 2. HELM OPERATIONS

❖ Deploying 5G core network with open5GS, Kubernetes and Helm

1. helm search hub 5g ## helm3 대체 or helm (Classic) install
2. helm search hub open5gs -o yaml

```
jslab@node1:~/opensource-5g-core-service-mesh$ helm search hub 5g
URL                                             CHART VERSION   APP VERSION     DESCRIPTION
https://hub.helm.sh/charts/adaptivenetlab/open5gs       1.0.3           2.1.7           A Helm chart for open5gs 5G Core
https://hub.helm.sh/charts/gilangvperdana/open5gs       1.0.3           2.1.7           A Helm chart for open5gs 5G Core
https://hub.helm.sh/charts/shubhamtatvamasi/orc8r       1.5.13          1.4             A Helm chart for magma orchestrator
https://hub.helm.sh/charts/gilangvperdana/ueransim      1.0.3           3.2.6           ueransim for 5G RAN simulation
https://hub.helm.sh/charts/adaptivenetlab/ueransim      1.0.3           3.2.6           ueransim for 5G RAN simulation
https://hub.helm.sh/charts/gradiant-openverso/u...      0.2.1           3.2.6           ueransim for 5G RAN simulation
https://hub.helm.sh/charts/gradiant-openverso/u...      0.2.0           3.2.6           ueransim gNodeB for 5G RAN simulation
jslab@node1:~/opensource-5g-core-service-mesh$ helm search hub open5gs -o yaml
- app_version: 2.1.7
  description: A Helm chart for open5gs 5G Core
  url: https://hub.helm.sh/charts/adaptivenetlab/open5gs
  version: 1.0.3
- app_version: 2.1.7
  description: A Helm chart for open5gs 5G Core
  url: https://hub.helm.sh/charts/gilangvperdana/open5gs
  version: 1.0.3
- app_version: 2.4.4
  description: 'Helm chart to deploy Open5gs services on Kubernetes. '
  url: https://hub.helm.sh/charts/gradiant-openverso/open5gs
  version: 0.5.0
```

부록 2. HELM OPERATIONS

❖ Deploying 5G core network with Free5GC, Kubernetes and Helm

1. sudo su - root
2. sudo kubectl version -o yaml
3. sudo helm list -A ### verify helm installation

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

```
jslab@jslab:~$ sudo su - root
root@jslab:~# sudo kubectl version -o yaml
clientVersion:
  buildDate: "2022-07-13T14:59:18Z"
  compiler: gc
  gitCommit: b058e1760c79f46a834ba59bd7a3486ecf28237d
  gitTreeState: clean
  gitVersion: v1.22.12
  goVersion: go1.16.15
  major: "1"
  minor: "22"
  platform: linux/amd64
serverVersion:
  buildDate: "2022-07-13T14:53:39Z"
  compiler: gc
  gitCommit: b058e1760c79f46a834ba59bd7a3486ecf28237d
  gitTreeState: clean
  gitVersion: v1.22.12
  goVersion: go1.16.15
  major: "1"
  minor: "22"
  platform: linux/amd64

root@jslab:~# sudo helm list -A
NAME                  NAMESPACE                     REVISION        UPDATED                                 STATUS          CHART                         APP VERSION
ks-core               kubesphere-system             2               2022-11-27 14:46:25.843149166 +0000 UTC deployed        ks-core-0.1.0                 v3.1.0
notification-manager  kubesphere-monitoring-system  1               2022-11-24 15:53:01.464190149 +0000 UTC deployed        notification-manager-1.4.0    1.4.0
snapshot-controller   kube-system                   2               2022-11-27 14:45:28.282048052 +0000 UTC deployed        snapshot-controller-0.2.0     4.0.0
root@jslab:~#
```

부록 2. HELM OPERATIONS

❖ Deploying 5G core network with Free5GC, Kubernetes and Helm

1. git clone https://github.com/k8snetworkplumbingwg/multus-cni.git && cd multus-cni
2. cat ./deployments/multus-daemonset-thick.yml | kubectl apply -f -
3. sudo kubectl get pods --all-namespaces ### verify installation

```
root@jslab:~# git clone https://github.com/k8snetworkplumbingwg/multus-cni.git && cd multus-cni
Cloning into 'multus-cni'...
remote: Enumerating objects: 39097, done.
remote: Counting objects: 100% (1664/1664), done.
remote: Compressing objects: 100% (904/904), done.
remote: Total 39097 (delta 728), reused 1562 (delta 677), pack-reused 37433
Receiving objects: 100% (39097/39097), 50.09 MiB | 10.20 MiB/s, done.
Resolving deltas: 100% (17500/17500), done.
root@jslab:~/multus-cni# cat ./deployments/multus-daemonset-thick.yml | kubectl apply -f -
customresourcedefinition.apiextensions.k8s.io/network-attachment-definitions.k8s.cni.cncf.io created
clusterrole.rbac.authorization.k8s.io/multus created
clusterrolebinding.rbac.authorization.k8s.io/multus created
serviceaccount/multus created
configmap/multus-daemon-config created
daemonset.apps/kube-multus-ds created
root@jslab:~/multus-cni# sudo kubectl get pods --all-namespaces
```

```
root@jslab:~/multus-cni# sudo kubectl get pods --all-namespaces
NAMESPACE                      NAME                                              READY   STATUS    RESTARTS        AGE
kube-system                    calico-kube-controllers-69d878584c-q86k8          1/1     Running   1 (2d22h ago)   2d23h
kube-system                    calico-node-4gdz4                                 1/1     Running   1 (2d22h ago)   2d23h
kube-system                    coredns-b5648d655-h4ckb                           1/1     Running   1 (2d22h ago)   2d23h
kube-system                    coredns-b5648d655-jqhjn                           1/1     Running   1 (2d22h ago)   2d23h
kube-system                    kube-apiserver-jslab                              1/1     Running   1 (2d22h ago)   2d23h
kube-system                    kube-controller-manager-jslab                     1/1     Running   1 (2d22h ago)   2d23h
kube-system                    kube-multus-ds-rj29r                              1/1     Running   0               19s
kube-system                    kube-proxy-kwz4h                                  1/1     Running   1 (2d22h ago)   2d23h
kube-system                    kube-scheduler-jslab                              1/1     Running   1 (2d22h ago)   2d23h
kube-system                    nodelocaldns-n2ckt                                1/1     Running   1 (2d22h ago)   2d23h
kube-system                    openebs-localpv-provisioner-57bbf864d5-mncss      1/1     Running   1 (2d22h ago)   2d23h
kube-system                    snapshot-controller-0                             1/1     Running   1 (2d22h ago)   2d23h
kubesphere-controls-system     default-http-backend-5bf68ff9b8-tjc2v             1/1     Running   1 (2d22h ago)   2d23h
kubesphere-controls-system     kubectl-admin-6dbcb94855-fljcj                    1/1     Running   1 (2d22h ago)   2d23h
kubesphere-monitoring-system   alertmanager-main-0                               2/2     Running   2 (2d22h ago)   2d23h
kubesphere-monitoring-system   kube-state-metrics-687d66b747-jspd9               3/3     Running   3 (2d22h ago)   2d23h
kubesphere-monitoring-system   node-exporter-gpwrf                               2/2     Running   2 (2d22h ago)   2d23h
kubesphere-monitoring-system   notification-manager-deployment-78664576cb-ntdhn  2/2     Running   2 (2d22h ago)   2d23h
kubesphere-monitoring-system   notification-manager-operator-7d44854f54-4qp9h    2/2     Running   2 (2d22h ago)   2d23h
kubesphere-monitoring-system   prometheus-k8s-0                                  2/2     Running   2 (2d22h ago)   2d23h
kubesphere-monitoring-system   prometheus-operator-8955bbd98-hpgwn               2/2     Running   2 (2d22h ago)   2d23h
kubesphere-system              ks-apiserver-6cd95fb98f-b8qkj                     1/1     Running   1 (2d22h ago)   2d23h
kubesphere-system              ks-console-7d9857b6c-wpzzl                        1/1     Running   1 (2d22h ago)   2d23h
kubesphere-system              ks-controller-manager-5958b94c9c-5gr74            1/1     Running   1 (2d22h ago)   2d23h
kubesphere-system              ks-installer-64f89fdb56-g6jkt                     1/1     Running   1 (2d22h ago)   2d23h
root@jslab:~/multus-cni#
```

부록 2. HELM OPERATIONS

❖ Deploying 5G core network with Free5GC, Kubernetes and Helm

1. helm repo add towards5gs https://raw.githubusercontent.com/Orange-OpenSource/towards5gs-helm/main/repo/
2. sudo kubectl create namespace jslab5gc
3. helm repo update
4. helm repo list
5. helm search repo

```
root@jslab:~/multus-cni# helm repo add towards5gs https://raw.githubusercontent.com/Orange-OpenSource/towards5gs-helm/main/repo/
"towards5gs" has been added to your repositories
root@jslab:~/multus-cni# sudo kubectl create namespace jslab5gc
namespace/jslab5gc created
root@jslab:~/multus-cni# helm repo update
Hang tight while we grab the latest from your chart repositories...
...Successfully got an update from the "towards5gs" chart repository
Update Complete. ⎈Happy Helming!⎈
root@jslab:~/multus-cni# helm repo list
NAME            URL
towards5gs      https://raw.githubusercontent.com/Orange-OpenSource/towards5gs-helm/main/repo/
root@jslab:~/multus-cni# helm search repo
NAME                                CHART VERSION   APP VERSION     DESCRIPTION
towards5gs/free5gc                  1.1.3           v3.2.0          A Helm chart to deploy Free5gc
towards5gs/free5gc-amf              0.2.3           v3.2.0          A Helm chart to deploy the Free5GC AMF
towards5gs/free5gc-ausf             0.2.3           v3.2.0          A Helm chart to deploy the Free5GC AUSF
towards5gs/free5gc-n3iwf            0.2.3           v3.2.0          A Helm chart to deploy the Free5GC N3IWF
towards5gs/free5gc-nrf              0.2.3           v3.2.0          A Helm chart to deploy the Free5GC NRF
towards5gs/free5gc-nssf             0.2.3           v3.2.0          A Helm chart to deploy the Free5GC NSSF
towards5gs/free5gc-pcf              0.2.3           v3.2.0          A Helm chart to deploy the Free5GC PCF
towards5gs/free5gc-smf              0.2.3           v3.2.0          A Helm chart to deploy the Free5GC SMF
towards5gs/free5gc-udm              0.2.3           v3.2.0          A Helm chart to deploy the Free5GC UDM
towards5gs/free5gc-udr              0.2.3           v3.2.0          A Helm chart to deploy the Free5GC UDR
towards5gs/free5gc-upf              0.2.3           v3.2.0          A Helm chart to deploy the Free5GC User Plane
towards5gs/free5gc-webui            0.1.3           v3.2.0          A Helm chart to deploy the Free5GC WEBUI
towards5gs/free5gcControlPlane      0.1.2           v3.0.5          DEPRECATED - A Helm chart to deploy the control...
towards5gs/free5gcN3iwf             0.1.2           v3.0.5          DEPRECATED - A Helm chart to deploy the n3iwf f...
towards5gs/free5gcUserPlane         0.1.2           v3.0.5          DEPRECATED - Helm chart to deploy the user plan...
towards5gs/networks5g               0.1.2           0.1.2           DEPRECATED - A Helm chart to deploy the user pl...
towards5gs/ueransim                 2.0.14          v3.2.6          A Helm chart to deploy UERANSIM
root@jslab:~/multus-cni#
```

sudo kubectl create namespace jslab5gs

helm repo add jslab5gs
https://gradiant.github.io/openverso-charts/

sudo helm -n jslab5gs install jslab5gsjs-v1 jslab5gsjs/open5gs

watch kubectl get pods -n jslab5gcjs

부록 2. HELM OPERATIONS

❖ Deploying 5G core network with Free5GC, Kubernetes and Helm

1. sudo helm -n jslab5gc install jslab5gc-v1 towards5gs/free5gc
2. sudo helm -n jslab5gc uninstall jslab5gc-v1
3. kubectl get svc -n jslab5gc
4. watch kubectl get pods -n jslab5gc

```
root@jslab:~/multus-cni# sudo helm -n jslab5gc install jslab5gc-v1 towards5gs/free5gc
NAME: jslab5gc-v1
LAST DEPLOYED: Sun Nov 27 15:37:40 2022
NAMESPACE: jslab5gc
STATUS: deployed
REVISION: 1
NOTES:
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2021 Orange
# SPDX-License-Identifier: Apache-2.0
#
# This software is distributed under the Apache License 2.0,
# the text of which is available at https://github.com/Orange-OpenSource/towards5gs-helm/blob/main/LICENSE
# or see the "LICENSE" file for more details.
#
# Author: Abderaouf KHICHANE, Ilhem FAJJARI
# Software description: An open-source project providing Helm charts to deploy 5G components (Core + RAN) on top of Kubernetes
#
#
# Visit the project at https://github.com/Orange-OpenSource/towards5gs-helm
#

1. Get the list of created Pods by running:
  kubectl get pods --namespace jslab5gc -l "project="
root@jslab:~/multus-cni# kubectl get svc -n jslab5gc
```

```
root@jslab:~/multus-cni# kubectl get svc -n jslab5gc
NAME           TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)          AGE
amf-namf       ClusterIP   10.233.25.133   <none>        80/TCP           15s
ausf-nausf     ClusterIP   10.233.36.8     <none>        80/TCP           15s
mongodb        ClusterIP   10.233.52.22    <none>        27017/TCP        15s
nrf-nnrf       ClusterIP   10.233.25.134   <none>        8000/TCP         15s
nssf-nnssf     ClusterIP   10.233.41.109   <none>        80/TCP           15s
pcf-npcf       ClusterIP   10.233.17.10    <none>        80/TCP           15s
smf-nsmf       ClusterIP   10.233.52.84    <none>        80/TCP           15s
udm-nudm       ClusterIP   10.233.56.118   <none>        80/TCP           15s
udr-nudr       ClusterIP   10.233.10.92    <none>        80/TCP           15s
webui-service  NodePort    10.233.27.170   <none>        5000:30500/TCP   15s
root@jslab:~/multus-cni# watch kubectl get pods -n jslab5gc
root@jslab:~/multus-cni#
```

부록 2. HELM OPERATIONS

❖ Deploying 5G core network with Free5GC, Kubernetes and Helm

1. sudo helm -n jslab5gc install jslab5gc-v1 towards5gs/free5gc
2. sudo helm -n jslab5gc uninstall jslab5gc-v1
3. kubectl get svc -n jslab5gc
4. watch kubectl get pods -n jslab5gc

```
root@jslab:~/multus-cni# watch kubectl get pods -n jslab5gc
Every 2.0s: kubectl get pods -n jslab5gc                                jslab: Sun Nov 27 15:43:07 2022

NAME                                          READY   STATUS              RESTARTS   AGE
jslab5gc-v1-free5gc-amf-amf-5c548c9dcc-q9mzg      0/1     Init:0/1            0          5m25s
jslab5gc-v1-free5gc-ausf-ausf-5774d545f9-xflmm    1/1     Running             0          5m24s
jslab5gc-v1-free5gc-nrf-nrf-7f4bb4f796-l6r24      1/1     Running             0          5m24s
jslab5gc-v1-free5gc-nssf-nssf-6d97bfd6f6-zhp7w    1/1     Running             0          5m25s
jslab5gc-v1-free5gc-pcf-pcf-766878b98f-2svgc      1/1     Running             0          5m25s
jslab5gc-v1-free5gc-smf-smf-6fbb8f4ccb-tbkcd      0/1     Init:0/1            0          5m25s
jslab5gc-v1-free5gc-udm-udm-85fd6854b5-ncqc6      1/1     Running             0          5m24s
jslab5gc-v1-free5gc-udr-udr-6bb6fc4b57-ltm48      1/1     Running             0          5m25s
jslab5gc-v1-free5gc-upf-upf-75655bdfcf-9smsw      0/1     ContainerCreating   0          5m24s
jslab5gc-v1-free5gc-webui-webui-76645cbfd8-ww8ld  1/1     Running             0          5m24s
mongodb-0                                     1/1     Running             0          5m23s
```

부록 2. HELM OPERATIONS

❖ Deploying 5G core network with Free5GC, Kubernetes and Helm

1. helm show values towards5gs/free5gc

```
root@jslab:~/multus-cni# helm show values towards5gs/free5gc
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2021 Orange
# SPDX-License-Identifier: Apache-2.0
#
# This software is distributed under the Apache License 2.0,
# the text of which is available at todo
# or see the "LICENSE" file for more details.
#
# Author: Abderaouf KHICHANE, Ilhem FAJJARI, Ayoub BOUSSELMI
# Software description: An open-source project providing Helm charts to deploy
5G components (Core + RAN) on top of Kubernetes
#
# Default values for free5gc-chart.
# This is a YAML-formatted file.
# Declare variables to be passed into your templates.

global:
  name: free5gc
  userPlaneArchitecture: single  # possible values are "single" and "ulcl"
  nrf:
    service:
      name: nrf-nnrf
      type: ClusterIP
      port: "8000"
      nodePort: "30800"
  sbi:
    scheme: http
  amf:
    n2if:  # NGAP
      ipAddress: 10.100.50.249
    service:
      ngap:
        enabled: false
        name: amf-n2
        port: 38412
        nodeport: 31412
        protocol: SCTP
        type: NodePort
```

```
smf:
    n4if:
      ipAddress: 10.100.50.244
  #Global network parametes
  n2network:
    name: n2network
    masterIf: eth0
    subnetIP: 10.100.50.248
    cidr: 29
    gatewayIP: 10.100.50.254
    excludeIP: 10.100.50.254
  n3network:
    name: n3network
    masterIf: eth0
    subnetIP: 10.100.50.232
    cidr: 29
    gatewayIP: 10.100.50.238
    excludeIP: 10.100.50.238
  n4network:
    name: n4network
    masterIf: eth0
    subnetIP: 10.100.50.240
    cidr: 29
    gatewayIP: 10.100.50.246
    excludeIP: 10.100.50.246
  n6network:
    name: n6network
    masterIf: eth1
    subnetIP: 10.100.100.0
    cidr: 24
    gatewayIP: 10.100.100.1
    excludeIP: 10.100.100.254
  n9network:
    name: n9network
    masterIf: eth0
    subnetIP: 10.100.50.224
    cidr: 29
    gatewayIP: 10.100.50.230
    excludeIP: 10.100.50.230
#
```

```
# These parameters can be used to enable/disable deployment of subcharts
deployMongoDB: true
deployAMF: true
deployAUSF: true
deployN3IWF: false
deployNRF: true
deployNSSF: true
deployPCF: true
deploySMF: true
deployUDM: true
deployUDR: true
deployUPF: true
deployWEBUI: true

# Disable the deployment of mongodb as an NRF subchart
free5gc-nrf:
  db:
    enabled: false

# This section can be used to override the default values in the MongoDB chart
(remember MongoDB is a subchart of the free5gcControlplane chart since control
plane NFs rely on it.
mongodb:
  fullnameOverride: "mongodb"
  useStatefulSet: true
  auth:
    enabled: false
  persistence:
    size: 6Gi
    mountPath: /bitnami/mongodb/data/db/
  service:
    name: mongodb
    type: ClusterIP
    port: 27017
    nodePort: "30017"

root@jslab:~/multus-cni#
```

부록 2. HELM OPERATIONS

❖ Deploying 5G core network with Free5GC, Kubernetes and Helm (Helm Operations 1 Page 요약)

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

1. sudo su - root
2. sudo kubectl version -o yaml
3. sudo helm list -A
4. git clone https://github.com/k8snetworkplumbingwg/multus-cni.git && cd multus-cni
5. cat ./deployments/multus-daemonset-thick.yml | kubectl apply -f -
6. sudo kubectl get pods --all-namespaces
7. helm repo add towards5gs https://raw.githubusercontent.com/Orange-OpenSource/towards5gs-helm/main/repo/
8. sudo kubectl create namespace jslab5gc
9. helm repo update
10. helm repo list
11. helm search repo
12. sudo helm -n jslab5gc install jslab5gc-v1 towards5gs/free5gc
13. sudo helm -n jslab5gc uninstall jslab5gc-v1
14. kubectl get svc -n jslab5gc
15. watch kubectl get pods -n jslab5gc

helm show values towards5gs/free5gc

Source: https://medium.com/rahasak/deploying-5g-core-network-with-free5gc-kubernets-and-helm-charts-29741cea3922

부록 2. HELM OPERATIONS

❖ Prerequisite for Free5GC@Helm

- sudo touch /etc/systemd/network/eth0.netdev
- sudo touch /etc/systemd/network/eth0.network
- sudo nano /etc/systemd/network/eth0.netdev

```
=========
[NetDev]
Name=eth0
Kind=dummy
=========
```

- sudo nano /etc/systemd/network/eth0.network

```
=========
[Match]
Name=eth0
[Network]
Address=10.100.50.100
Mask=255.255.255.0
=========
```

- sudo systemctl restart systemd-networkd
- ip a

❖ Prerequisite for Free5GC@Helm

- sudo touch /etc/systemd/network/eth1.netdev
- sudo touch /etc/systemd/network/eth1.network
- sudo nano /etc/systemd/network/eth1.netdev

```
=========
[NetDev]
Name=eth1
Kind=dummy
=========
```

- sudo nano /etc/systemd/network/eth1.network

```
=========
[Match]
Name=eth1
[Network]
Address=10.100.100.100
Mask=255.255.255.0
=========
```

- sudo systemctl restart systemd-networkd
- ip a

Source: https://medium.com/@chauhan.inderpreet/5g-core-free5gc-on-kubernetes-microk8s-fa23104891f7

부록 2. HELM OPERATIONS

❖ Helm Chart to deploy UERANSIM

1. # deploy helm
2. # -n free5gc (namespace)
3. # free5gc-v1 (name of the helm deployment)
4. # towards5gs/ueransim (chart name)
5. **helm -n jslab5gc install ueransim-free5gc towards5gs/ueransim**

```
root@jslab:~/multus-cni# helm -n jslab5gc install ueransim-free5gc towards5gs/ueransim
NAME: ueransim-free5gc
LAST DEPLOYED: Sun Nov 27 16:05:44 2022
NAMESPACE: jslab5gc
STATUS: deployed
REVISION: 1
NOTES:
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2021 Orange
# SPDX-License-Identifier: Apache-2.0
#
# This software is distributed under the Apache Licens
# the text of which is available at https://github.com
# or see the "LICENSE" file for more details.
#
# Author: Abderaouf KHICHANE, Ilhem FAJJARI
# Software description: An open-source project providi
#
#
# Visit the project at https://github.com/Orange-OpenS
#

1. Run UE connectivity test by running these commands:
  helm --namespace jslab5gc test ueransim-free5gc

If you want to run connectivity tests manually, follow

1. Get the UE Pod name by running:
  export POD_NAME=$(kubectl get pods --namespace jslab

2. Check that uesimtun0 interface has been created by
  kubectl --namespace jslab5gc logs $POD_NAME
  kubectl --namespace jslab5gc exec -it $POD_NAME -- i

3. Try to access internet from the UE by running:
  kubectl --namespace jslab5gc exec -it $POD_NAME -- p
  kubectl --namespace jslab5gc exec -it $POD_NAME -- c
  kubectl --namespace jslab5gc exec -it $POD_NAME -- traceroute -i uesimtun0 www.google.com
root@jslab:~/multus-cni#
```

```
1. Run UE connectivity test by running these commands:
  helm --namespace jslab5gc test ueransim-free5gc

If you want to run connectivity tests manually, follow:

1. Get the UE Pod name by running:
  export POD_NAME=$(kubectl get pods --namespace jslab5gc -l "component=ue" -o jsonpath="{.items[0].metadata.name}")

2. Check that uesimtun0 interface has been created by running these commands:
  kubectl --namespace jslab5gc logs $POD_NAME
  kubectl --namespace jslab5gc exec -it $POD_NAME -- ip address

3. Try to access internet from the UE by running:
  kubectl --namespace jslab5gc exec -it $POD_NAME -- ping -I uesimtun0 www.google.com
  kubectl --namespace jslab5gc exec -it $POD_NAME -- curl --interface uesimtun0 www.google.com
  kubectl --namespace jslab5gc exec -it $POD_NAME -- traceroute -i uesimtun0 www.google.com
```

부록 2. HELM OPERATIONS

❖ Run UE connectivity test by running these commands

1. export POD_NAME=$(kubectl get pods --namespace free5gc -l "component=ue" -o jsonpath="{.items[0].metadata.name}")
2. kubectl --namespace free5gc logs $POD_NAME
3. kubectl --namespace free5gc exec -it $POD_NAME -- ip address
4. kubectl --namespace free5gc exec -it $POD_NAME -- ping -I uesimtun0 www.google.com
5. kubectl --namespace free5gc exec -it $POD_NAME -- curl --interface uesimtun0 www.google.com
6. kubectl --namespace free5gc exec -it $POD_NAME -- traceroute -i uesimtun0 www.google.com

부록 2. HELM OPERATIONS

❖ Deploying 5G core network with Free5GC, Kubernetes and Helm

- helm show values towards5gs/free5gc

```
root@5g:~# helm show values towards5gs/free5gc
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2021 Orange
# SPDX-License-Identifier: Apache-2.0
#
# This software is distributed under the Apache License 2.0,
# the text of which is available at todo
# or see the "LICENSE" file for more details.
#
# Author: Abderaouf KHICHANE, Ilhem FAJJARI, Ayoub BOUSSELMI
# Software description: An open-source project providing Helm charts to deploy 5G components (Core + RAN)
#
# Default values for free5gc-chart.
# This is a YAML-formatted file.
# Declare variables to be passed into your templates.

global:
  name: free5gc
  userPlaneArchitecture: single  # possible values are "single" and "ulcl"
  nrf:
    service:
      name: nrf-nnrf
      type: ClusterIP
      port: "8000"
      nodePort: "30800"
  sbi:
    scheme: http
```

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

```
amf:
  n2if:  # NGAP
    ipAddress: 10.100.50.249
  service:
    ngap:
      enabled: false
      name: amf-n2
      port: 38412
      nodeport: 31412
      protocol: SCTP
      type: NodePort
smf:
  n4if:
    ipAddress: 10.100.50.244
#Global network parametes
n2network:
  name: n2network
  masterIf: eth0
  subnetIP: 10.100.50.248
  cidr: 29
  gatewayIP: 10.100.50.254
  excludeIP: 10.100.50.254
n3network:
  name: n3network
  masterIf: eth0
  subnetIP: 10.100.50.232
  cidr: 29
  gatewayIP: 10.100.50.238
  excludeIP: 10.100.50.238
n4network:
  name: n4network
  masterIf: eth0
  subnetIP: 10.100.50.240
  cidr: 29
  gatewayIP: 10.100.50.246
  excludeIP: 10.100.50.246
```

```
  n6network:
    name: n6network
    masterIf: eth1
    subnetIP: 10.100.100.0
    cidr: 24
    gatewayIP: 10.100.100.1
    excludeIP: 10.100.100.254
  n9network:
    name: n9network
    masterIf: eth0
    subnetIP: 10.100.50.224
    cidr: 29
    gatewayIP: 10.100.50.230
    excludeIP: 10.100.50.230


# These parameters can be u
enable/disable deployment o
deployMongoDB: true
deployAMF: true
deployAUSF: true
deployN3IWF: false
deployNRF: true
deployNSSF: true
deployPCF: true
deploySMF: true
deployUDM: true
deployUDR: true
deployUPF: true
deployWEBUI: true
```

```
# Disable the deployment of mongodb as an NRF subchart
free5gc-nrf:
  db:
    enabled: false

# This section can be used to override the default values in the MongoDB chart (remember MongoDB is a subchart of the free5gcControlplane chart since control plane NFs rely on it.
mongodb:
  fullnameOverride: "mongodb"
  useStatefulSet: true
  auth:
    enabled: false
  persistence:
    size: 6Gi
    mountPath: /bitnami/mongodb/data/db/
  service:
    name: mongodb
    type: ClusterIP
    port: 27017
    nodePort: "30017"
```

Note: https://helm.sh/docs/intro/using_helm/

부록 2. HELM OPERATIONS

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm

- helm show values towards5gs/ueransim

```
root@5g:~# helm show values towards5gs/ueransim
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2021 Orange
# SPDX-License-Identifier: Apache
#
# This software is distributed un
# the text of which is available
# or see the "LICENSE" file for m
#
# Author: Abderaouf KHICHANE, Ilh
# Software description: An open-s
#
# Default values for ueransim-cha
# This is a YAML-formatted file.
# Declare variables to be passed

global:
  multiCluster: false
  #Global network parametes
  n2network:
    name: n2network
    masterIf: eth0
    subnetIP: 10.100.50.248
    cidr: 29
    gatewayIP: 10.100.50.254
    excludeIP: 10.100.50.254
  n3network:
    name: n3network
    masterIf: eth0
    subnetIP: 10.100.50.232
    cidr: 29
    gatewayIP: 10.100.50.238
    excludeIP: 10.100.50.238
```

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

```
projectName: ueransim

gnb:
  enabled: true
  name: gnb
  replicaCount: 1
  image:
    name: towards5gs/ueransim-gnb
    pullPolicy: IfNotPresent
  configmap:
    name: gnb-configmap
  volume:
    name: gnb-volume
    mount: /ueransim/config
  service:
    name: gnb-service
    type: ClusterIP
    port: 4997
    protocol: UDP

  n2if:  # NGAP
    ipAddress: 10.100.50.250
  n3if:  # GTP-U
    ipAddress: 10.100.50.236

amf:
  n2if:  # NGAP
    ipAddress: 10.100.50.249
    port: 38412
  service:
    ngap:
      enabled: false  # if true set gnb.amf.n2if.ipAddress to the
name of AMF NGAP service or the IP of the cluster hosting the AMF
```

```
  podAnnotations: {}
    # additional annotations
  imagePullSecrets: []
  podSecurityContext: {}
  resources:
    limits:
      cpu: 250m
      memory: 256Mi
    requests:
      cpu: 250m
      memory: 256Mi
  nodeSelector: {}
  tolerations: []
  affinity: {}

  configuration: |-
    mcc: '208' # Mobile Country Code value
    mnc: '93'  # Mobile Network Code value (2 or
    nci: '0x000000010'  # NR Cell Identity (36-bi
    idLength: 32        # NR gNB ID length in bit
    tac: 1      # Tracking Area Code
    # List of supported S-NSSAIs by this gNB
    slices:
      - sst: 0x1
        sd: 0x010203
    # Indicates whether or not SCTP stream number
should be ignored.
    ignoreStreamIds: true
```

```
ue:
  enabled: true
  name: ue
  replicaCount: 1
  image:
    name: towards5gs/ueransim-ue
    pullPolicy: IfNotPresent
  configmap:
    name: ue-configmap
  volume:
    name: ue-volume
    mount: /ueransim/config
  command: "./nr-ue -c ../config/ue
config.yaml"  # This is the command
will be launched in the UE containe
  # A script that will be run after
UE creation. It may be used to
periodically generate traffic
  script: ""
  # script: |-
  #   ping .....

  podAnnotations: {}
    # additional annotations
  imagePullSecrets: []
  podSecurityContext: {}
  securityContext:
    capabilities:
      add: ["NET_ADMIN"]
  resources:
    limits:
      cpu: 120m
      memory: 128Mi
    requests:
      cpu: 120m
      memory: 128Mi
  nodeSelector: {}
  tolerations: []
  affinity: {}
```

```
  configuration: |-
    supi: "imsi-208930000000003"  # IMSI number
    mcc: '208' # Mobile Country Code value
    mnc: '93' # Mobile Network Code value (2 or 3 digits)
    key: "8baf473f2f8fd09487cccbd7097c6862" # Operator code
(OP or OPC) of the UE
    op: "8e27b6af0e692e750f32667a3b14605d" # This value
specifies the OP type and it can be either 'OP' or 'OPC'
    opType: "OPC" # This value specifies the OP type and it
can be either 'OP' or 'OPC'
    amf: '8000' # Authentication Management Field (AMF) value
    imei: '356938035643803' # IMEI number o
    imeiSv: '4370816125816151'
    # UAC Access Identities Configuration
    uacAic:
      mps: false
      mcs: false
    # UAC Access Control Class
    uacAcc:
      normalClass: 0
      class11: false
      class12: false
      class13: false
      class14: false
      class15: false
    sessions:
      - type: "IPv4"
        apn: "internet"
        slice:
          sst: 0x01
          sd: 0x010203
    # Configured NSSAI for this UE by HPLMN
    configured-nssai:
      - sst: 0x01
        sd: 0x010203
    # Default Configured NSSAI for this UE
    default-nssai:
      - sst: 1
        sd: 1
```

```
  # Supported encryption and integrity
algorithms by this UE
    integrity:
      IA1: true
      IA2: true
      IA3: true
    ciphering:
      EA1: true
      EA2: true
      EA3: true
    # Integrity protection maximum data
rate for user plane
    integrityMaxRate:
      uplink: 'full'
      downlink: 'full'

  test:
    connectivity:
      name: ue-connectivity-test
      image: bitnami/kubectl:1.22.0
      configmap:
        name: connectivity-test-
configmap
      volume:
        name: connectivity-test-volume
        mount: /scripts
      ttlseconds: 50
```

부록 2. HELM OPERATIONS

❖ **K8s Operations** (as root)

- sudo kubectl get pods --all-namespaces

```
root@kubesphere:~/multus-cni# sudo kubectl get pods --all-namespaces
root@jslab:~/multus-cni# sudo kubectl get pods --all-namespaces
NAMESPACE                      NAME                                              READY   STATUS             RESTARTS          AGE
jslab5gc                       jslab5gc-v1-free5gc-amf-amf-5c548c9dcc-q9mzg      1/1     Running            0                 30m
jslab5gc                       jslab5gc-v1-free5gc-ausf-ausf-5774d545f9-xflmm    1/1     Running            0                 30m
jslab5gc                       jslab5gc-v1-free5gc-nrf-nrf-7f4bb4f796-l6r24      1/1     Running            0                 30m
jslab5gc                       jslab5gc-v1-free5gc-nssf-nssf-6d97bfd6f6-zhp7w    1/1     Running            0                 30m
jslab5gc                       jslab5gc-v1-free5gc-pcf-pcf-766878b98f-2svgc      1/1     Running            0                 30m
jslab5gc                       jslab5gc-v1-free5gc-smf-smf-6fbb8f4ccb-tbkcd      1/1     Running            0                 30m
jslab5gc                       jslab5gc-v1-free5gc-udm-udm-85fd6854b5-ncqc6      1/1     Running            0                 30m
jslab5gc                       jslab5gc-v1-free5gc-udr-udr-6bb6fc4b57-ltm48      1/1     Running            0                 30m
jslab5gc                       jslab5gc-v1-free5gc-upf-upf-54d8dbd786-bgmpw      0/1     Pending            0                 5m57s
jslab5gc                       jslab5gc-v1-free5gc-upf-upf-75655bdfcf-9smsw      0/1     CrashLoopBackOff   6 (101s ago)      30m
jslab5gc                       jslab5gc-v1-free5gc-webui-webui-76645cbfd8-ww8ld  1/1     Running            0                 30m
jslab5gc                       mongodb-0                                         1/1     Running            0                 30m
jslab5gc                       ueransim-free5gc-gnb-84d66db87d-j5v88             0/1     Pending            0                 2m55s
jslab5gc                       ueransim-free5gc-ue-84f88486c7-2tlrt              0/1     Pending            0                 2m55s
kube-system                    calico-kube-controllers-69d878584c-q86k8          1/1     Running            1 (2d23h ago)     3d
kube-system                    calico-node-4gdz4                                 1/1     Running            1 (2d23h ago)     3d
kube-system                    coredns-b5648d655-h4ckb                           1/1     Running            1 (2d23h ago)     3d
kube-system                    coredns-b5648d655-jqhjn                           1/1     Running            1 (2d23h ago)     3d
kube-system                    kube-apiserver-jslab                              1/1     Running            1 (2d23h ago)     3d
kube-system                    kube-controller-manager-jslab                     1/1     Running            1 (2d23h ago)     3d
kube-system                    kube-multus-ds-rj29r                              1/1     Running            0                 47m
kube-system                    kube-proxy-kwz4h                                  1/1     Running            1 (2d23h ago)     3d
kube-system                    kube-scheduler-jslab                              1/1     Running            1 (2d23h ago)     3d
kube-system                    nodelocaldns-n2ckt                                1/1     Running            1 (2d23h ago)     3d
kube-system                    openebs-localpv-provisioner-57bbf864d5-mncss      1/1     Running            1 (2d23h ago)     3d
kube-system                    snapshot-controller-0                             1/1     Running            1 (2d23h ago)     3d
kubesphere-controls-system     default-http-backend-5bf68ff9b8-tjc2v             1/1     Running            1 (2d23h ago)     3d
kubesphere-controls-system     kubectl-admin-6dbcb94855-fljcj                    1/1     Running            1 (2d23h ago)     3d
kubesphere-monitoring-system   alertmanager-main-0                               2/2     Running            2 (2d23h ago)     3d
kubesphere-monitoring-system   kube-state-metrics-687d66b747-jspd9               3/3     Running            3 (2d23h ago)     3d
kubesphere-monitoring-system   node-exporter-gpwrf                               2/2     Running            2 (2d23h ago)     3d
kubesphere-monitoring-system   notification-manager-deployment-78664576cb-ntdhn  2/2     Running            2 (2d23h ago)     3d
kubesphere-monitoring-system   notification-manager-operator-7d44854f54-4qp9h    2/2     Running            2 (2d23h ago)     3d
kubesphere-monitoring-system   prometheus-k8s-0                                  2/2     Running            2 (2d23h ago)     3d
kubesphere-monitoring-system   prometheus-operator-8955bbd98-hpgwn               2/2     Running            2 (2d23h ago)     3d
kubesphere-system              ks-apiserver-6cd95fb98f-b8qkj                     1/1     Running            1 (2d23h ago)     3d
kubesphere-system              ks-console-7d9857b6c-wpzzl                        1/1     Running            1 (2d23h ago)     3d
kubesphere-system              ks-controller-manager-5958b94c9c-5gr74            1/1     Running            1 (2d23h ago)     3d
kubesphere-system              ks-installer-64f89fdb56-g6jkt                     1/1     Running            1 (2d23h ago)     3d
```

부록 2. HELM OPERATIONS

- kubectl exec -it -n free5gc free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb -- ip a
- kubectl exec -it -n free5gc free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfnr -- ip a

```
jslab@jslab:~$ kubectl get pods -n free5gc
NAME                                        READY   STATU
free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb 1/1     Runni
free5gc-v1-free5gc-ausf-ausf-6fd5b5f6d-fp9c7 1/1     Runni
free5gc-v1-free5gc-nrf-nrf-5664d64868-rp8tn 1/1     Runni
free5gc-v1-free5gc-nssf-nssf-6c5658c97f-w8c48 1/1     Runni
free5gc-v1-free5gc-pcf-pcf-7c4bb7d9b-n2wxc 1/1     Runni
free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfnr 1/1     Runni
free5gc-v1-free5gc-udm-udm-7c9b4dbd5f-wsfz7 1/1     Runni
free5gc-v1-free5gc-udr-udr-fcdfdfb7d-625tz 1/1     Runni
free5gc-v1-free5gc-upf-upf-57c686dd86-tf6jj 0/1     Conta
free5gc-v1-free5gc-webui-webui-76db6dbdc7-vfckq 1/1     Runni
mongodb-0                                   1/1     Runni
ueransim-v1-gnb-6cdbcff47b-rq7nq            1/1     Runni
ueransim-v1-ue-d6b68575-mpzk7               1/1     Runni
jslab@jslab:~$
```

```
jslab@jslab:~$ kubectl exec -it -n free5gc free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb -- ip a
Defaulted container "amf" out of: amf, wait-nrf (init)
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
2: tunl0@NONE: <NOARP> mtu 1480 qdisc noop state DOWN qlen 1000
    link/ipip 0.0.0.0 brd 0.0.0.0
4: eth0@if27: <BROADCAST,MULTICAST,UP,LOWER_UP,M-DOWN> mtu 1480 qdisc noqueue state UP
    link/ether 66:55:1f:4d:53:e7 brd ff:ff:ff:ff:ff:ff
    inet 10.244.120.76/32 brd 10.244.120.76 scope global eth0
       valid_lft forever preferred_lft forever
5: n2@if9: <BROADCAST,MULTICAST,UP,LOWER_UP,M-DOWN> mtu 1500 qdisc noqueue state UP
    link/ether da:2d:b3:cd:72:06 brd ff:ff:ff:ff:ff:ff
    inet 10.100.50.249/29 brd 10.100.50.255 scope global n2
       valid_lft forever preferred_lft forever
```

부록 2. HELM OPERATIONS

- kubectl exec -it -n free5gc free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb -- ip a
- kubectl exec -it -n free5gc free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfnr -- ip a

```
jslab@jslab:~$ kubectl get pods -n free5gc
NAME                                          READY   STATU
free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb   1/1     Runni
free5gc-v1-free5gc-ausf-ausf-6fd5b5f6d-fp9c7  1/1     Runni
free5gc-v1-free5gc-nrf-nrf-5664d64868-rp8tn   1/1     Runni
free5gc-v1-free5gc-nssf-nssf-6c5658c97f-w8c48 1/1     Runni
free5gc-v1-free5gc-pcf-pcf-7c4bb7d9b-n2wxc    1/1     Runni
free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfnr   1/1     Runni
free5gc-v1-free5gc-udm-udm-7c9b4dbd5f-wsfz7   1/1     Runni
free5gc-v1-free5gc-udr-udr-fcdfdfb7d-625tz    1/1     Runni
free5gc-v1-free5gc-upf-upf-57c686dd86-tf6jj   0/1     Conta
free5gc-v1-free5gc-webui-webui-76db6dbdc7-vfckq 1/1   Runni
mongodb-0                                     1/1     Runni
ueransim-v1-gnb-6cdbcff47b-rq7nq              1/1     Runni
ueransim-v1-ue-d6b68575-mpzk7                 1/1     Runni
jslab@jslab:~$
```

```
jslab@jslab:~$ kubectl exec -it -n free5gc free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfnr -- ip a
Defaulted container "smf" out of: smf, wait-nrf (init)
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
2: tunl0@NONE: <NOARP> mtu 1480 qdisc noop state DOWN qlen 1000
    link/ipip 0.0.0.0 brd 0.0.0.0
4: eth0@if23: <BROADCAST,MULTICAST,UP,LOWER_UP,M-DOWN> mtu 1480 qdisc noqueue state UP
    link/ether ae:70:a2:48:c8:9b brd ff:ff:ff:ff:ff:ff
    inet 10.244.120.72/32 brd 10.244.120.72 scope global eth0
       valid_lft forever preferred_lft forever
5: n4@if9: <BROADCAST,MULTICAST,UP,LOWER_UP,M-DOWN> mtu 1500 qdisc noqueue state UP
    link/ether ea:b9:25:4f:da:76 brd ff:ff:ff:ff:ff:ff
    inet 10.100.50.244/29 brd 10.100.50.247 scope global n4
       valid_lft forever preferred_lft forever
```

부록 2. HELM OPERATIONS

- kubectl exec -it -n free5gc free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb -- ip a
- kubectl exec -it -n free5gc free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfnr -- ip a
- **kubectl exec -it -n free5gc free5gc-v1-free5gc-udr-udr-fcdfdfb7d-625tz -- ip a**

```
jslab@jslab:~$ kubectl get pods -n free5gc
NAME                                      READY   STATU
free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb       1/1     Runni
free5gc-v1-free5gc-ausf-ausf-6fd5b5f6d-fp9c7      1/1     Runni
free5gc-v1-free5gc-nrf-nrf-5664d64868-rp8tn       1/1     Runni
free5gc-v1-free5gc-nssf-nssf-6c5658c97f-w8c48     1/1     Runni
free5gc-v1-free5gc-pcf-pcf-7c4bb7d9b-n2wxc        1/1     Runni
free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfnr       1/1     Runni
free5gc-v1-free5gc-udm-udm-7c9b4dbd5f-wsfz7       1/1     Runni
free5gc-v1-free5gc-udr-udr-fcdfdfb7d-625tz        1/1     Runni
free5gc-v1-free5gc-upf-upf-57c686dd86-tf6jj       0/1     Conta
free5gc-v1-free5gc-webui-webui-76db6dbdc7-vfckq   1/1     Runni
mongodb-0                                 1/1     Runni
ueransim-v1-gnb-6cdbcff47b-rq7nq          1/1     Runni
ueransim-v1-ue-d6b68575-mpzk7             1/1     Runni
jslab@jslab:~$
```

```
Jslab@jslab:~$ kubectl exec -it -n free5gc free5gc-v1-free5gc-udr-udr-fcdfdfb7d-625tz -- ip a
Defaulted container "udr" out of: udr, wait-nrf (init)
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
2: tunl0@NONE: <NOARP> mtu 1480 qdisc noop state DOWN qlen 1000
    link/ipip 0.0.0.0 brd 0.0.0.0
4: eth0@if24: <BROADCAST,MULTICAST,UP,LOWER_UP,M-DOWN> mtu 1480 qdisc noqueue state UP
    link/ether 0e:54:63:65:e8:50 brd ff:ff:ff:ff:ff:ff
    inet 10.244.120.73/32 brd 10.244.120.73 scope global eth0
       valid_lft forever preferred_lft forever
```

부록 2. HELM OPERATIONS

❖ Deploying 5G core network with open5GS, Kubernetes and Helm

1. helm repo add openverso https://gradiant.github.io/openverso-charts/
2. sudo kubectl create namespace jslab
3. helm repo update
4. helm repo list

KubeSphere Dashboard 확인
'project'

```
root@5g:~# helm repo add openverso https://gradiant.github.io/openverso-charts/
"openverso" has been added to your repositories
root@5g:~# sudo kubectl create namespace jslab
namespace/jslab created
root@5g:~# helm repo update
Hang tight while we grab the latest from your chart repositories...
...Unable to get an update from the "towards5gs" chart repository
(https://raw.githubusercontent.com/Orange-OpenSource/towards5gs-helm/main/repo/):
        Get "https://raw.githubusercontent.com/Orange-OpenSource/towards5gs-helm/main/repo/index.yaml":
dial tcp: lookup raw.githubusercontent.com on 127.0.0.53:53: read udp 127.0.0.1:52728->127.0.0.53:53:
i/o timeout
...Successfully got an update from the "openverso" chart repository
Update Complete. ⎈Happy Helming!⎈
root@5g:~# helm repo list
NAME            URL
towards5gs      https://raw.githubusercontent.com/Orange-OpenSource/towards5gs-helm/main/repo/
openverso       https://gradiant.github.io/openverso-charts/
```

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

Source: https://github.com/Gradiant/openverso-charts
Source: https://levelup.gitconnected.com/opensource-5g-core-with-service-mesh-bba4ded044fa (Reference for Service Mesh Test)

부록 2. HELM OPERATIONS

❖ Deploying 5G core network with open5GS, Kubernetes and Helm

5. helm search repo
6. sudo helm -n jslab install open5gs openverso/open5gs
7. helm -n jslab uninstall open5gs

```
root@5g:~# helm search repo
NAME                                    CHART VERSION   APP VERSION     DESCRIPTION
openverso/iperf3                        0.1.2           1.0.0           iPerf3 is a tool for active measurements of the...
openverso/oai-enb                       0.1.0           1.2.2           OpenAirInterface enodeb
openverso/oai-gnb                       0.3.1           2021.w32        description
openverso/open5gs                       0.5.0           2.4.4           Helm chart to deploy Open5gs services on Kubern...
openverso/srs-enb                       0.1.1           20.10.1         SRS enodeb
openverso/srs-epc                       0.1.0           20.10.1         SRS epc
openverso/srs-lte                       0.1.1           20.04.1         SRSLte enodeb + ue.
openverso/srs-ue                        0.1.1           20.10.1         SRS ue
openverso/ueransim                      0.2.1           3.2.6           ueransim for 5G RAN simulation
openverso/ueransim-gnb                  0.2.0           3.2.6           ueransim gNodeB for 5G RAN simulation
towards5gs/free5gc                      1.1.2           v3.1.1          A Helm chart to deploy Free5gc
towards5gs/free5gc-amf                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-ausf                 0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-n3iwf                0.2.1           v3.1.1          A Helm c
towards5gs/free5gc-nrf                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-nssf                 0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-pcf                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-smf                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-udm                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-udr                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-upf                  0.2.1           v3.1.1          A Helm c
towards5gs/free5gc-webui                0.1.2           v3.1.1          A Helm c
towards5gs/free5gcControlPlane          0.1.2           v3.0.5          DEPRECAT
towards5gs/free5gcN3iwf                 0.1.2           v3.0.5          DEPRECAT
towards5gs/free5gcUserPlane             0.1.2           v3.0.5          DEPRECAT
towards5gs/networks5g                   0.1.2           0.1.2           DEPRECAT
towards5gs/ueransim                     2.0.14          v3.2.6          A Helm chart to deploy UERANSIM
root@5g:~#
```

```
root@5g:~# helm search repo
NAME                            CHART VERSION   APP VERSION     DESCRIPTION
openverso/iperf3                0.1.2           1.0.0           iPerf3 is a tool for active measurements of the...
openverso/oai-enb               0.1.0           1.2.2           OpenAirInterface enodeb
openverso/oai-gnb               0.3.1           2021.w32        description
openverso/open5gs               0.5.0           2.4.4           Helm chart to deploy Open5gs services on Kubern...
openverso/srs-enb               0.1.1           20.10.1         SRS enodeb
openverso/srs-epc               0.1.0           20.10.1         SRS epc
openverso/srs-lte               0.1.1           20.04.1         SRSLte enodeb + ue.
openverso/srs-ue                0.1.1           20.10.1         SRS ue
openverso/ueransim              0.2.1           3.2.6           ueransim for 5G RAN simulation
openverso/ueransim-gnb          0.2.0           3.2.6           ueransim gNodeB for 5G RAN simulation
```

부록 2. HELM OPERATIONS

❖ Deploying 5G core network with open5GS, Kubernetes and Helm

5. helm search repo
6. sudo helm -n jslab install open5gs openverso/open5gs
7. sudo helm -n jslab install ueransim openverso/ueransim
8. sudo helm -n jslab install gnb openverso/ueransim-gnb
9. helm -n jslab uninstall open5gs

KubeSphere Dashboard 확인
'pod'

```
root@5g:~# sudo helm -n jslab install open5gs openverso/open5gs
NAME: open5gs
LAST DEPLOYED: Sun Jul 10 12:11:56 2022
NAMESPACE: jslab
STATUS: deployed
REVISION: 1
TEST SUITE: None
NOTES:
You have deployed open5gs 5G core services:
** 5G AMF Service **
Internal Access:
For services running at the same k8s namespace, AMF IP can be resolved at `open5gs-amf`.
You can also get the AMF clusterIP with:
```
kubectl get svc -n jslab open5gs-amf -o jsonpath='{.spec.clusterIP}')
```
---
External IP Access to this AMF service was not enabled (check amf.externalService.enabled).
---
** MME **
Internal Access:
For services running at the same k8s namespace, MME IP can be resolved at `open5gs-mme`.
You can also get the MME clusterIP with:
```
kubectl get svc -n jslab open5gs-mme -o jsonpath='{.spec.clusterIP}')
```
---
External IP Access to this MME service was not enabled (check mme.externalService.enabled).
---
** WEBUI **
Access Open5gs web ui at:
  http://open5gs-jslab.ingress.lab5g.gradiant.org
With user: "admin" and password "1423"
```

Source: https://helm.sh/ko/

부록 2. HELM OPERATIONS

❖ Kubernetes Operations

- kubectl get svc -A

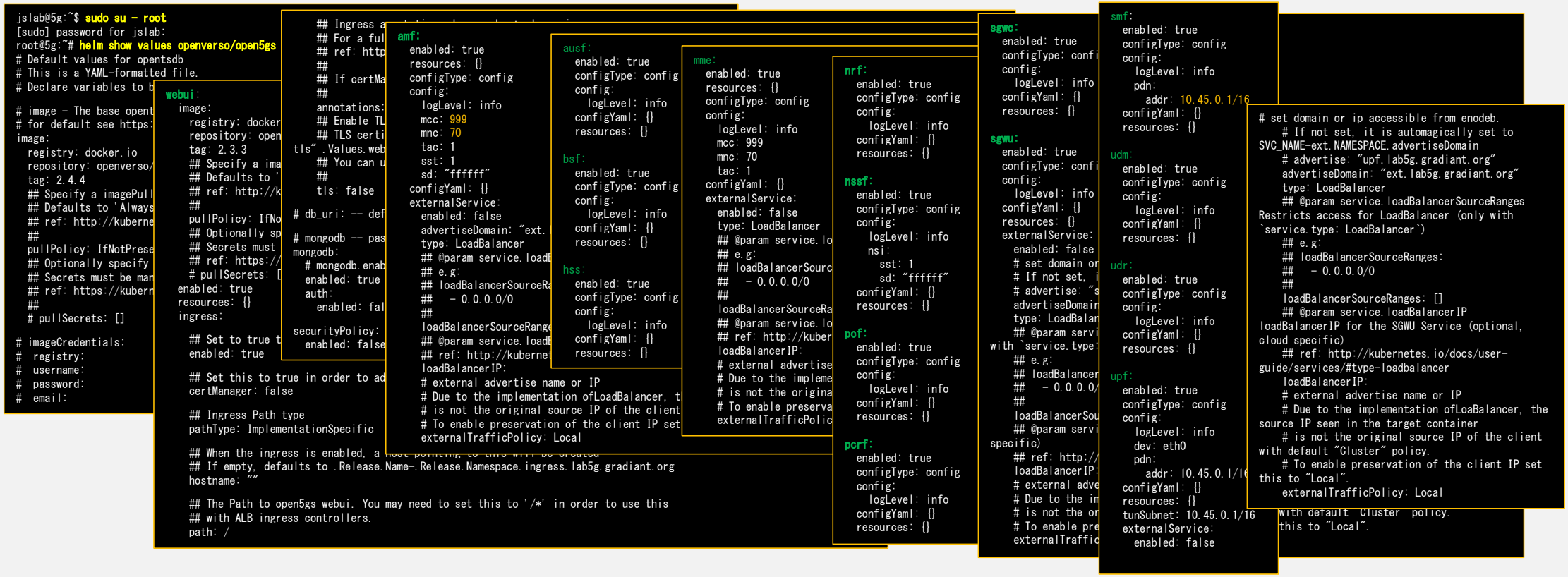
KubeSphere Dashboard 확인
'service'

```
root@node1:~/multus-cni# kubectl get svc -A
NAMESPACE                      NAME                      TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)                                 AGE
default                        deathstar                 ClusterIP   10.233.21.159   <none>        80/TCP                                  13d
default                        kubernetes                ClusterIP   10.233.0.1      <none>        443/TCP                                 13d
jslab                          gnb-ueransim-gnb          ClusterIP   None            <none>        4997/UDP,2152/UDP                       6d21h
jslab                          open5gs-amf               ClusterIP   10.233.29.253   <none>        7777/TCP,38412/SCTP                     7d1h
jslab                          open5gs-ausf              ClusterIP   10.233.51.236   <none>        7777/TCP                                7d1h
jslab                          open5gs-bsf               ClusterIP   10.233.33.243   <none>        7777/TCP                                7d1h
jslab                          open5gs-hss               ClusterIP   10.233.5.68     <none>        3868/SCTP                               7d1h
jslab                          open5gs-mme               ClusterIP   10.233.19.242   <none>        36412/SCTP,3868/SCTP,2123/UDP           7d1h
jslab                          open5gs-mongodb           ClusterIP   10.233.29.173   <none>        27017/TCP                               7d1h
jslab                          open5gs-nrf               ClusterIP   10.233.62.190   <none>        7777/TCP                                7d1h
jslab                          open5gs-nssf              ClusterIP   10.233.60.110   <none>        7777/TCP                                7d1h
jslab                          open5gs-pcf               ClusterIP   10.233.32.80    <none>        7777/TCP                                7d1h
jslab                          open5gs-pcrf              ClusterIP   10.233.45.169   <none>        3868/SCTP                               7d1h
jslab                          open5gs-sgwc              ClusterIP   10.233.18.209   <none>        2123/UDP,8805/UDP                       7d1h
jslab                          open5gs-sgwu              ClusterIP   10.233.46.237   <none>        2152/UDP,8805/UDP                       7d1h
jslab                          open5gs-smf               ClusterIP   10.233.36.49    <none>        2123/UDP,8805/UDP,3868/SCTP,7777/TCP    7d1h
jslab                          open5gs-udm               ClusterIP   10.233.6.211    <none>        7777/TCP                                7d1h
jslab                          open5gs-udr               ClusterIP   10.233.40.1     <none>        7777/TCP                                7d1h
jslab                          open5gs-upf               ClusterIP   10.233.43.230   <none>        2152/UDP,8805/UDP                       7d1h
jslab                          open5gs-webui             ClusterIP   10.233.42.148   <none>        3000/TCP                                7d1h
jslab                          ueransim-gnb              ClusterIP   None            <none>        4997/UDP,2152/UDP                       6d21h
jslab5gc                       amf-namf                  ClusterIP   10.233.35.85    <none>        80/TCP                                  7m5s
jslab5gc                       ausf-nausf                ClusterIP   10.233.63.94    <none>        80/TCP                                  7m5s
jslab5gc                       gnb-service               ClusterIP   10.233.27.76    <none>        4997/UDP                                63s
jslab5gc                       mongodb                   ClusterIP   10.233.7.86     <none>        27017/TCP                               7m5s
jslab5gc                       nrf-nnrf                  ClusterIP   10.233.43.245   <none>        8000/TCP                                7m5s
jslab5gc                       nssf-nnssf                ClusterIP   10.233.9.116    <none>        80/TCP                                  7m5s
jslab5gc                       pcf-npcf                  ClusterIP   10.233.37.62    <none>        80/TCP                                  7m5s
jslab5gc                       smf-nsmf                  ClusterIP   10.233.14.19    <none>        80/TCP                                  7m5s
jslab5gc                       udm-nudm                  ClusterIP   10.233.47.99    <none>        80/TCP                                  7m5s
jslab5gc                       udr-nudr                  ClusterIP   10.233.20.3     <none>        80/TCP                                  7m5s
jslab5gc                       webui-service             NodePort    10.233.20.18    <none>        5000:30500/TCP                          7m5s
```

부록 2. HELM OPERATIONS

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm (참고)

- helm show values openverso/open5gs



부록 2. HELM OPERATIONS

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm (참고)

- helm show values openverso/ueransim-gnb

```
root@5g:~# helm show values openverso/ueransim-gnb
## @section Global parameters
## Global Docker image parameters
## Please, note that this will override the image parameters, including dependencies, configured to use the global value
## Current available global Docker image parameters: imageRegistry, imagePullSecrets and storageClass

## @param global.imageRegistry Global Docker image registry
## @param global.imagePullSecrets Global Docker registry se
## @param global.storageClass Global StorageClass for Persi
##
global:
  imageRegistry:
  ## E.g.
  ## imagePullSecrets:
  ##   - myRegistryKeySecretName
  ##
  imagePullSecrets: []
  storageClass:

## @section Common parameters

## @param kubeVersion Override Kubernetes version
##
kubeVersion:
## @param nameOverride String to partially override common.
##
nameOverride:
## @param fullnameOverride String to fully override common.
##
fullnameOverride:
## @param commonLabels Labels to add to all deployed objects
```

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

```
##
commonLabels: {}
## @param commonAnnotations Annotations to add to all deployed
objects
##
commonAnnotations: {}
## @param clusterDomain Kubernetes cluster domain name
##
clusterDomain: cluster.local
## @param extraDeploy Array of extra objects to deploy with the
release
##
extraDeploy: []

image:
  registry: docker.io
  repository: openverso/ueransim
  tag: 3.2.6
  ## Specify a imagePullPolicy
  ## Defaults to 'Always' if image tag is 'latest', else set to
'IfNotPresent'
  ## ref: http://kubernetes.io/docs/user-guide/images/#pre-pull
images
  ##
  pullPolicy: Always
  ## Optionally specify an array of imagePullSecrets.
  ## Secrets must be manually created in the namespace.
  ## ref: https://kubernetes.io/docs/tasks/
```

```
configure-pod-container/pull-image-private-registry/
  ## e.g:
  ## pullSecrets:
  ##   - myRegistryKeySecretName
  ##
  pullSecrets: []
  ## Enable debug mode
  ##
  debug: false

name: ueransim-gnb
amf:
  # if set amf.ip takes precedence over amf.hostname
  ip:
  hostname: open5gs-amf
interfaces:
  n2:
    dev: eth0
  n3:
    dev: eth0
  radio:
    dev: eth0
mcc: '999'
mnc: '70'
sst: 1
sd: "0xffffff"
tac: '0001'
```

```
resources:
  limits: {}
  requests: {}
podSecurityContext:
  enabled: false
containerSecurityContext:
  enabled: false
podLabels: {}
podAnnotations: {}
affinity: {}
nodeSelector: {}
tolerations: []

ues:
  enabled: false
  count: 1
  initialMSISDN: '0000000001'
  key: 465B5CE8B199B49FAA5F0A2EE238A6BC
  op: E8ED289DEBA952E4283B54E88E6183CA
  opType: OPC
  apn: internet
  resources:
    limits: {}
    requests: {}
  podSecurityContext:
    enabled: false
  containerSecurityContext:
    enabled: false
  podLabels: {}
  podAnnotations: {}
  affinity: {}
  nodeSelector: {}
  tolerations: []

50.238
```

부록 2. HELM OPERATIONS

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm (참고)

- helm show values openverso/ueransim

```
root@5g:~# helm show values towards5gs/ueransim
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2021 Orange
# SPDX-License-Identifier: Apache-2.0
#
# This software is distributed und
# the text of which is available a
# or see the "LICENSE" file for mo
#
# Author: Abderaouf KHICHANE, Ilhe
# Software description: An open-so
#
# Default values for ueransim-char
# This is a YAML-formatted file.
# Declare variables to be passed i

global:
  multiCluster: false
  #Global network parametes
  n2network:
    name: n2network
    masterIf: eth0
    subnetIP: 10.100.50.248
    cidr: 29
    gatewayIP: 10.100.50.254
    excludeIP: 10.100.50.254
  n3network:
    name: n3network
    masterIf: eth0
    subnetIP: 10.100.50.232
    cidr: 29
    gatewayIP: 10.100.50.238
    excludeIP: 10.100.50.238
```

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

```
projectName: ueransim

gnb:
  enabled: true
  name: gnb
  replicaCount: 1
  image:
    name: towards5gs/ueransim-gnb
    pullPolicy: IfNotPresent
  configmap:
    name: gnb-configmap
  volume:
    name: gnb-volume
    mount: /ueransim/config
  service:
    name: gnb-service
    type: ClusterIP
    port: 4997
    protocol: UDP

  n2if:  # NGAP
    ipAddress: 10.100.50.250
  n3if:  # GTP-U
    ipAddress: 10.100.50.236

amf:
  n2if:  # NGAP
    ipAddress: 10.100.50.249
    port: 38412
  service:
    ngap:
      enabled: false  # if true set gnb.amf.n2if.ipAddress to the
name of AMF NGAP service or the IP of the cluster hosting the AMF
```

```
  podAnnotations: {}
    # additional annotations
  imagePullSecrets: []
  podSecurityContext: {}
  resources:
    limits:
      cpu: 250m
      memory: 256Mi
    requests:
      cpu: 250m
      memory: 256Mi
  nodeSelector: {}
  tolerations: []
  affinity: {}

  configuration: |-
    mcc: '208' # Mobile Country Code value
    mnc: '93'  # Mobile Network Code value (2 or
    nci: '0x000000010'  # NR Cell Identity (36-bi
    idLength: 32        # NR gNB ID length in bit
    tac: 1     # Tracking Area Code
    # List of supported S-NSSAIs by this gNB
    slices:
      - sst: 0x1
        sd: 0x010203
    # Indicates whether or not SCTP stream number
should be ignored.
    ignoreStreamIds: true
```

```
ue:
  enabled: true
  name: ue
  replicaCount: 1
  image:
    name: towards5gs/ueransim-ue
    pullPolicy: IfNotPresent
  configmap:
    name: ue-configmap
  volume:
    name: ue-volume
    mount: /ueransim/config
  command: "./nr-ue -c ../config/ue
config.yaml"  # This is the command
will be launched in the UE containe
  # A script that will be run after
UE creation. It may be used to
periodically generate traffic
  script: ""
  # script: |-
  #   ping .....

  podAnnotations: {}
    # additional annotations
  imagePullSecrets: []
  podSecurityContext: {}
  securityContext:
    capabilities:
      add: ["NET_ADMIN"]
  resources:
    limits:
      cpu: 120m
      memory: 128Mi
    requests:
      cpu: 120m
      memory: 128Mi
  nodeSelector: {}
  tolerations: []
  affinity: {}
```

```
  configuration: |-
    supi: "imsi-208930000000003"  # IMSI number
    mcc: '208' # Mobile Country Code value
    mnc: '93' # Mobile Network Code value (2 or 3 digits)
    key: "8baf473f2f8fd09487cccbd7097c6862" # Operator code
(OP or OPC) of the UE
    op: "8e27b6af0e692e750f32667a3b14605d" # This value
specifies the OP type and it can be either 'OP' or 'OPC'
    opType: "OPC" # This value specifies the OP type and it
can be either 'OP' or 'OPC'
    amf: '8000' # Authentication Management Field (AMF) value
    imei: '356938035643803' # IMEI number of
    imeiSv: '4370816125816151'
    # UAC Access Identities Configuration
    uacAic:
      mps: false
      mcs: false
    # UAC Access Control Class
    uacAcc:
      normalClass: 0
      class11: false
      class12: false
      class13: false
      class14: false
      class15: false
    sessions:
      - type: "IPv4"
        apn: "internet"
        slice:
          sst: 0x01
          sd: 0x010203
    # Configured NSSAI for this UE by HPLMN
    configured-nssai:
      - sst: 0x01
        sd: 0x010203
    # Default Configured NSSAI for this UE
    default-nssai:
      - sst: 1
        sd: 1
```

```
    # Supported encryption and integrity
  algorithms by this UE
      integrity:
        IA1: true
        IA2: true
        IA3: true
      ciphering:
        EA1: true
        EA2: true
        EA3: true
    # Integrity protection maximum data
  rate for user plane
      integrityMaxRate:
        uplink: 'full'
        downlink: 'full'

  test:
    connectivity:
      name: ue-connectivity-test
      image: bitnami/kubectl:1.22.0
      configmap:
        name: connectivity-test-
  configmap
      volume:
        name: connectivity-test-volume
        mount: /scripts
      ttlseconds: 50
```

부록 2. HELM OPERATIONS

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm (참고)

- **gnb@ueransim:** helm show values openverso/ueransim

```
root@5g:~# helm show values towards5gs/ueransim
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2021 Orange
# SPDX-License-Identifier: Apache-2.0
#
# This software is distributed under the Apache License 2.0,
# the text of which is available at todo
# or see the "LICENSE" file for more details.
#
# Author: Abderaouf KHICHANE, Ilhem FAJJARI, Ayoub BOUSSELMI
# Software description: An open-source project providing Helm charts to deploy 5G c
#
# Default values for ueransim-chart.
# This is a YAML-formatted file.
# Declare variables to be passed into your templates.

global:
  multiCluster: false
  #Global network parametes
  n2network:
    name: n2network
    masterIf: eth0
    subnetIP: 10.100.50.248
    cidr: 29
    gatewayIP: 10.100.50.254
    excludeIP: 10.100.50.254
  n3network:
    name: n3network
    masterIf: eth0
    subnetIP: 10.100.50.232
    cidr: 29
    gatewayIP: 10.100.50.238
    excludeIP: 10.100.50.238
```

```
projectName: ueransim

gnb:
  enabled: true
  name: gnb
  replicaCount: 1
  image:
    name: towards5gs/ueransim-gnb
    pullPolicy: IfNotPresent
  configmap:
    name: gnb-configmap
  volume:
    name: gnb-volume
    mount: /ueransim/config
  service:
    name: gnb-service
    type: ClusterIP
    port: 4997
    protocol: UDP

  n2if:  # NGAP
    ipAddress: 10.100.50.250
  n3if:  # GTP-U
    ipAddress: 10.100.50.236

  amf:
    n2if:  # NGAP
      ipAddress: 10.100.50.249
      port: 38412
    service:
      ngap:
        enabled: false  # if true set gnb.amf.n2if.ipAddress to the name of AMF
NGAP service or the IP of the cluster hosting the AMF
```

```
  podAnnotations: {}
    # additional annotations
  imagePullSecrets: []
  podSecurityContext: {}
  resources:
    limits:
      cpu: 250m
      memory: 256Mi
    requests:
      cpu: 250m
      memory: 256Mi
  nodeSelector: {}
  tolerations: []
  affinity: {}

  configuration: |-
    mcc: '208' # Mobile Country Code value
    mnc: '93'  # Mobile Network Code value (2 or 3 digits)
    nci: '0x000000010'  # NR Cell Identity (36-bit)
    idLength: 32        # NR gNB ID length in bits [22...32]
    tac: 1     # Tracking Area Code
    # List of supported S-NSSAIs by this gNB
    slices:
      - sst: 0x1
        sd: 0x010203
    # Indicates whether or not SCTP stream number errors should be
ignored.
    ignoreStreamIds: true
```

부록 2. HELM OPERATIONS

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm (참고)

- **ue@ueransim:** helm show values openverso/ueransim

```
root@5g:~# helm show values towards5gs/ueransim
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2
# SPDX-License-Identifier: Apache-2.0
#
# This software is distributed under the
# the text of which is available at todo
# or see the "LICENSE" file for more deta
#
# Author: Abderaouf KHICHANE, Ilhem FAJJA
# Software description: An open-source pr
#
# Default values for ueransim-chart.
# This is a YAML-formatted file.
# Declare variables to be passed into you

global:
  multiCluster: false
  #Global network parametes
  n2network:
    name: n2network
    masterIf: eth0
    subnetIP: 10.100.50.248
    cidr: 29
    gatewayIP: 10.100.50.254
    excludeIP: 10.100.50.254
  n3network:
    name: n3network
    masterIf: eth0
    subnetIP: 10.100.50.232
    cidr: 29
    gatewayIP: 10.100.50.238
    excludeIP: 10.100.50.238
```

```
ue:
  enabled: true
  name: ue
  replicaCount: 1
  image:
    name: towards5gs/ueransim-ue
    pullPolicy: IfNotPresent
  configmap:
    name: ue-configmap
  volume:
    name: ue-volume
    mount: /ueransim/config
  command: "./nr-ue -c ../config/ue-config.yaml"  # Thi
command that will be launched in the UE container
  # A script that will be run after the UE creation. It
used to periodically generate traffic
  script: ""
  # script: |-
  #   ping .....

  podAnnotations: {}
    # additional annotations
  imagePullSecrets: []
  podSecurityContext: {}
  securityContext:
    capabilities:
            add: ["NET_ADMIN"]
  resources:
    limits:
      cpu: 120m
      memory: 128Mi
    requests:
      cpu: 120m
      memory: 128Mi
```

```
 nodeSelector: {}
  tolerations: []
  affinity: {}
 configuration: |-
    supi: "imsi-208930000000003"  # IMSI number
    mcc: '208' # Mobile Country Code value
    mnc: '93' # Mobile Network Code value (2 or 3 digits)
    key: "8baf473f2f8fd09487cccbd7097c6862" # Operator co
of the UE
    op: "8e27b6af0e692e750f32667a3b14605d" # This value s
type and it can be either 'OP' or 'OPC'
    opType: "OPC" # This value specifies the OP type and
either 'OP' or 'OPC'
    amf: '8000' # Authentication Management Field (AMF) v
    imei: '356938035643803' # IMEI number of the device
    imeiSv: '4370816125816151'
    # UAC Access Identities Configuration
    uacAic:
      mps: false
      mcs: false
    # UAC Access Control Class
    uacAcc:
      normalClass: 0
      class11: false
      class12: false
      class13: false
      class14: false
      class15: false
    sessions:
      - type: "IPv4"
        apn: "internet"
        slice:
          sst: 0x01
          sd: 0x010203
```

imsi-208930000000003

```
# Configured NSSAI for this UE by HPLMN
   configured-nssai:
     - sst: 0x01
       sd: 0x010203
   # Default Configured NSSAI for this UE
   default-nssai:
     - sst: 1
       sd: 1
# Supported encryption and integrity algorithms by this UE
   integrity:
     IA1: true
     IA2: true
     IA3: true
   ciphering:
     EA1: true
     EA2: true
     EA3: true
   # Integrity protection maximum data rate for user plane
   integrityMaxRate:
     uplink: 'full'
     downlink: 'full'

 test:
   connectivity:
     name: ue-connectivity-test
     image: bitnami/kubectl:1.22.0
     configmap:
       name: connectivity-test-configmap
     volume:
       name: connectivity-test-volume
       mount: /scripts
     ttlseconds: 50
```


THANK
YOU

BACKUP

❖ Build Open5GS

- **Open5GS 설치: Install Open5GS with a Package Manager (Ubuntu Server 20.04)**
  - https://open5gs.org/open5gs/docs/guide/01-quickstart/
- **웹 UI 설치: Install the WebUI of Open5GS**
- **구성: Configure Open5GS**
- **eNB/gNB UE 연동: Turn on your eNB/gNB and UE**
- **실행/정지: : Starting and Stopping Open5GS**

Open5GS: C-language Open Source implementation for 5G Core and EPC, i.e. the core network of LTE/NR network (Release-16)

UERANSIM: the open-source state-of-the-art 5G UE and RAN (gNodeB) implementation. It can be considered as a 5G mobile phone and a base station in basic terms. The project can be used for testing 5G Core Network and studying 5G System.

- 5GC - Open5GS v2.4.0 - https://github.com/open5gs/open5gs
- UE / RAN - UERANSIM v3.2.5 - https://github.com/aligungr/UERANSIM

https://open5gs.org/open5gs/docs/
https://open5gs.org/open5gs/docs/guide/01-quickstart/

BACKUP

❖ Deploying 5G core network with Free5GC, Kubernetes and Helm

```
sudo su - root
cd /home/jslab/multus-cni/
```

1. sudo kubectl version -o yaml
2. sudo helm list -A
3. git clone https://github.com/k8snetworkplumbingwg/multus-cni.git && cd multus-cni
4. dir
5. cd deployments
6. cat multus-daemonset-thick.yml | kubectl apply -f -
7. sudo kubectl get pods --all-namespaces
8. helm repo add jslabrepo5gc https://raw.githubusercontent.com/Orange-OpenSource/towards5gs-helm/main/repo/
9. helm repo update
10. helm repo list
11. helm search repo
12. sudo kubectl create namespace jslab5gc
13. sudo helm -n jslab5gc install jslab5gc-v1 jslabrepo5gc/free5gc
14. sudo helm -n jslab5gc uninstall jslab5gc-v1
15. kubectl get svc -n jslab5gc
16. watch kubectl get pods -n jslab5gc
17. helm show values jslabrepo5gc/free5gc

BACKUP

❖ Prometheus

1. helm repo add prometheus-community https://prometheus-community.github.io/helm-charts
2. helm repo update
3. >> helm search repo prometheus-community
4. kubectl create namespace prometheus
5. helm install prometheus prometheus-community/kube-prometheus-stack -n prometheus
6. >> kubectl get pods -n prometheus

Rancher 로 대체 시연

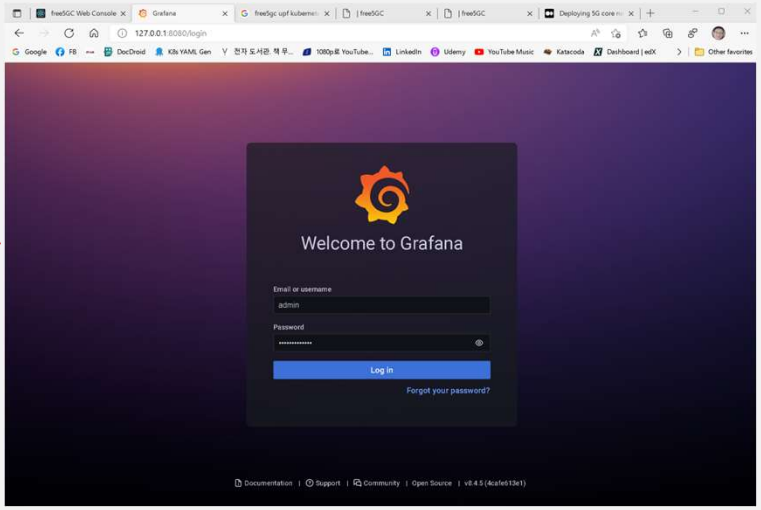
Source: https://kubesphere.io/docs/v3.3/faq/observability/byop/
Source: https://medium.com/rahasak/deploying-5g-core-network-with-free5gc-kubernets-and-helm-charts-29741cea3922

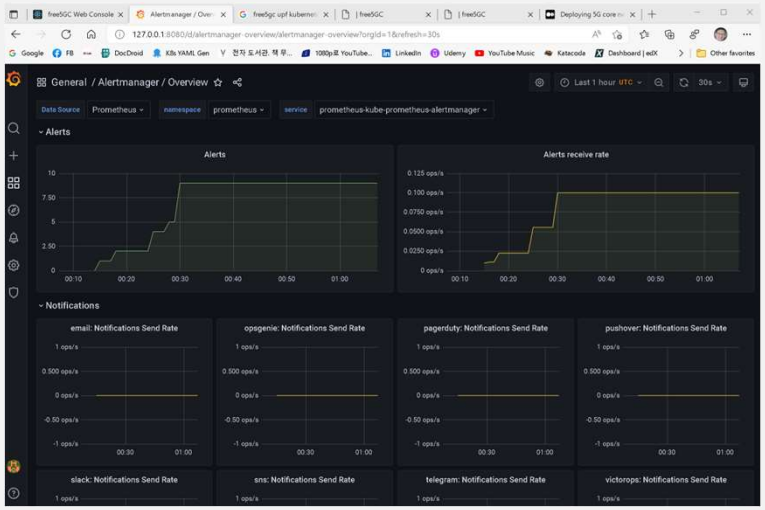
BACKUP

❖ Grafana

1. >> kubectl get svc -n prometheus | grep grafana
2. >> kubectl port-forward -n prometheus svc/prometheus-grafana 8080:80
3. >> kubectl get secret --namespace prometheus prometheus-grafana -o yaml
4. kubectl port-forward --namespace prometheus svc/prometheus-grafana 8080:80
5. ssh -L localhost:8080:localhost:8080 jslab@192.168.50.50 ### @ Windows Terminal
6. http://127.0.0.1:8080 ### @ Windows PC with admin / prom-operator

Rancher 로 시연





Source: https://medium.com/rahasak/deploying-5g-core-network-with-free5gc-kubernets-and-helm-charts-29741cea3922

BACKUP

❖ Orange-OpenSource/towards5gs-helm (선택 참고)

1. curl -fsSL -o get_helm.sh https://raw.githubusercontent.com/helm/helm/master/scripts/get-helm-3
2. chmod 700 get_helm.sh
3. ./get_helm.sh
4. helm repo add towards5gs 'https://raw.githubusercontent.com/Orange-OpenSource/towards5gs-helm/main/repo/'
5. helm repo update
6. helm search repo

7. helm -n free5gc install ueransim-v1 towards5gs/free5gc-upf

Source: https://github.com/Orange-OpenSource/towards5gs-helm/tree/main/docs

BACKUP

❖ Install go (선택 참고)

1. sudo apt -y install git gcc g++ cmake autoconf libtool pkg-config libmnl-dev libyaml-dev
2. go get -u github.com/sirupsen/logrus
3. sudo sysctl -w net.ipv4.ip_forward=1
4. sudo iptables -t nat -A POSTROUTING -o ens33 -j MASQUERADE
5. sudo systemctl stop ufw
6. go version
7. cd ~
8. wget https://golang.org/dl/go1.15.8.linux-amd64.tar.gz
9. sudo tar -C /usr/local -xzf go1.15.8.linux-amd64.tar.gz
10. mkdir -p ~/go/{bin,pkg,src}
11. echo 'export GOPATH=$HOME/go' >> ~/.bashrc
12. echo 'export GOROOT=/usr/local/go' >> ~/.bashrc
13. echo 'export PATH=$PATH:$GOPATH/bin:$GOROOT/bin' >> ~/.bashrc
14. echo 'export GO111MODULE=auto' >> ~/.bashrc
15. source ~/.bashrc
16. sudo apt -y update

Source: https://www.free5gc.org/installations/stage-3-free5gc-install/

BACKUP

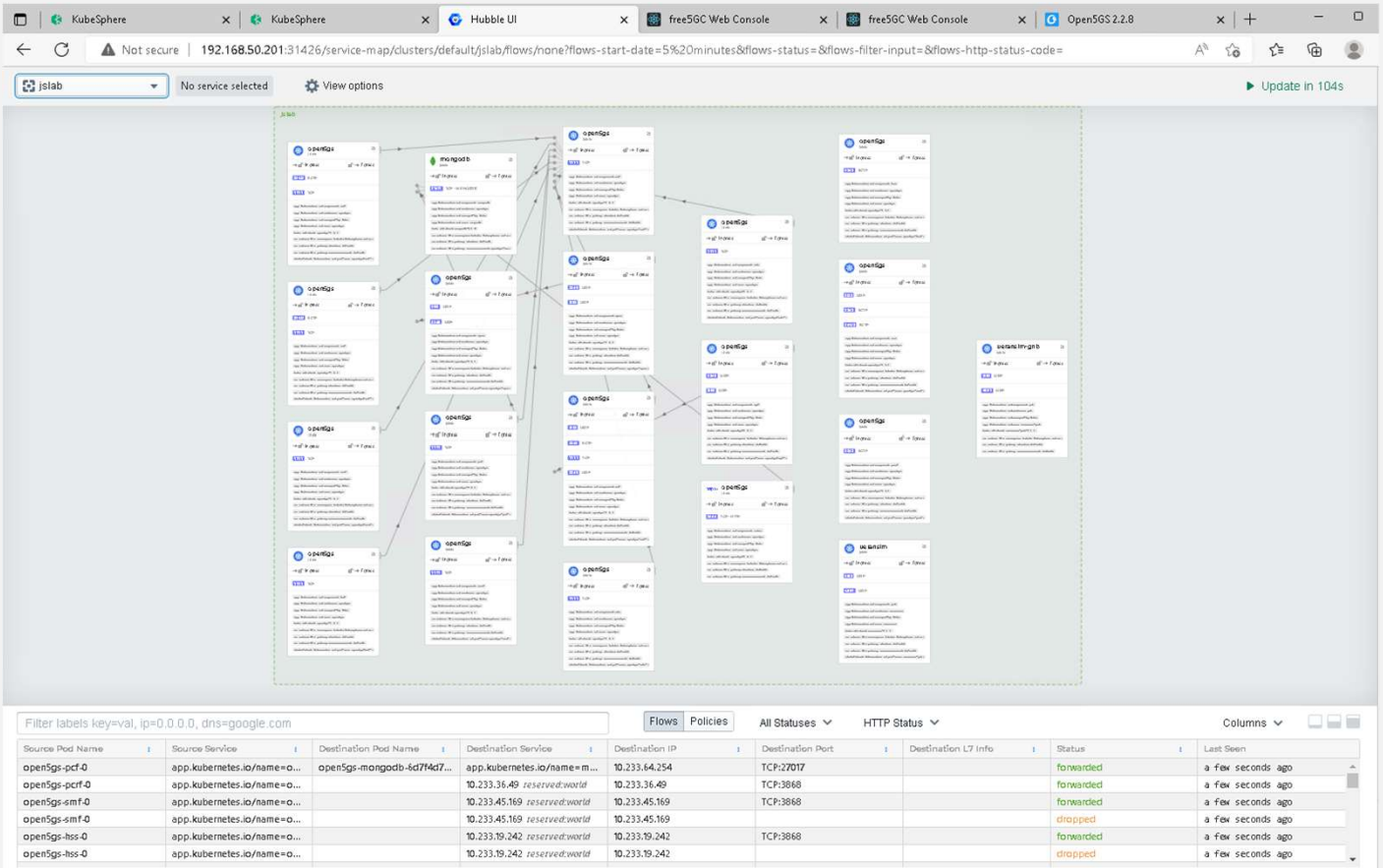
❖ Install gtp5g kernel module(선택 참고)

1. uname -r
2. ### git clone https://github.com/free5gc/gtp5g.git
3. ### git clone -b v0.3.1 https://github.com/free5gc/gtp5g.git
4. git clone https://github.com/PrinzOwO/gtp5g.git
5. cd gtp5g
6. make
7. sudo make install
8. helm -n <namespace> install <free5GC-release-name> ./free5gc/
9. kubectl -n <namespace> get pods -l "project=free5gc“
10. helm -n <namespace> install <UERANSIM-release-name> ./ueransim/
11. kubectl -n <namespace> get pods -l "app=ueransim“
12. kubectl -n <namespace> exec -it <ue-pod-name> -- bash

Source: https://github.com/Orange-OpenSource/towards5gs-helm/blob/main/docs/demo/Setup-free5gc-and-test-with-UERANSIM.md

BACKUP

❖ Cloud Native @ KubeSphere



BACKUP

- Bash 쉘로 만들어진 프로그램(스크립트)
- 스크립트를 만들기 위해서는 쉘 내부 지시자를 사용해야 하는데 그러기 위해서는 맨 첫줄에 #! 로 시작하는 매직 코드(magic code)가 필요

❖ Run UE connectivity test by running these commands

1. export POD_NAME=$(kubectl get pods --namespace jslab5gs -l "component=ues" -o jsonpath="{.items[0].metadata.name}")
2. kubectl --namespace jslab5gs logs $POD_NAME
3. kubectl --namespace jslab5gs exec -it $POD_NAME -- ip address
4. kubectl --namespace jslab5gs exec -it $POD_NAME -- ping -I uesimtun0 www.google.com
5. kubectl --namespace jslab5gs exec -it $POD_NAME -- curl --interface uesimtun0 www.google.com
6. kubectl --namespace jslab5gs exec -it $POD_NAME -- traceroute -i uesimtun0 www.google.com

BACKUP

❖ Deploying 5G core network (예: Free5GC @ Kubernetes and Helm)

```
root@5g:~# helm show values towards5gs/free5gc
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2021 Orange
# SPDX-License-Identifier: Apache-2.0
#
# This software is distributed under the Apache License 2.0,
# the text of which is available at todo
# or see the "LICENSE" file for more details.
#
# Author: Abderaouf KHICHANE, Ilhem FAJJARI, Ayoub BOUSSELMI
# Software description: An open-source project providing Helm charts to deploy 5G components
#(Core + RAN) on top of Kubernetes
#
# Default values for free5gc-chart.
# This is a YAML-formatted file.
# Declare variables to be passed into your templates.

global:
  name: free5gc
  userPlaneArchitecture: single  # possible values are "single" and "ulcl"
  nrf:
    service:
      name: nrf-nnrf
      type: ClusterIP
      port: "8000"
      nodePort: "30800"
  sbi:
    scheme: http
```

```
amf:
   n2if:  # NGAP
     ipAddress: 10.100.50.249
   service:
     ngap:
       enabled: false
       name: amf-n2
       port: 38412
       nodeport: 31412
       protocol: SCTP
       type: NodePort
 smf:
   n4if:
     ipAddress: 10.100.50.244
 #Global network parametes
 n2network:
   name: n2network
   masterIf: eth0
   subnetIP: 10.100.50.248
   cidr: 29
   gatewayIP: 10.100.50.254
   excludeIP: 10.100.50.254
 n3network:
   name: n3network
   masterIf: eth0
   subnetIP: 10.100.50.232
   cidr: 29
   gatewayIP: 10.100.50.238
   excludeIP: 10.100.50.238
 n4network:
   name: n4network
   masterIf: eth0
   subnetIP: 10.100.50.240
   cidr: 29
   gatewayIP: 10.100.50.246
   excludeIP: 10.100.50.246
```

```
   n6network:
     name: n6network
     masterIf: eth1
     subnetIP: 10.100.100.0
     cidr: 24
     gatewayIP: 10.100.100.1
     excludeIP: 10.100.100.254
   n9network:
     name: n9network
     masterIf: eth0
     subnetIP: 10.100.50.224
     cidr: 29
     gatewayIP: 10.100.50.230
     excludeIP: 10.100.50.230


 # These parameters can be used to
 enable/disable deployment of subcharts
 deployMongoDB: true
 deployAMF: true
 deployAUSF: true
 deployN3IWF: false
 deployNRF: true
 deployNSSF: true
 deployPCF: true
 deploySMF: true
 deployUDM: true
 deployUDR: true
 deployUPF: true
 deployWEBUI: true
```

```
# Disable the deployment of mongodb as an NRF
subchart
free5gc-nrf:
  db:
    enabled: false

# This section can be used to override the
default values in the MongoDB chart (remember
MongoDB is a subchart of the
free5gcControlplane chart since control plane
NFs rely on it.
mongodb:
  fullnameOverride: "mongodb"
  useStatefulSet: true
  auth:
    enabled: false
  persistence:
    size: 6Gi
    mountPath: /bitnami/mongodb/data/db/
  service:
    name: mongodb
    type: ClusterIP
    port: 27017
    nodePort: "30017"
```

Note: https://helm.sh/docs/intro/using_helm/

BACKUP

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm

- helm show values towards5gs/ueransim

```
root@5g:~# helm show values towards5gs/ueransim
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2021 Orange
# SPDX-License-Identifier: Apache
#
# This software is distributed un
# the text of which is available
# or see the "LICENSE" file for m
#
# Author: Abderaouf KHICHANE, Ilh
# Software description: An open-s
#
# Default values for ueransim-cha
# This is a YAML-formatted file.
# Declare variables to be passed

global:
  multiCluster: false
  #Global network parametes
  n2network:
    name: n2network
    masterIf: eth0
    subnetIP: 10.100.50.248
    cidr: 29
    gatewayIP: 10.100.50.254
    excludeIP: 10.100.50.254
  n3network:
    name: n3network
    masterIf: eth0
    subnetIP: 10.100.50.232
    cidr: 29
    gatewayIP: 10.100.50.238
    excludeIP: 10.100.50.238
```

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

```
projectName: ueransim

gnb:
  enabled: true
  name: gnb
  replicaCount: 1
  image:
    name: towards5gs/ueransim-gnb
    pullPolicy: IfNotPresent
  configmap:
    name: gnb-configmap
  volume:
    name: gnb-volume
    mount: /ueransim/config
  service:
    name: gnb-service
    type: ClusterIP
    port: 4997
    protocol: UDP

  n2if:  # NGAP
    ipAddress: 10.100.50.250
  n3if:  # GTP-U
    ipAddress: 10.100.50.236

amf:
  n2if:  # NGAP
    ipAddress: 10.100.50.249
    port: 38412
  service:
    ngap:
      enabled: false  # if true set gnb.amf.n2if.ipAddress to the
name of AMF NGAP service or the IP of the cluster hosting the AMF
```

```
  podAnnotations: {}
    # additional annotations
  imagePullSecrets: []
  podSecurityContext: {}
  resources:
    limits:
      cpu: 250m
      memory: 256Mi
    requests:
      cpu: 250m
      memory: 256Mi
  nodeSelector: {}
  tolerations: []
  affinity: {}

  configuration: |-
    mcc: '208' # Mobile Country Code value
    mnc: '93'  # Mobile Network Code value (2 or
    nci: '0x000000010'  # NR Cell Identity (36-bi
    idLength: 32        # NR gNB ID length in bit
    tac: 1      # Tracking Area Code
    # List of supported S-NSSAIs by this gNB
    slices:
      - sst: 0x1
        sd: 0x010203
    # Indicates whether or not SCTP stream number
should be ignored.
    ignoreStreamIds: true
```

```
ue:
  enabled: true
  name: ue
  replicaCount: 1
  image:
    name: towards5gs/ueransim-ue
    pullPolicy: IfNotPresent
  configmap:
    name: ue-configmap
  volume:
    name: ue-volume
    mount: /ueransim/config
  command: "./nr-ue -c ../config/ue
config.yaml"  # This is the command
will be launched in the UE containe
  # A script that will be run after
UE creation. It may be used to
periodically generate traffic
  script: ""
  # script: |-
  #   ping .....

  podAnnotations: {}
    # additional annotations
  imagePullSecrets: []
  podSecurityContext: {}
  securityContext:
    capabilities:
      add: ["NET_ADMIN"]
  resources:
    limits:
      cpu: 120m
      memory: 128Mi
    requests:
      cpu: 120m
      memory: 128Mi
  nodeSelector: {}
  tolerations: []
  affinity: {}
```

```
  configuration: |-
    supi: "imsi-208930000000003"  # IMSI number
    mcc: '208' # Mobile Country Code value
    mnc: '93' # Mobile Network Code value (2 or 3 digits)
    key: "8baf473f2f8fd09487cccbd7097c6862" # Operator code
(OP or OPC) of the UE
    op: "8e27b6af0e692e750f32667a3b14605d" # This value
specifies the OP type and it can be either 'OP' or 'OPC'
    opType: "OPC" # This value specifies the OP type and it
can be either 'OP' or 'OPC'
    amf: '8000' # Authentication Management Field (AMF) value
    imei: '356938035643803' # IMEI number of
    imeiSv: '4370816125816151'
    # UAC Access Identities Configuration
    uacAic:
      mps: false
      mcs: false
    # UAC Access Control Class
    uacAcc:
      normalClass: 0
      class11: false
      class12: false
      class13: false
      class14: false
      class15: false
    sessions:
      - type: "IPv4"
        apn: "internet"
        slice:
          sst: 0x01
          sd: 0x010203
    # Configured NSSAI for this UE by HPLMN
    configured-nssai:
      - sst: 0x01
        sd: 0x010203
    # Default Configured NSSAI for this UE
    default-nssai:
      - sst: 1
        sd: 1
```

```
    # Supported encryption and integrity
algorithms by this UE
    integrity:
      IA1: true
      IA2: true
      IA3: true
    ciphering:
      EA1: true
      EA2: true
      EA3: true
    # Integrity protection maximum data
rate for user plane
    integrityMaxRate:
      uplink: 'full'
      downlink: 'full'

  test:
    connectivity:
      name: ue-connectivity-test
      image: bitnami/kubectl:1.22.0
      configmap:
        name: connectivity-test-
configmap
      volume:
        name: connectivity-test-volume
        mount: /scripts
      ttlseconds: 50
```

BACKUP

❖ **K8s Operations** (as root)

- sudo kubectl get pods --all-namespaces

```
root@kubesphere:~/multus-cni# sudo kubectl get pods --all-namespaces
root@jslab:~/multus-cni# sudo kubectl get pods --all-namespaces
NAMESPACE                      NAME                                              READY   STATUS             RESTARTS          AGE
jslab5gc                       jslab5gc-v1-free5gc-amf-amf-5c548c9dcc-q9mzg      1/1     Running            0                 30m
jslab5gc                       jslab5gc-v1-free5gc-ausf-ausf-5774d545f9-xflmm    1/1     Running            0                 30m
jslab5gc                       jslab5gc-v1-free5gc-nrf-nrf-7f4bb4f796-l6r24      1/1     Running            0                 30m
jslab5gc                       jslab5gc-v1-free5gc-nssf-nssf-6d97bfd6f6-zhp7w    1/1     Running            0                 30m
jslab5gc                       jslab5gc-v1-free5gc-pcf-pcf-766878b98f-2svgc      1/1     Running            0                 30m
jslab5gc                       jslab5gc-v1-free5gc-smf-smf-6fbb8f4ccb-tbkcd      1/1     Running            0                 30m
jslab5gc                       jslab5gc-v1-free5gc-udm-udm-85fd6854b5-ncqc6      1/1     Running            0                 30m
jslab5gc                       jslab5gc-v1-free5gc-udr-udr-6bb6fc4b57-ltm48      1/1     Running            0                 30m
jslab5gc                       jslab5gc-v1-free5gc-upf-upf-54d8dbd786-bgmpw      0/1     Pending            0                 5m57s
jslab5gc                       jslab5gc-v1-free5gc-upf-upf-75655bdfcf-9smsw      0/1     CrashLoopBackOff   6 (101s ago)      30m
jslab5gc                       jslab5gc-v1-free5gc-webui-webui-76645cbfd8-ww8ld  1/1     Running            0                 30m
jslab5gc                       mongodb-0                                         1/1     Running            0                 30m
jslab5gc                       ueransim-free5gc-gnb-84d66db87d-j5v88             0/1     Pending            0                 2m55s
jslab5gc                       ueransim-free5gc-ue-84f88486c7-2tlrt              0/1     Pending            0                 2m55s
kube-system                    calico-kube-controllers-69d878584c-q86k8          1/1     Running            1 (2d23h ago)     3d
kube-system                    calico-node-4gdz4                                 1/1     Running            1 (2d23h ago)     3d
kube-system                    coredns-b5648d655-h4ckb                           1/1     Running            1 (2d23h ago)     3d
kube-system                    coredns-b5648d655-jqhjn                           1/1     Running            1 (2d23h ago)     3d
kube-system                    kube-apiserver-jslab                              1/1     Running            1 (2d23h ago)     3d
kube-system                    kube-controller-manager-jslab                     1/1     Running            1 (2d23h ago)     3d
kube-system                    kube-multus-ds-rj29r                              1/1     Running            0                 47m
kube-system                    kube-proxy-kwz4h                                  1/1     Running            1 (2d23h ago)     3d
kube-system                    kube-scheduler-jslab                              1/1     Running            1 (2d23h ago)     3d
kube-system                    nodelocaldns-n2ckt                                1/1     Running            1 (2d23h ago)     3d
kube-system                    openebs-localpv-provisioner-57bbf864d5-mncss      1/1     Running            1 (2d23h ago)     3d
kube-system                    snapshot-controller-0                             1/1     Running            1 (2d23h ago)     3d
kubesphere-controls-system     default-http-backend-5bf68ff9b8-tjc2v             1/1     Running            1 (2d23h ago)     3d
kubesphere-controls-system     kubectl-admin-6dbcb94855-fljcj                    1/1     Running            1 (2d23h ago)     3d
kubesphere-monitoring-system   alertmanager-main-0                               2/2     Running            2 (2d23h ago)     3d
kubesphere-monitoring-system   kube-state-metrics-687d66b747-jspd9               3/3     Running            3 (2d23h ago)     3d
kubesphere-monitoring-system   node-exporter-gpwrf                               2/2     Running            2 (2d23h ago)     3d
kubesphere-monitoring-system   notification-manager-deployment-78664576cb-ntdhn  2/2     Running            2 (2d23h ago)     3d
kubesphere-monitoring-system   notification-manager-operator-7d44854f54-4qp9h    2/2     Running            2 (2d23h ago)     3d
kubesphere-monitoring-system   prometheus-k8s-0                                  2/2     Running            2 (2d23h ago)     3d
kubesphere-monitoring-system   prometheus-operator-8955bbd98-hpgwn               2/2     Running            2 (2d23h ago)     3d
kubesphere-system              ks-apiserver-6cd95fb98f-b8qkj                     1/1     Running            1 (2d23h ago)     3d
kubesphere-system              ks-console-7d9857b6c-wpzzl                        1/1     Running            1 (2d23h ago)     3d
kubesphere-system              ks-controller-manager-5958b94c9c-5gr74            1/1     Running            1 (2d23h ago)     3d
kubesphere-system              ks-installer-64f89fdb56-g6jkt                     1/1     Running            1 (2d23h ago)     3d
```

BACKUP

- kubectl exec -it -n free5gc free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb -- ip a
- kubectl exec -it -n free5gc free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfnr -- ip a

```
jslab@jslab:~$ kubectl get pods -n free5gc
NAME                                        READY   STATU
free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb 1/1     Runni
free5gc-v1-free5gc-ausf-ausf-6fd5b5f6d-fp9c7 1/1     Runni
free5gc-v1-free5gc-nrf-nrf-5664d64868-rp8tn 1/1     Runni
free5gc-v1-free5gc-nssf-nssf-6c5658c97f-w8c48 1/1     Runni
free5gc-v1-free5gc-pcf-pcf-7c4bb7d9b-n2wxc 1/1     Runni
free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfnr 1/1     Runni
free5gc-v1-free5gc-udm-udm-7c9b4dbd5f-wsfz7 1/1     Runni
free5gc-v1-free5gc-udr-udr-fcdfdfb7d-625tz 1/1     Runni
free5gc-v1-free5gc-upf-upf-57c686dd86-tf6jj 0/1     Conta
free5gc-v1-free5gc-webui-webui-76db6dbdc7-vfckq 1/1     Runni
mongodb-0                                   1/1     Runni
ueransim-v1-gnb-6cdbcff47b-rq7nq            1/1     Runni
ueransim-v1-ue-d6b68575-mpzk7               1/1     Runni
jslab@jslab:~$
```

```
jslab@jslab:~$ kubectl exec -it -n free5gc free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb -- ip a
Defaulted container "amf" out of: amf, wait-nrf (init)
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
2: tunl0@NONE: <NOARP> mtu 1480 qdisc noop state DOWN qlen 1000
    link/ipip 0.0.0.0 brd 0.0.0.0
4: eth0@if27: <BROADCAST,MULTICAST,UP,LOWER_UP,M-DOWN> mtu 1480 qdisc noqueue state UP
    link/ether 66:55:1f:4d:53:e7 brd ff:ff:ff:ff:ff:ff
    inet 10.244.120.76/32 brd 10.244.120.76 scope global eth0
       valid_lft forever preferred_lft forever
5: n2@if9: <BROADCAST,MULTICAST,UP,LOWER_UP,M-DOWN> mtu 1500 qdisc noqueue state UP
    link/ether da:2d:b3:cd:72:06 brd ff:ff:ff:ff:ff:ff
    inet 10.100.50.249/29 brd 10.100.50.255 scope global n2
       valid_lft forever preferred_lft forever
```

BACKUP

- kubectl exec -it -n free5gc free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb -- ip a
- kubectl exec -it -n free5gc free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfnr -- ip a

```
jslab@jslab:~$ kubectl get pods -n free5gc
NAME                                          READY   STATU
free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb   1/1     Runni
free5gc-v1-free5gc-ausf-ausf-6fd5b5f6d-fp9c7  1/1     Runni
free5gc-v1-free5gc-nrf-nrf-5664d64868-rp8tn   1/1     Runni
free5gc-v1-free5gc-nssf-nssf-6c5658c97f-w8c48 1/1     Runni
free5gc-v1-free5gc-pcf-pcf-7c4bb7d9b-n2wxc    1/1     Runni
free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfnr   1/1     Runni
free5gc-v1-free5gc-udm-udm-7c9b4dbd5f-wsfz7   1/1     Runni
free5gc-v1-free5gc-udr-udr-fcdfdfb7d-625tz    1/1     Runni
free5gc-v1-free5gc-upf-upf-57c686dd86-tf6jj   0/1     Conta
free5gc-v1-free5gc-webui-webui-76db6dbdc7-vfckq 1/1   Runni
mongodb-0                                     1/1     Runni
ueransim-v1-gnb-6cdbcff47b-rq7nq              1/1     Runni
ueransim-v1-ue-d6b68575-mpzk7                 1/1     Runni
jslab@jslab:~$
```

```
jslab@jslab:~$ kubectl exec -it -n free5gc free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfnr -- ip a
Defaulted container "smf" out of: smf, wait-nrf (init)
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
2: tunl0@NONE: <NOARP> mtu 1480 qdisc noop state DOWN qlen 1000
    link/ipip 0.0.0.0 brd 0.0.0.0
4: eth0@if23: <BROADCAST,MULTICAST,UP,LOWER_UP,M-DOWN> mtu 1480 qdisc noqueue state UP
    link/ether ae:70:a2:48:c8:9b brd ff:ff:ff:ff:ff:ff
    inet 10.244.120.72/32 brd 10.244.120.72 scope global eth0
       valid_lft forever preferred_lft forever
5: n4@if9: <BROADCAST,MULTICAST,UP,LOWER_UP,M-DOWN> mtu 1500 qdisc noqueue state UP
    link/ether ea:b9:25:4f:da:76 brd ff:ff:ff:ff:ff:ff
    inet 10.100.50.244/29 brd 10.100.50.247 scope global n4
       valid_lft forever preferred_lft forever
```

BACKUP

- kubectl exec -it -n free5gc free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb -- ip a
- kubectl exec -it -n free5gc free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfnr -- ip a
- **kubectl exec -it -n free5gc free5gc-v1-free5gc-udr-udr-fcdfdfb7d-625tz -- ip a**

```
jslab@jslab:~$ kubectl get pods -n free5gc
NAME                                        READY   STATU
free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb       1/1     Runni
free5gc-v1-free5gc-ausf-ausf-6fd5b5f6d-fp9c7      1/1     Runni
free5gc-v1-free5gc-nrf-nrf-5664d64868-rp8tn       1/1     Runni
free5gc-v1-free5gc-nssf-nssf-6c5658c97f-w8c48     1/1     Runni
free5gc-v1-free5gc-pcf-pcf-7c4bb7d9b-n2wxc        1/1     Runni
free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfnr       1/1     Runni
free5gc-v1-free5gc-udm-udm-7c9b4dbd5f-wsfz7       1/1     Runni
free5gc-v1-free5gc-udr-udr-fcdfdfb7d-625tz        1/1     Runni
free5gc-v1-free5gc-upf-upf-57c686dd86-tf6jj       0/1     Conta
free5gc-v1-free5gc-webui-webui-76db6dbdc7-vfckq   1/1     Runni
mongodb-0                                         1/1     Runni
ueransim-v1-gnb-6cdbcff47b-rq7nq                  1/1     Runni
ueransim-v1-ue-d6b68575-mpzk7                     1/1     Runni
jslab@jslab:~$
```

```
Jslab@jslab:~$ kubectl exec -it -n free5gc free5gc-v1-free5gc-udr-udr-fcdfdfb7d-625tz -- ip a
Defaulted container "udr" out of: udr, wait-nrf (init)
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
2: tunl0@NONE: <NOARP> mtu 1480 qdisc noop state DOWN qlen 1000
    link/ipip 0.0.0.0 brd 0.0.0.0
4: eth0@if24: <BROADCAST,MULTICAST,UP,LOWER_UP,M-DOWN> mtu 1480 qdisc noqueue state UP
    link/ether 0e:54:63:65:e8:50 brd ff:ff:ff:ff:ff:ff
    inet 10.244.120.73/32 brd 10.244.120.73 scope global eth0
       valid_lft forever preferred_lft forever
```

BACKUP

❖ Deploying 5G core network with open5GS, Kubernetes and Helm

1. helm repo add openverso https://gradiant.github.io/openverso-charts/
2. sudo kubectl create namespace jslab
3. helm repo update
4. helm repo list

KubeSphere Dashboard 확인
'project'

```
root@5g:~# helm repo add openverso https://gradiant.github.io/openverso-charts/
"openverso" has been added to your repositories
root@5g:~# sudo kubectl create namespace jslab
namespace/jslab created
root@5g:~# helm repo update
Hang tight while we grab the latest from your chart repositories...
...Unable to get an update from the "towards5gs" chart repository
(https://raw.githubusercontent.com/Orange-OpenSource/towards5gs-helm/main/repo/):
        Get "https://raw.githubusercontent.com/Orange-OpenSource/towards5gs-helm/main/repo/index.yaml":
dial tcp: lookup raw.githubusercontent.com on 127.0.0.53:53: read udp 127.0.0.1:52728->127.0.0.53:53:
i/o timeout
...Successfully got an update from the "openverso" chart repository
Update Complete. ⎈Happy Helming!⎈
root@5g:~# helm repo list
NAME            URL
towards5gs      https://raw.githubusercontent.com/Orange-OpenSource/towards5gs-helm/main/repo/
openverso       https://gradiant.github.io/openverso-charts/
```

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

Source: https://github.com/Gradiant/openverso-charts
Source: https://levelup.gitconnected.com/opensource-5g-core-with-service-mesh-bba4ded044fa (Reference for Service Mesh Test)

BACKUP

❖ Deploying 5G core network with open5GS, Kubernetes and Helm

5. helm search repo
6. sudo helm -n jslab install open5gs openverso/open5gs
7. helm -n jslab uninstall open5gs

```
root@5g:~# helm search repo
NAME                                    CHART VERSION   APP VERSION     DESCRIPTION
openverso/iperf3                        0.1.2           1.0.0           iPerf3 is a tool for active measurements of the...
openverso/oai-enb                       0.1.0           1.2.2           OpenAirInterface enodeb
openverso/oai-gnb                       0.3.1           2021.w32        description
openverso/open5gs                       0.5.0           2.4.4           Helm chart to deploy Open5gs services on Kubern...
openverso/srs-enb                       0.1.1           20.10.1         SRS enodeb
openverso/srs-epc                       0.1.0           20.10.1         SRS epc
openverso/srs-lte                       0.1.1           20.04.1         SRSLte enodeb + ue.
openverso/srs-ue                        0.1.1           20.10.1         SRS ue
openverso/ueransim                      0.2.1           3.2.6           ueransim for 5G RAN simulation
openverso/ueransim-gnb                  0.2.0           3.2.6           ueransim gNodeB for 5G RAN simulation
towards5gs/free5gc                      1.1.2           v3.1.1          A Helm chart to deploy Free5gc
towards5gs/free5gc-amf                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-ausf                 0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-n3iwf                0.2.1           v3.1.1          A Helm c
towards5gs/free5gc-nrf                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-nssf                 0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-pcf                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-smf                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-udm                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-udr                  0.2.2           v3.1.1          A Helm c
towards5gs/free5gc-upf                  0.2.1           v3.1.1          A Helm c
towards5gs/free5gc-webui                0.1.2           v3.1.1          A Helm c
towards5gs/free5gcControlPlane          0.1.2           v3.0.5          DEPRECAT
towards5gs/free5gcN3iwf                 0.1.2           v3.0.5          DEPRECAT
towards5gs/free5gcUserPlane             0.1.2           v3.0.5          DEPRECAT
towards5gs/networks5g                   0.1.2           0.1.2           DEPRECAT
towards5gs/ueransim                     2.0.14          v3.2.6          A Helm chart to deploy UERANSIM
root@5g:~#
```

```
root@5g:~# helm search repo
NAME                            CHART VERSION   APP VERSION     DESCRIPTION
openverso/iperf3                0.1.2           1.0.0           iPerf3 is a tool for active measurements of the...
openverso/oai-enb               0.1.0           1.2.2           OpenAirInterface enodeb
openverso/oai-gnb               0.3.1           2021.w32        description
openverso/open5gs               0.5.0           2.4.4           Helm chart to deploy Open5gs services on Kubern...
openverso/srs-enb               0.1.1           20.10.1         SRS enodeb
openverso/srs-epc               0.1.0           20.10.1         SRS epc
openverso/srs-lte               0.1.1           20.04.1         SRSLte enodeb + ue.
openverso/srs-ue                0.1.1           20.10.1         SRS ue
openverso/ueransim              0.2.1           3.2.6           ueransim for 5G RAN simulation
openverso/ueransim-gnb          0.2.0           3.2.6           ueransim gNodeB for 5G RAN simulation
```

BACKUP

❖ Deploying 5G core network with open5GS, Kubernetes and Helm

5. helm search repo
6. sudo helm -n jslab install open5gs openverso/open5gs
7. sudo helm -n jslab install ueransim openverso/ueransim
8. sudo helm -n jslab install gnb openverso/ueransim-gnb
9. helm -n jslab uninstall open5gs

KubeSphere Dashboard 확인
'pod'

```
root@5g:~# sudo helm -n jslab install open5gs openverso/open5gs
NAME: open5gs
LAST DEPLOYED: Sun Jul 10 12:11:56 2022
NAMESPACE: jslab
STATUS: deployed
REVISION: 1
TEST SUITE: None
NOTES:
You have deployed open5gs 5G core services:
** 5G AMF Service **
Internal Access:
For services running at the same k8s namespace, AMF IP can be resolved at `open5gs-amf`.
You can also get the AMF clusterIP with:
```
kubectl get svc -n jslab open5gs-amf -o jsonpath='{.spec.clusterIP}')
```
---
External IP Access to this AMF service was not enabled (check amf.externalService.enabled).
---
** MME **
Internal Access:
For services running at the same k8s namespace, MME IP can be resolved at `open5gs-mme`.
You can also get the MME clusterIP with:
```
kubectl get svc -n jslab open5gs-mme -o jsonpath='{.spec.clusterIP}')
```
---
External IP Access to this MME service was not enabled (check mme.externalService.enabled).
---
** WEBUI **
Access Open5gs web ui at:
  http://open5gs-jslab.ingress.lab5g.gradiant.org
With user: "admin" and password "1423"
```

Source: https://helm.sh/ko/

BACKUP

❖ Kubernetes Operations

- **kubectl get svc -A**

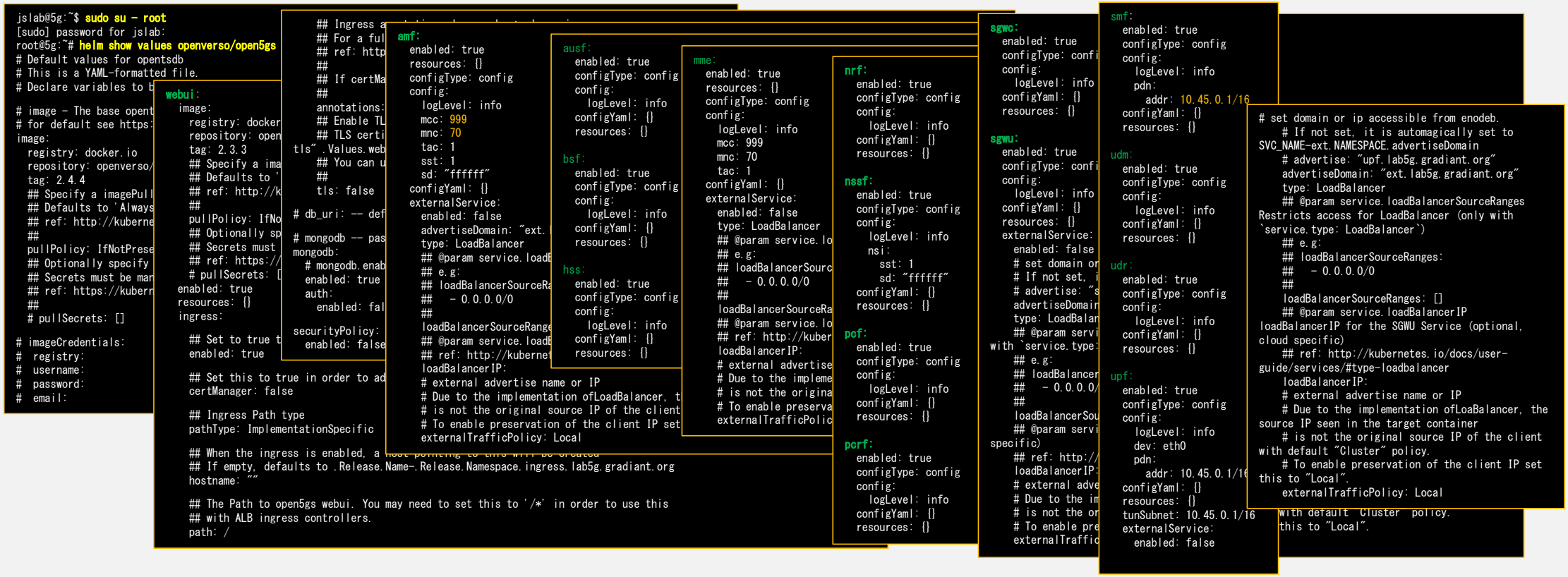
```
root@node1:~/multus-cni# kubectl get svc -A
NAMESPACE     NAME                TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)                                 AGE
default       deathstar           ClusterIP   10.233.21.159   <none>        80/TCP                                  13d
default       kubernetes          ClusterIP   10.233.0.1      <none>        443/TCP                                 13d
jslab         gnb-ueransim-gnb    ClusterIP   None            <none>        4997/UDP,2152/UDP                       6d21h
jslab         open5gs-amf         ClusterIP   10.233.29.253   <none>        7777/TCP,38412/SCTP                     7d1h
jslab         open5gs-ausf        ClusterIP   10.233.51.236   <none>        7777/TCP                                7d1h
jslab         open5gs-bsf         ClusterIP   10.233.33.243   <none>        7777/TCP                                7d1h
jslab         open5gs-hss         ClusterIP   10.233.5.68     <none>        3868/SCTP                               7d1h
jslab         open5gs-mme         ClusterIP   10.233.19.242   <none>        36412/SCTP,3868/SCTP,2123/UDP           7d1h
jslab         open5gs-mongodb     ClusterIP   10.233.29.173   <none>        27017/TCP                               7d1h
jslab         open5gs-nrf         ClusterIP   10.233.62.190   <none>        7777/TCP                                7d1h
jslab         open5gs-nssf        ClusterIP   10.233.60.110   <none>        7777/TCP                                7d1h
jslab         open5gs-pcf         ClusterIP   10.233.32.80    <none>        7777/TCP                                7d1h
jslab         open5gs-pcrf        ClusterIP   10.233.45.169   <none>        3868/SCTP                               7d1h
jslab         open5gs-sgwc        ClusterIP   10.233.18.209   <none>        2123/UDP,8805/UDP                       7d1h
jslab         open5gs-sgwu        ClusterIP   10.233.46.237   <none>        2152/UDP,8805/UDP                       7d1h
jslab         open5gs-smf         ClusterIP   10.233.36.49    <none>        2123/UDP,8805/UDP,3868/SCTP,7777/TCP    7d1h
jslab         open5gs-udm         ClusterIP   10.233.6.211    <none>        7777/TCP                                7d1h
jslab         open5gs-udr         ClusterIP   10.233.40.1     <none>        7777/TCP                                7d1h
jslab         open5gs-upf         ClusterIP   10.233.43.230   <none>        2152/UDP,8805/UDP                       7d1h
jslab         open5gs-webui       ClusterIP   10.233.42.148   <none>        3000/TCP                                7d1h
jslab         ueransim-gnb        ClusterIP   None            <none>        4997/UDP,2152/UDP                       6d21h
jslab5gc      amf-namf            ClusterIP   10.233.35.85    <none>        80/TCP                                  7m5s
jslab5gc      ausf-nausf          ClusterIP   10.233.63.94    <none>        80/TCP                                  7m5s
jslab5gc      gnb-service         ClusterIP   10.233.27.76    <none>        4997/UDP                                63s
jslab5gc      mongodb             ClusterIP   10.233.7.86     <none>        27017/TCP                               7m5s
jslab5gc      nrf-nnrf            ClusterIP   10.233.43.245   <none>        8000/TCP                                7m5s
jslab5gc      nssf-nnssf          ClusterIP   10.233.9.116    <none>        80/TCP                                  7m5s
jslab5gc      pcf-npcf            ClusterIP   10.233.37.62    <none>        80/TCP                                  7m5s
jslab5gc      smf-nsmf            ClusterIP   10.233.14.19    <none>        80/TCP                                  7m5s
jslab5gc      udm-nudm            ClusterIP   10.233.47.99    <none>        80/TCP                                  7m5s
jslab5gc      udr-nudr            ClusterIP   10.233.20.3     <none>        80/TCP                                  7m5s
jslab5gc      webui-service       NodePort    10.233.20.18    <none>        5000:30500/TCP                          7m5s
```

KubeSphere Dashboard 확인
'service'

BACKUP

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm (참고)

- helm show values openverso/open5gs



BACKUP

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm (참고)

- helm show values openverso/ueransim-gnb

```
root@5g:~# helm show values openverso/ueransim-gnb
## @section Global parameters
## Global Docker image parameters
## Please, note that this will override the image parameters, including dependencies, configured to use the global value
## Current available global Docker image parameters: imageRegistry, imagePullSecrets and storageClass

## @param global.imageRegistry Global Docker image registry
## @param global.imagePullSecrets Global Docker registry se
## @param global.storageClass Global StorageClass for Persi
##
global:
  imageRegistry:
  ## E.g.
  ## imagePullSecrets:
  ##   - myRegistryKeySecretName
  ##
  imagePullSecrets: []
  storageClass:

## @section Common parameters

## @param kubeVersion Override Kubernetes version
##
kubeVersion:
## @param nameOverride String to partially override common.
##
nameOverride:
## @param fullnameOverride String to fully override common.
##
fullnameOverride:
## @param commonLabels Labels to add to all deployed objects
```

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

```
##
commonLabels: {}
## @param commonAnnotations Annotations to add to all deployed
objects
##
commonAnnotations: {}
## @param clusterDomain Kubernetes cluster domain name
##
clusterDomain: cluster.local
## @param extraDeploy Array of extra objects to deploy with the
release
##
extraDeploy: []

image:
  registry: docker.io
  repository: openverso/ueransim
  tag: 3.2.6
  ## Specify a imagePullPolicy
  ## Defaults to 'Always' if image tag is 'latest', else set to
'IfNotPresent'
  ## ref: http://kubernetes.io/docs/user-guide/images/#pre-pull
images
  ##
  pullPolicy: Always
  ## Optionally specify an array of imagePullSecrets.
  ## Secrets must be manually created in the namespace.
  ## ref: https://kubernetes.io/docs/tasks/
```

```
configure-pod-container/pull-image-private-registry/
  ## e.g:
  ## pullSecrets:
  ##   - myRegistryKeySecretName
  ##
  pullSecrets: []
  ## Enable debug mode
  ##
  debug: false

name: ueransim-gnb
amf:
  # if set amf.ip takes precedence over amf.hostname
  ip:
  hostname: open5gs-amf
interfaces:
  n2:
    dev: eth0
  n3:
    dev: eth0
  radio:
    dev: eth0
mcc: '999'
mnc: '70'
sst: 1
sd: "0xffffff"
tac: '0001'
```

```
resources:
  limits: {}
  requests: {}
podSecurityContext:
  enabled: false
containerSecurityContext:
  enabled: false
podLabels: {}
podAnnotations: {}
affinity: {}
nodeSelector: {}
tolerations: []

ues:
  enabled: false
  count: 1
  initialMSISDN: '0000000001'
  key: 465B5CE8B199B49FAA5F0A2EE238A6BC
  op: E8ED289DEBA952E4283B54E88E6183CA
  opType: OPC
  apn: internet
  resources:
    limits: {}
    requests: {}
  podSecurityContext:
    enabled: false
  containerSecurityContext:
    enabled: false
  podLabels: {}
  podAnnotations: {}
  affinity: {}
  nodeSelector: {}
  tolerations: []

50.238
```

BACKUP

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm (참고)

- helm show values openverso/ueransim

```
root@5g:~# helm show values towards5gs/ueransim
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2021 Orange
# SPDX-License-Identifier: Apache-2.0
#
# This software is distributed und
# the text of which is available a
# or see the "LICENSE" file for mo
#
# Author: Abderaouf KHICHANE, Ilhe
# Software description: An open-so
#
# Default values for ueransim-char
# This is a YAML-formatted file.
# Declare variables to be passed i

global:
  multiCluster: false
  #Global network parametes
  n2network:
    name: n2network
    masterIf: eth0
    subnetIP: 10.100.50.248
    cidr: 29
    gatewayIP: 10.100.50.254
    excludeIP: 10.100.50.254
  n3network:
    name: n3network
    masterIf: eth0
    subnetIP: 10.100.50.232
    cidr: 29
    gatewayIP: 10.100.50.238
    excludeIP: 10.100.50.238
```

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

```
projectName: ueransim

gnb:
  enabled: true
  name: gnb
  replicaCount: 1
  image:
    name: towards5gs/ueransim-gnb
    pullPolicy: IfNotPresent
  configmap:
    name: gnb-configmap
  volume:
    name: gnb-volume
    mount: /ueransim/config
  service:
    name: gnb-service
    type: ClusterIP
    port: 4997
    protocol: UDP

  n2if:  # NGAP
    ipAddress: 10.100.50.250
  n3if:  # GTP-U
    ipAddress: 10.100.50.236

amf:
  n2if:  # NGAP
    ipAddress: 10.100.50.249
    port: 38412
  service:
    ngap:
      enabled: false  # if true set gnb.amf.n2if.ipAddress to the
name of AMF NGAP service or the IP of the cluster hosting the AMF
```

```
podAnnotations: {}
  # additional annotations
imagePullSecrets: []
podSecurityContext: {}
resources:
  limits:
    cpu: 250m
    memory: 256Mi
  requests:
    cpu: 250m
    memory: 256Mi
nodeSelector: {}
tolerations: []
affinity: {}

configuration: |-
  mcc: '208' # Mobile Country Code value
  mnc: '93'  # Mobile Network Code value (2 or
  nci: '0x000000010'  # NR Cell Identity (36-bi
  idLength: 32        # NR gNB ID length in bit
  tac: 1     # Tracking Area Code
  # List of supported S-NSSAIs by this gNB
  slices:
    - sst: 0x1
      sd: 0x010203
  # Indicates whether or not SCTP stream number
should be ignored.
  ignoreStreamIds: true
```

```
ue:
  enabled: true
  name: ue
  replicaCount: 1
  image:
    name: towards5gs/ueransim-ue
    pullPolicy: IfNotPresent
  configmap:
    name: ue-configmap
  volume:
    name: ue-volume
    mount: /ueransim/config
  command: "./nr-ue -c ../config/ue
config.yaml"  # This is the command
will be launched in the UE containe
  # A script that will be run after
UE creation. It may be used to
periodically generate traffic
  script: ""
  # script: |-
  #   ping .....

  podAnnotations: {}
    # additional annotations
  imagePullSecrets: []
  podSecurityContext: {}
  securityContext:
    capabilities:
      add: ["NET_ADMIN"]
  resources:
    limits:
      cpu: 120m
      memory: 128Mi
    requests:
      cpu: 120m
      memory: 128Mi
  nodeSelector: {}
  tolerations: []
  affinity: {}
```

```
configuration: |-
    supi: "imsi-208930000000003"  # IMSI number
    mcc: '208' # Mobile Country Code value
    mnc: '93' # Mobile Network Code value (2 or 3 digits)
    key: "8baf473f2f8fd09487cccbd7097c6862" # Operator code
(OP or OPC) of the UE
    op: "8e27b6af0e692e750f32667a3b14605d" # This value
specifies the OP type and it can be either 'OP' or 'OPC'
    opType: "OPC" # This value specifies the OP type and it
can be either 'OP' or 'OPC'
    amf: '8000' # Authentication Management Field (AMF) value
    imei: '356938035643803' # IMEI number of
    imeiSv: '4370816125816151'
    # UAC Access Identities Configuration
    uacAic:
      mps: false
      mcs: false
    # UAC Access Control Class
    uacAcc:
      normalClass: 0
      class11: false
      class12: false
      class13: false
      class14: false
      class15: false
    sessions:
      - type: "IPv4"
        apn: "internet"
        slice:
          sst: 0x01
          sd: 0x010203
    # Configured NSSAI for this UE by HPLMN
    configured-nssai:
      - sst: 0x01
        sd: 0x010203
    # Default Configured NSSAI for this UE
    default-nssai:
      - sst: 1
        sd: 1
```

```
  # Supported encryption and integrity
algorithms by this UE
    integrity:
      IA1: true
      IA2: true
      IA3: true
    ciphering:
      EA1: true
      EA2: true
      EA3: true
    # Integrity protection maximum data
rate for user plane
    integrityMaxRate:
      uplink: 'full'
      downlink: 'full'

  test:
    connectivity:
      name: ue-connectivity-test
      image: bitnami/kubectl:1.22.0
      configmap:
        name: connectivity-test-
configmap
      volume:
        name: connectivity-test-volume
        mount: /scripts
      ttlseconds: 50
```

BACKUP

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm (참고)

- **gnb@ueransim:** helm show values openverso/ueransim

```
root@5g:~# helm show values towards5gs/ueransim
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2021 Orange
# SPDX-License-Identifier: Apache-2.0
#
# This software is distributed under the Apache License 2.0,
# the text of which is available at todo
# or see the "LICENSE" file for more details.
#
# Author: Abderaouf KHICHANE, Ilhem FAJJARI, Ayoub BOUSSELMI
# Software description: An open-source project providing Helm charts to deploy 5G c
#
# Default values for ueransim-chart.
# This is a YAML-formatted file.
# Declare variables to be passed into your templates.

global:
  multiCluster: false
  #Global network parametes
  n2network:
    name: n2network
    masterIf: eth0
    subnetIP: 10.100.50.248
    cidr: 29
    gatewayIP: 10.100.50.254
    excludeIP: 10.100.50.254
  n3network:
    name: n3network
    masterIf: eth0
    subnetIP: 10.100.50.232
    cidr: 29
    gatewayIP: 10.100.50.238
    excludeIP: 10.100.50.238
```

```
projectName: ueransim

gnb:
  enabled: true
  name: gnb
  replicaCount: 1
  image:
    name: towards5gs/ueransim-gnb
    pullPolicy: IfNotPresent
  configmap:
    name: gnb-configmap
  volume:
    name: gnb-volume
    mount: /ueransim/config
  service:
    name: gnb-service
    type: ClusterIP
    port: 4997
    protocol: UDP

  n2if:  # NGAP
    ipAddress: 10.100.50.250
  n3if:  # GTP-U
    ipAddress: 10.100.50.236

  amf:
    n2if:  # NGAP
      ipAddress: 10.100.50.249
      port: 38412
    service:
      ngap:
        enabled: false  # if true set gnb.amf.n2if.ipAddress to the name of AMF
NGAP service or the IP of the cluster hosting the AMF
```

```
  podAnnotations: {}
    # additional annotations
  imagePullSecrets: []
  podSecurityContext: {}
  resources:
    limits:
      cpu: 250m
      memory: 256Mi
    requests:
      cpu: 250m
      memory: 256Mi
  nodeSelector: {}
  tolerations: []
  affinity: {}

  configuration: |-
    mcc: '208' # Mobile Country Code value
    mnc: '93'  # Mobile Network Code value (2 or 3 digits)
    nci: '0x000000010'  # NR Cell Identity (36-bit)
    idLength: 32        # NR gNB ID length in bits [22...32]
    tac: 1     # Tracking Area Code
    # List of supported S-NSSAIs by this gNB
    slices:
      - sst: 0x1
        sd: 0x010203
    # Indicates whether or not SCTP stream number errors should be
ignored.
    ignoreStreamIds: true
```

BACKUP

❖ Deploying 5G RAN/UE with UERANSIM, Kubernetes and Helm (참고)

- **ue@ueransim:** helm show values openverso/ueransim

```
root@5g:~# helm show values towards5gs/ueransim
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2
# SPDX-License-Identifier: Apache-2.0
#
# This software is distributed under the
# the text of which is available at todo
# or see the "LICENSE" file for more deta
#
# Author: Abderaouf KHICHANE, Ilhem FAJJA
# Software description: An open-source pr
#
# Default values for ueransim-chart.
# This is a YAML-formatted file.
# Declare variables to be passed into you

global:
  multiCluster: false
  #Global network parametes
  n2network:
    name: n2network
    masterIf: eth0
    subnetIP: 10.100.50.248
    cidr: 29
    gatewayIP: 10.100.50.254
    excludeIP: 10.100.50.254
  n3network:
    name: n3network
    masterIf: eth0
    subnetIP: 10.100.50.232
    cidr: 29
    gatewayIP: 10.100.50.238
    excludeIP: 10.100.50.238
```

```
ue:
  enabled: true
  name: ue
  replicaCount: 1
  image:
    name: towards5gs/ueransim-ue
    pullPolicy: IfNotPresent
  configmap:
    name: ue-configmap
  volume:
    name: ue-volume
    mount: /ueransim/config
  command: "./nr-ue -c ../config/ue-config.yaml"  # Thi
command that will be launched in the UE container
  # A script that will be run after the UE creation. It
used to periodically generate traffic
  script: ""
  # script: |-
  #   ping .....

  podAnnotations: {}
    # additional annotations
  imagePullSecrets: []
  podSecurityContext: {}
  securityContext:
    capabilities:
            add: ["NET_ADMIN"]
  resources:
    limits:
      cpu: 120m
      memory: 128Mi
    requests:
      cpu: 120m
      memory: 128Mi
```

```
 nodeSelector: {}
  tolerations: []
  affinity: {}
 configuration: |-
    supi: "imsi-208930000000003"  # IMSI number
    mcc: '208' # Mobile Country Code value
    mnc: '93' # Mobile Network Code value (2 or 3 digits)
    key: "8baf473f2f8fd09487cccbd7097c6862" # Operator co
of the UE
    op: "8e27b6af0e692e750f32667a3b14605d" # This value s
type and it can be either 'OP' or 'OPC'
    opType: "OPC" # This value specifies the OP type and
either 'OP' or 'OPC'
    amf: '8000' # Authentication Management Field (AMF) v
    imei: '356938035643803' # IMEI number of the device
    imeiSv: '4370816125816151'
    # UAC Access Identities Configuration
    uacAic:
      mps: false
      mcs: false
    # UAC Access Control Class
    uacAcc:
      normalClass: 0
      class11: false
      class12: false
      class13: false
      class14: false
      class15: false
    sessions:
      - type: "IPv4"
        apn: "internet"
        slice:
          sst: 0x01
          sd: 0x010203
```

imsi-208930000000003

```
# Configured NSSAI for this UE by HPLMN
   configured-nssai:
     - sst: 0x01
       sd: 0x010203
   # Default Configured NSSAI for this UE
   default-nssai:
     - sst: 1
       sd: 1
# Supported encryption and integrity algorithms by this UE
   integrity:
     IA1: true
     IA2: true
     IA3: true
   ciphering:
     EA1: true
     EA2: true
     EA3: true
   # Integrity protection maximum data rate for user plane
   integrityMaxRate:
     uplink: 'full'
     downlink: 'full'

 test:
   connectivity:
     name: ue-connectivity-test
     image: bitnami/kubectl:1.22.0
     configmap:
       name: connectivity-test-configmap
     volume:
       name: connectivity-test-volume
       mount: /scripts
     ttlseconds: 50
```