

5G 테스트베드 (시연/실습)

(v3.0 2023)

2023년 4월

안종석

james@jslab.kr

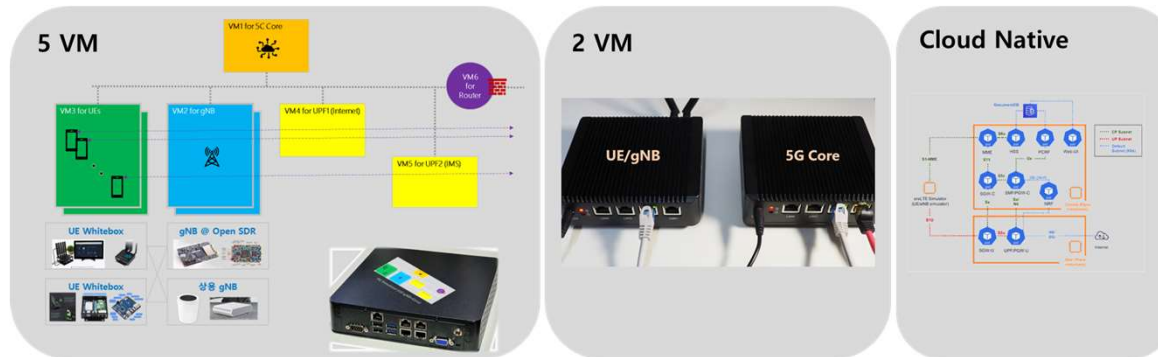


james@jslab.kr

JS Lab

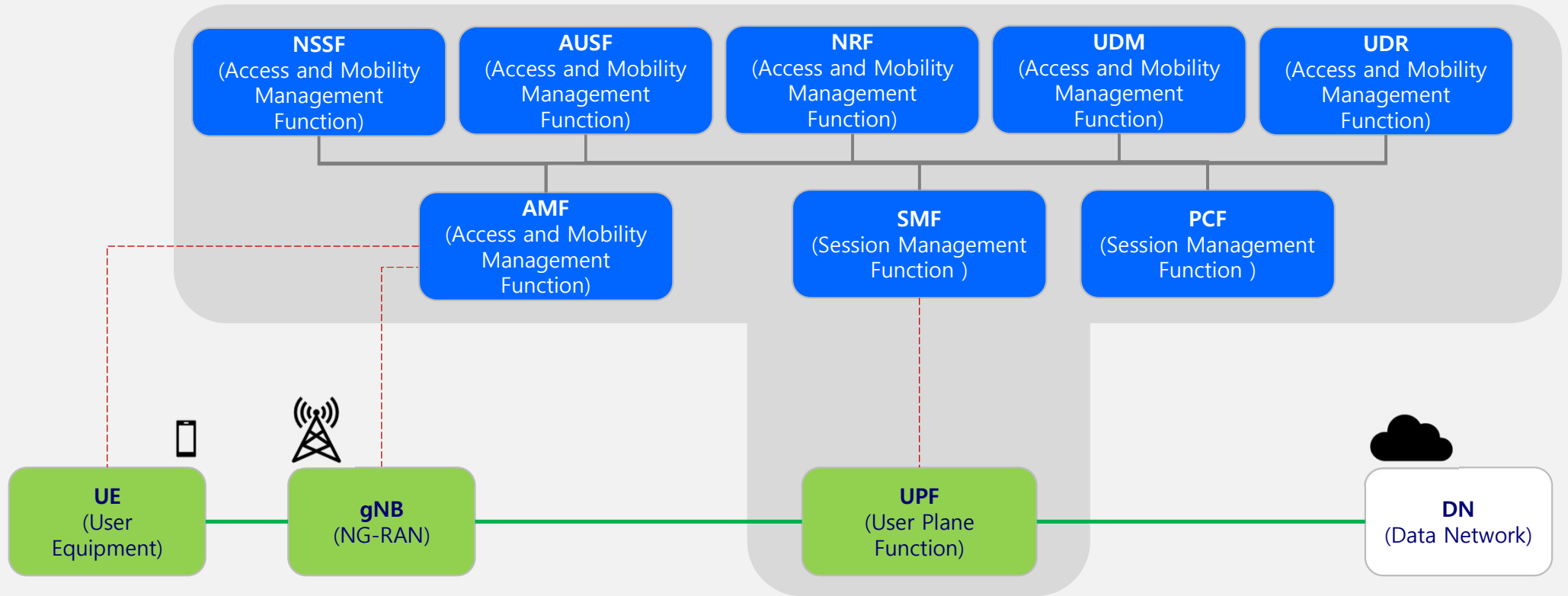
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I. 개요



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

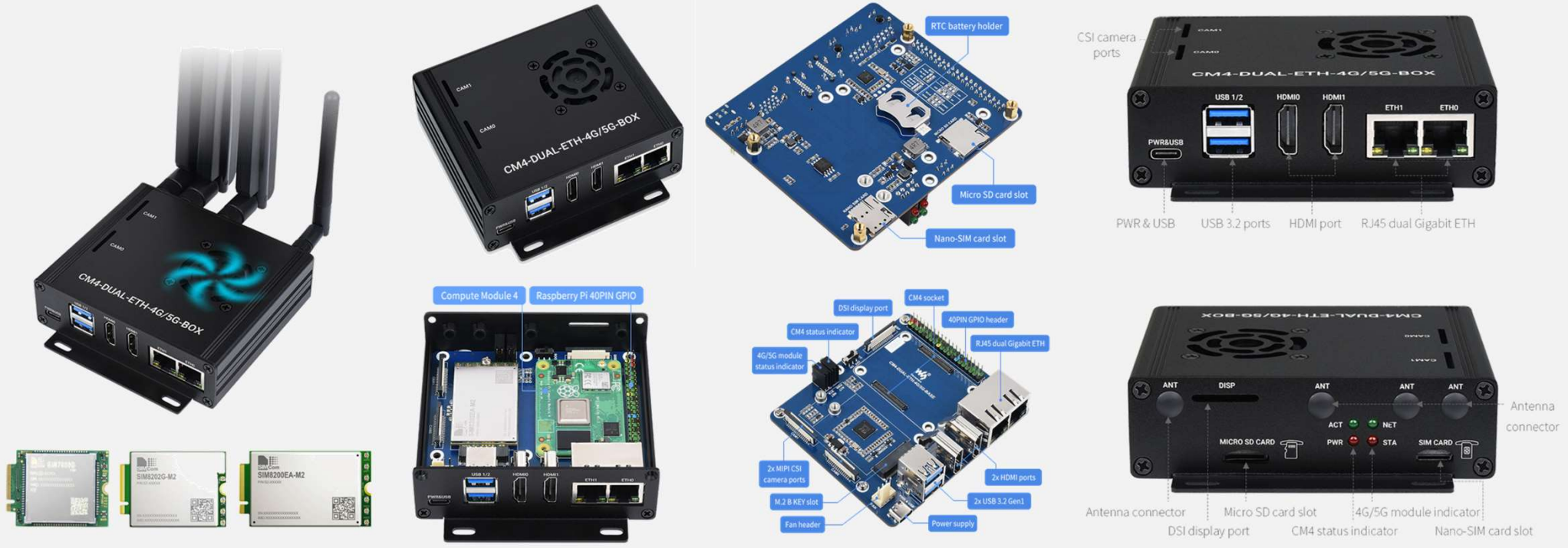
	HackRF One	Ettus B200	Ettus B210	BladeRF x40	RTL-SDR	LimeSDR
Frequency Range	1MHz-6GHz	70MHz-6GHz	70MHz-6GHz	300MHz-3.8GHz	22MHz-2.2GHz	100kHz-3.8GHz
RF Bandwidth	20MHz	61.44MHz	61.44MHz	40MHz	3.2MHz	61.44MHz
Sample Depth	8 bits	12 bits	12 bits	12 bits	8 bits	12 bits
Sample Rate	20MSPS	61.44MSPS	61.44MSPS	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



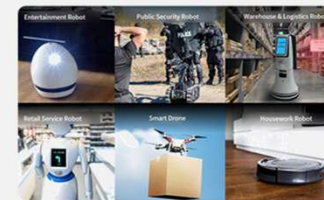
NETWORKED MEDICAL TREATMENT



INTELLIGENT AGRICULTURE



SMART CITY



SMART ROBOTS



5G Wireless Router

Combined with OpenWrt, turns the Raspberry Pi into a 5G wireless router, providing WiFi hotspot for smartphones to easily access the 5G Network

5G Live Webcast

While mounting an additional camera, it is able to do live webcast on webpage or platform through ffmpeg video streaming

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

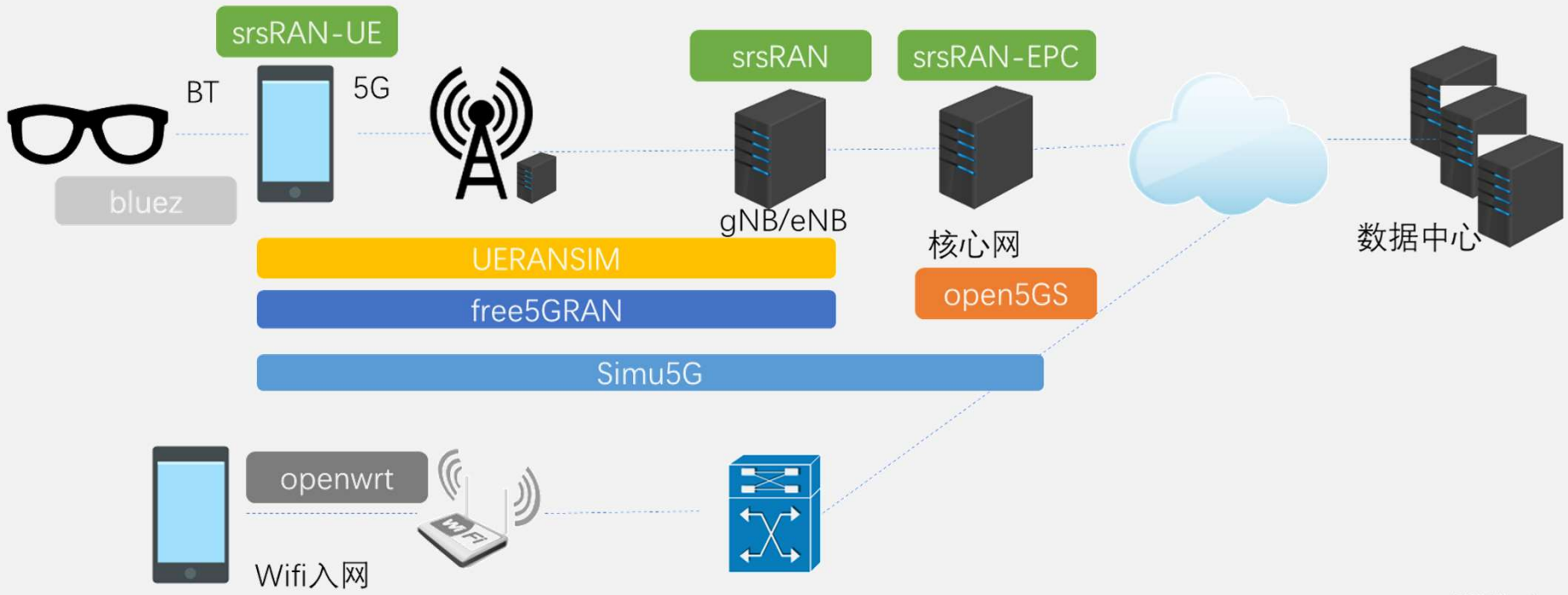


<https://docs.microsoft.com/ko-kr/azure/azure-percept/connect-over-cellular-usb-quectel>



I. 개요

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



CSDN @linus_ben

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



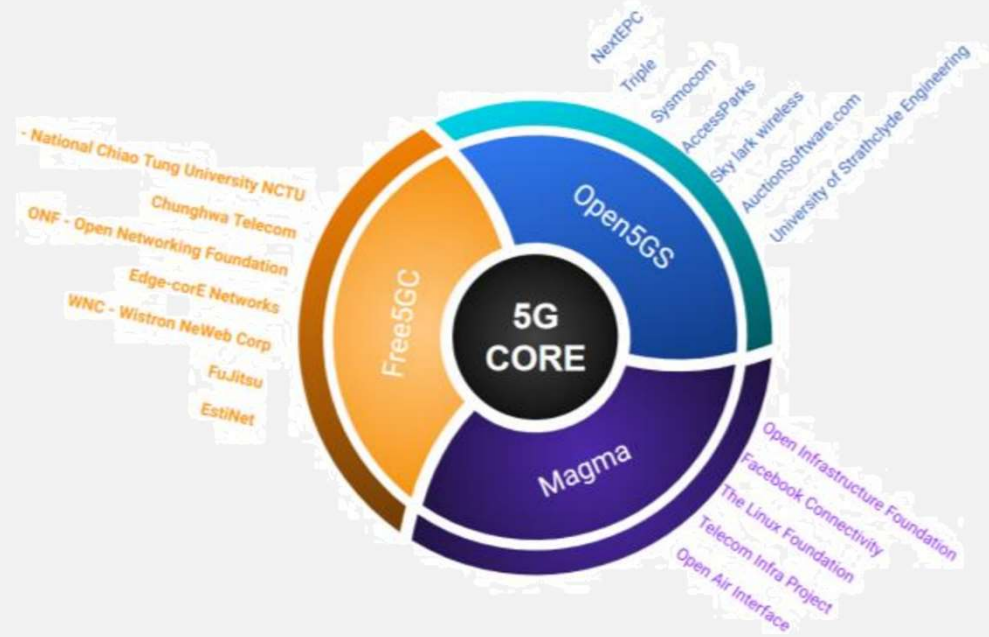
I. 개요

❖ 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

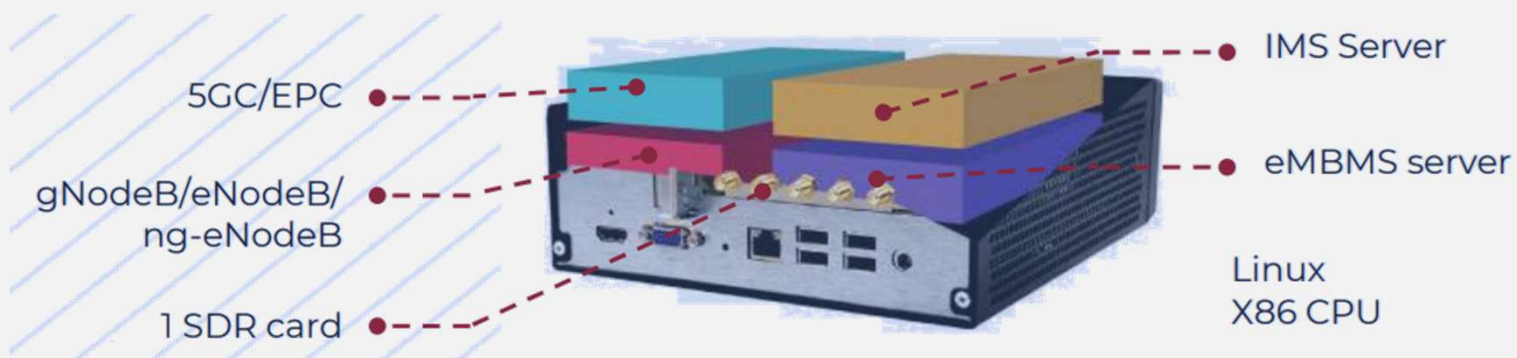
Source: 2021 International Conference on Information Science and Communications Technologies (ICISCT) | 978-1-6654-3258-0/21/\$31.00 ©2021 IEEE | DOI: 10.1109/ICISCT52966.2021.9670414



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)

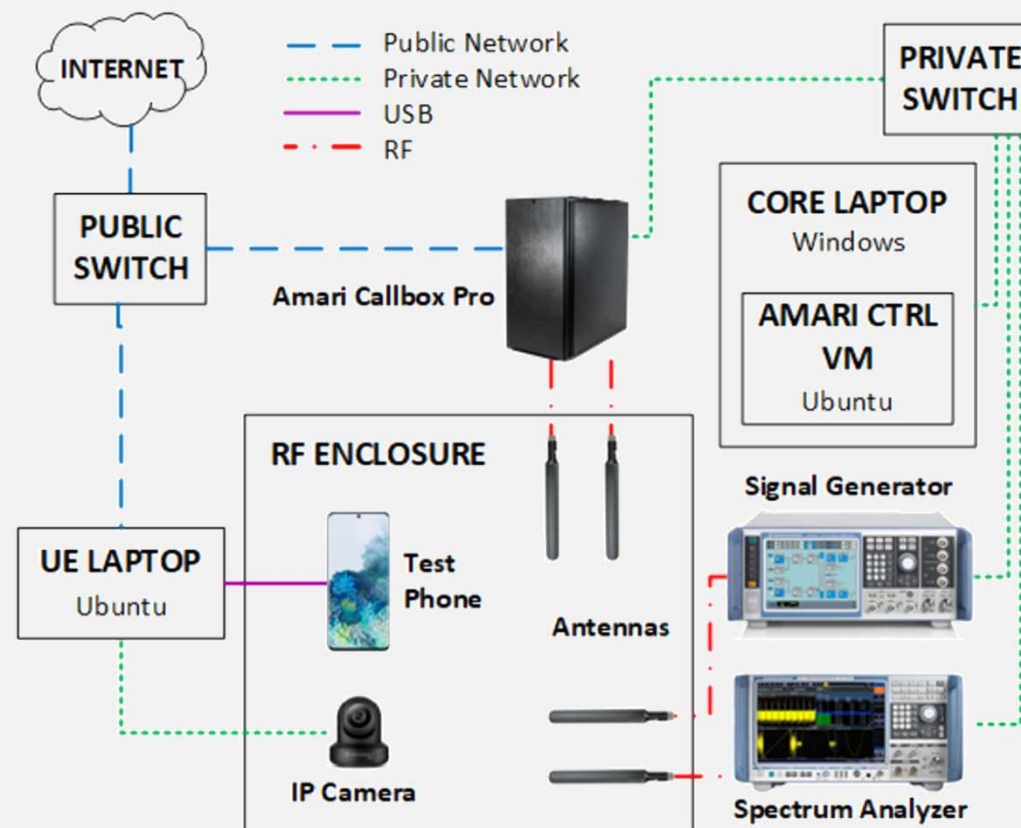


Source: <https://www.amarisoft.com/products/test-measurements/amari-ue-simbox/>



I. 개요

❖ Overview of Indoor System Architecture (IEEE)



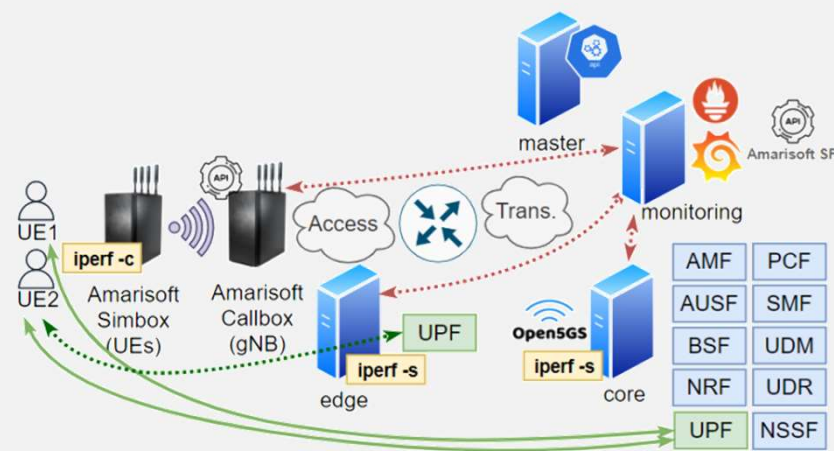
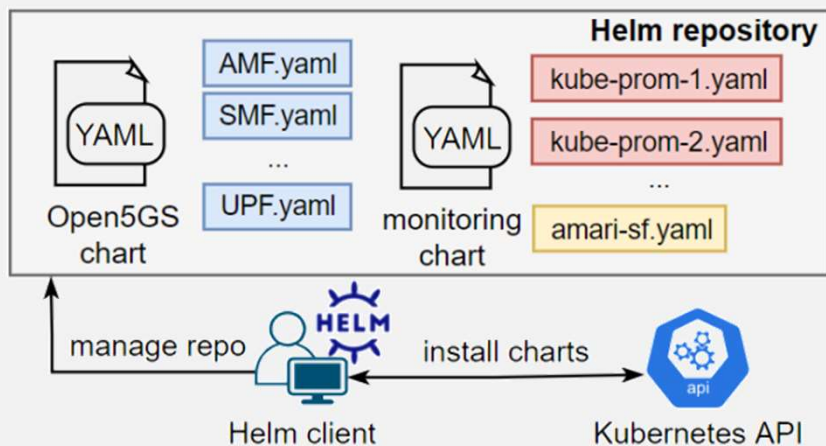
Source: Development of a Data-Driven Mobile 5G Testbed: Platform for Experimental Research (2021 IEEE International Mediterranean Conference on Communications and Networking)



I. 개요

❖ Cloud-native 5G 시험 플랫폼 (예): over-the-air transmissions and end-to-end monitoring of 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.

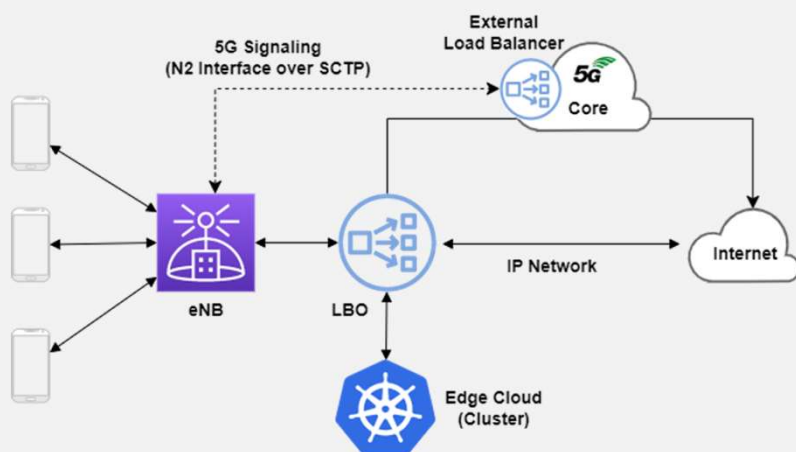


Source: https://arxiv.org/pdf/2207.11936.pdf?fbclid=IwAR2CjT8A2FlzQI9BXxv6h3TO-SjZclxjj8nr6XhNnVMmywJTKe3PGhsD1_M



I. 개요

❖ 5G Edge/LB



eBPF Project Landscape

ebpf.io/projects/

eBPF summit 2022 (28-29 September) [Register Now!](#)

eBPF

This page lists a number of open source projects that use eBPF as the underlying core technology. These projects are not necessarily under the [eBPF Foundation](#) but are listed here as a survey of the eBPF project landscape today. The ordering of applications is based on the number of Github stars (high to low), updated on a quarterly basis.

Applications (Emerging)

LoxiLB

eBPF based cloud-native load-balancer for 5G Edge

[Website](#) | [GitHub](#)

LoxiLB is an open-source cloud-native "external" service load-balancer for cloud-native 5G/edge workloads written from scratch using eBPF as its core-engine and based on Go Language. LoxiLB turns Kubernetes network load balancing for 5G/Edge services into high speed, flexible and programmable LB services.

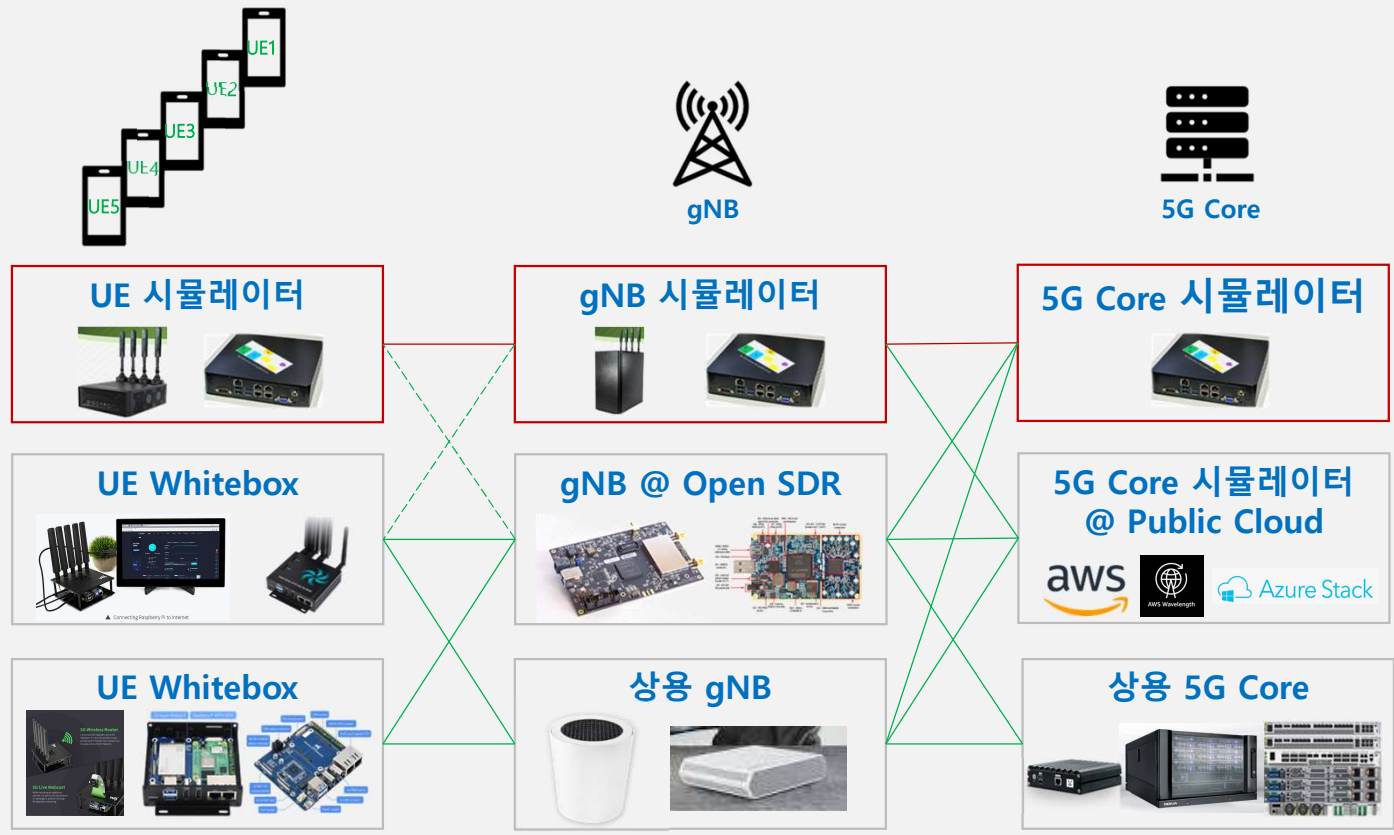
Source: <https://www.loxilb.io/>

Source: <https://ebpf.io/applications/?fbclid=IwAR3ZUv1TitcEgo1Pag8dpluaTwQdRHEYWcQW0kpuqLHtXuFUIOpT63Q37Jw>



I. 개요

❖ 5G 테스트베드 환경



I. 개요

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

FR1

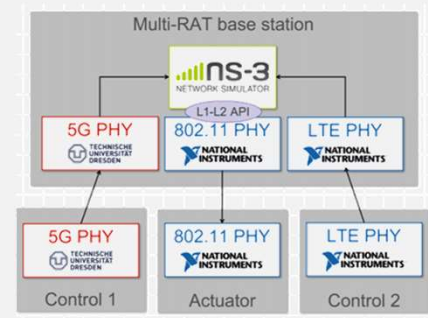
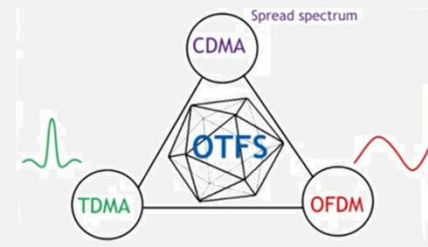
LTE Operating Band	NR Operating Band	Uplink		Downlink		Band Gap (MHz)	Duplex Mode
		Low	High	Low	High		
1	n1	1920 MHz	1980 MHz	2110 MHz	2170 MHz	130.00	FDD
2	n2	1850 MHz	1910 MHz	1930 MHz	1990 MHz	20	FDD
3	n3	1710 MHz	1785 MHz	1805 MHz	1880 MHz	20	FDD
4		1710 MHz	1755 MHz	2110 MHz	2155 MHz	355	FDD
5	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		Downlink		Band Gap (MHz)	Duplex Mode
		Low	High	Low	High		
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		Downlink		Band Gap (GHz)	Duplex Mode
		Low	High	Low	High		
	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

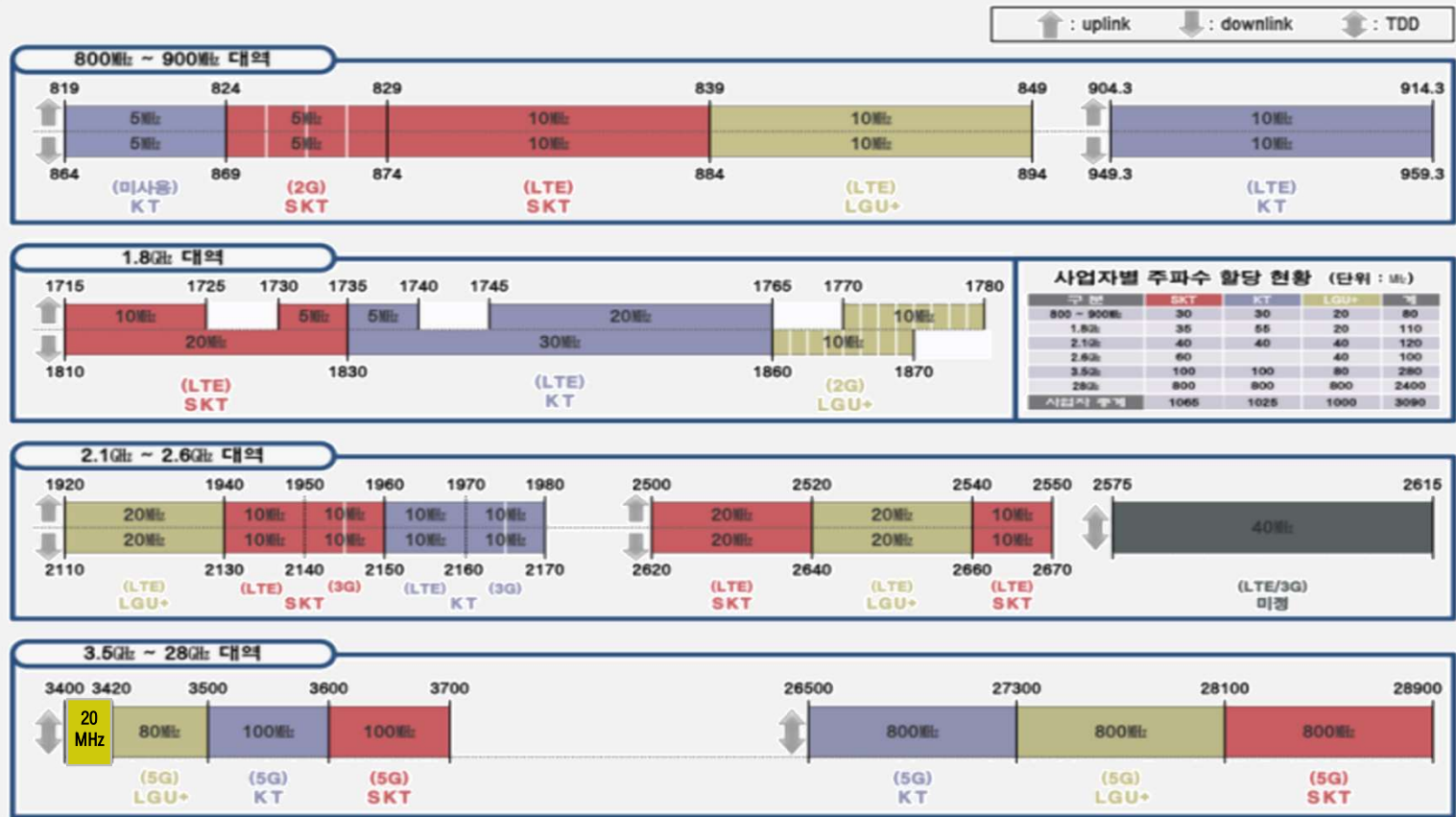


Source: Qorvo, Qualcomm, <https://www.cohere-tech.com/press-releases/coheres-universal-spectrum-multiplier-software-doubles-both-4g-and-5g-spectrum-performance>



I. 개요

❖ 국내 이동통신 사업자 주파수 할당 현황 (2020.01)



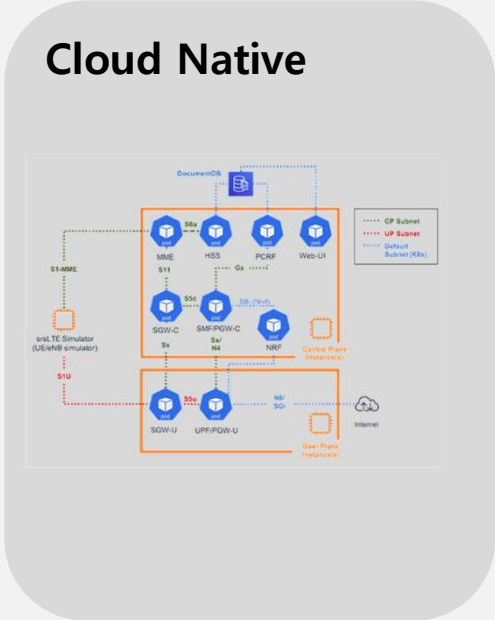
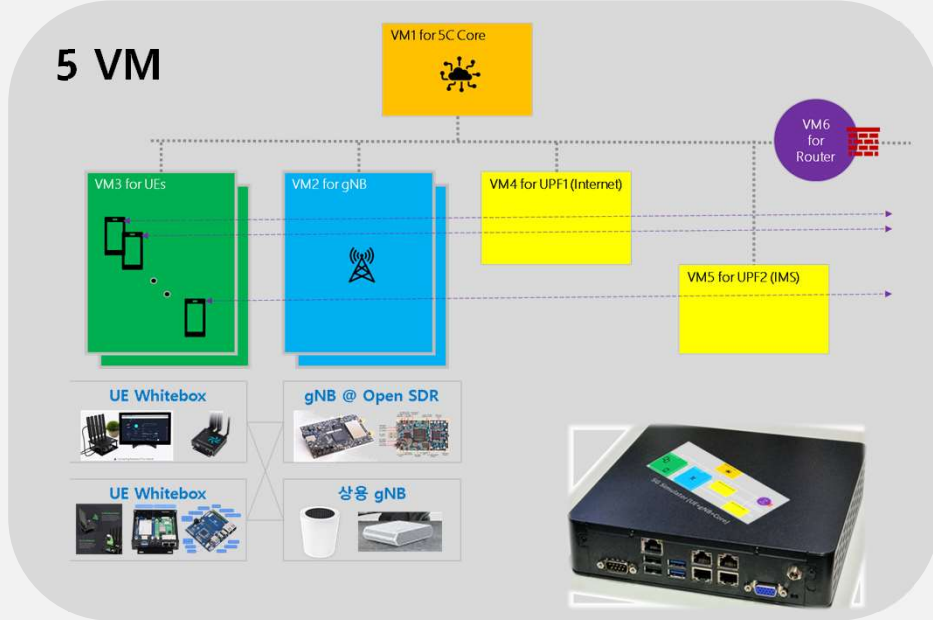
Source: 과기정통부, KCA



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)



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/1-56NGWEIOLZ7q-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



I. 개요

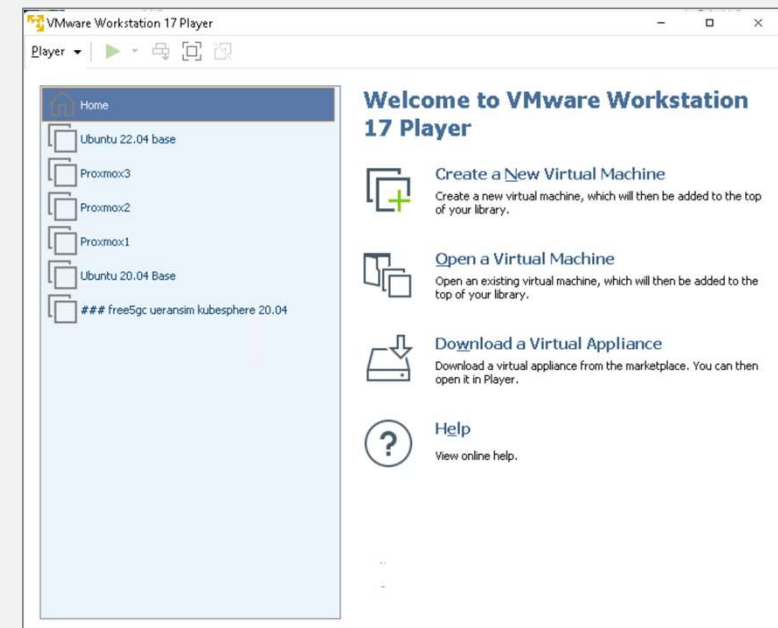
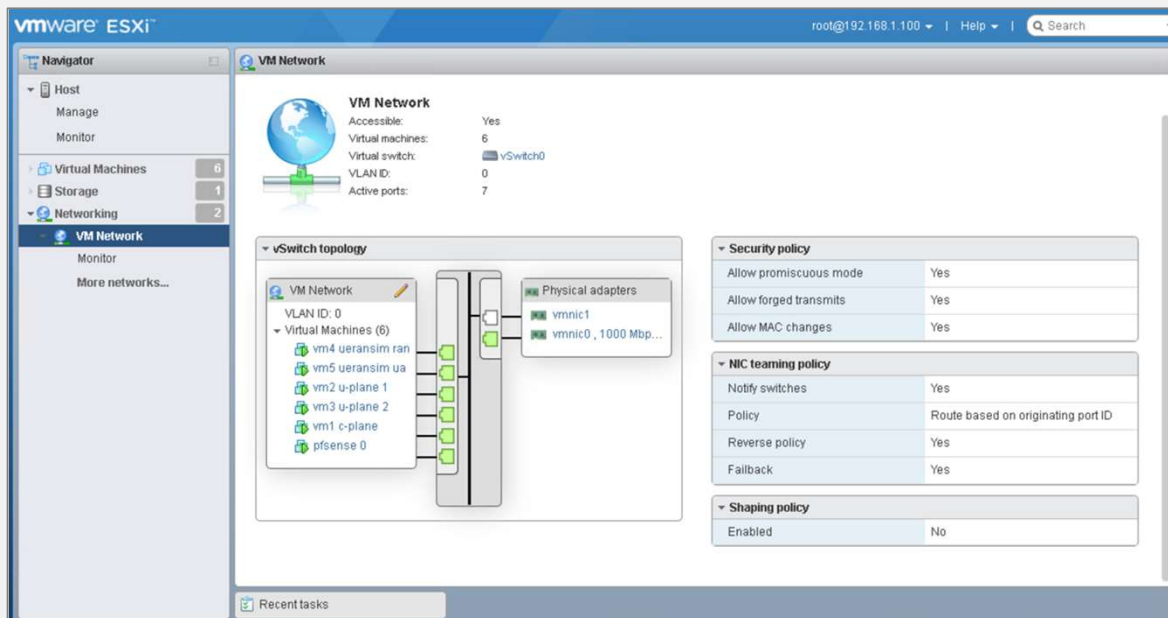
❖ Hypervisor 설치

• 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>

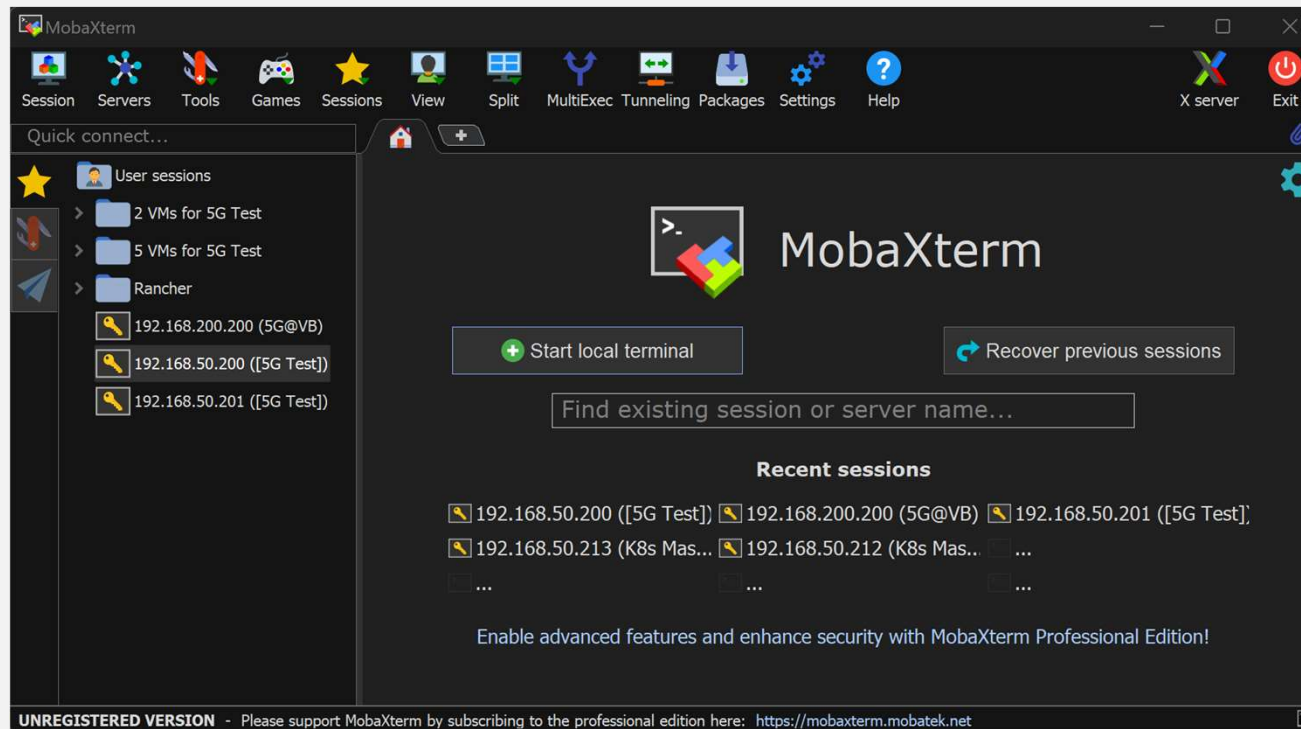


I. 개요

❖ SSH 터미널 설치

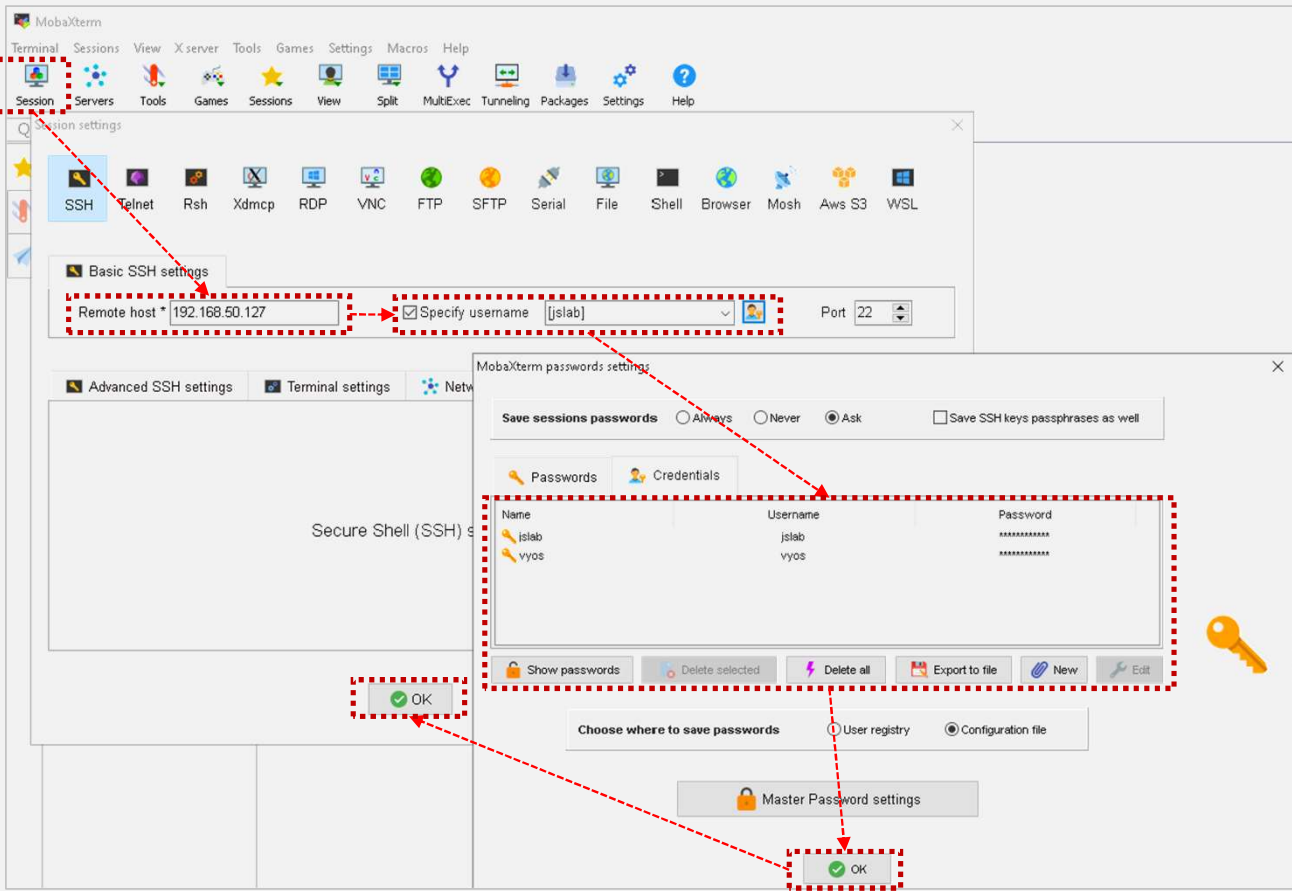
• MobaXterm download:

✓ <https://mobaxterm.mobatek.net/download.html>



I. 개요

❖ SSH 터미널 접속



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

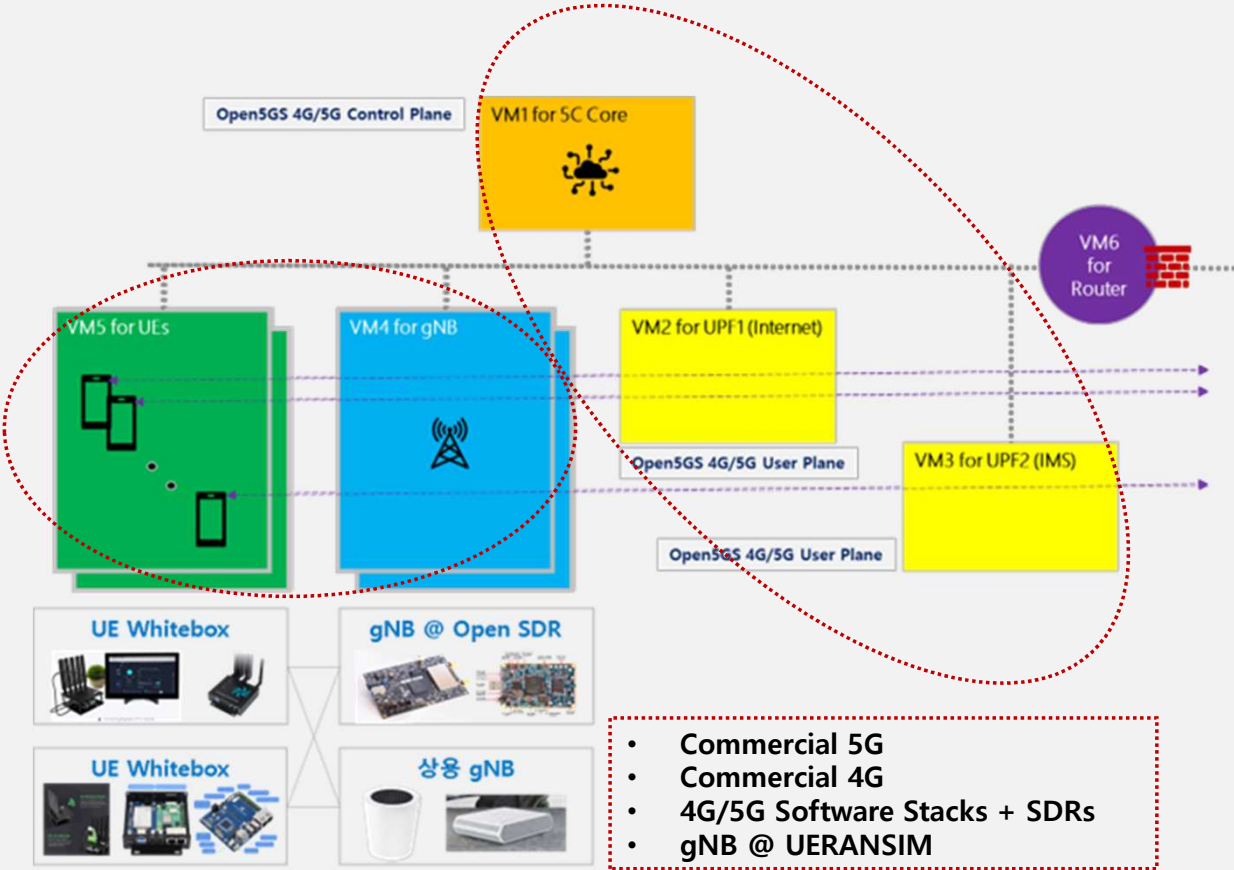


II. Testbed 1 (5 VMs)

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)

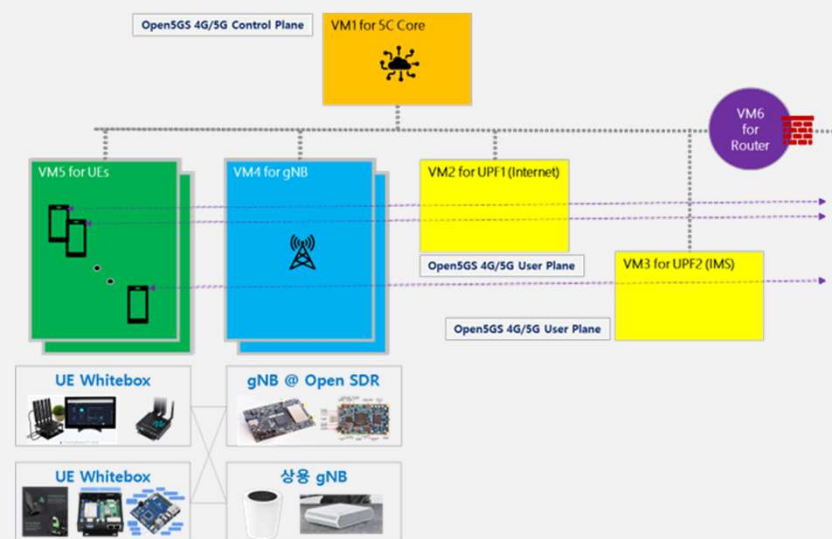
❖ Open5GS 호환 하드웨어 (eNodeBs / gNodeBs tested)

• 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/>

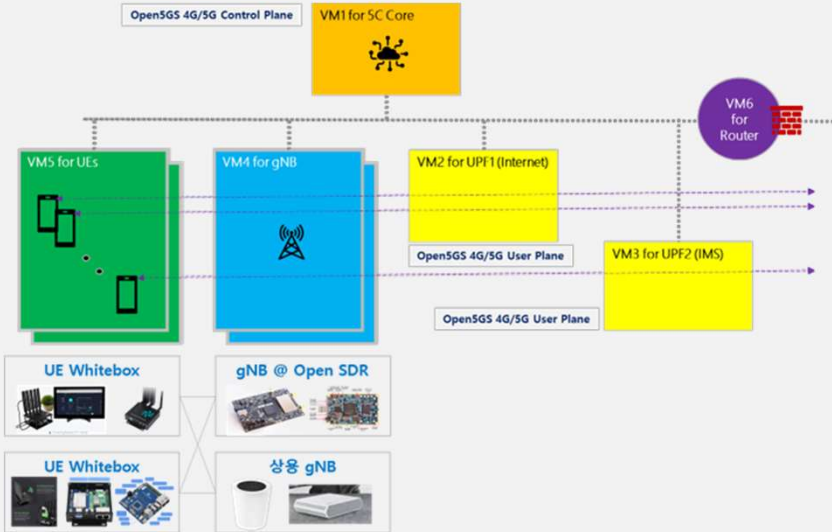


II. TESTBED 1 (5 VM)

❖ 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



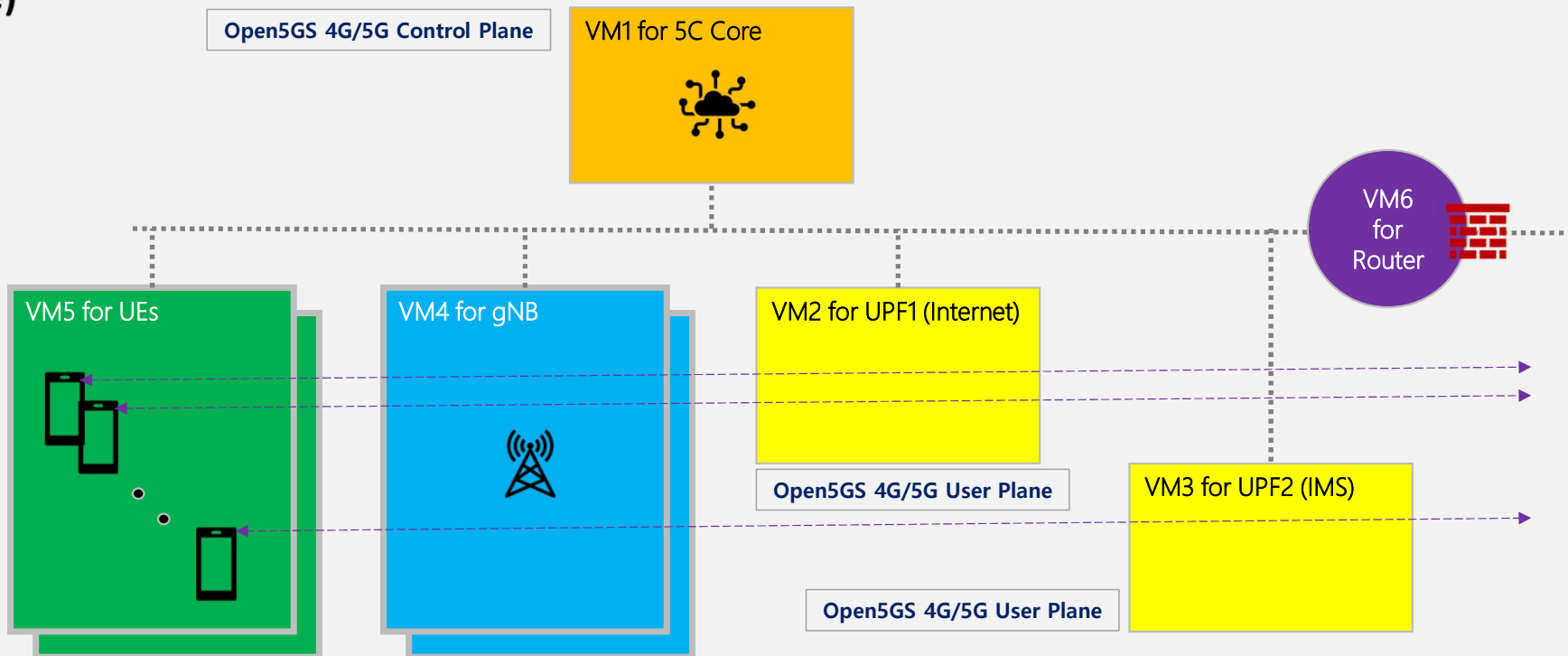
Source: <https://open5gs.org/open5gs/docs/hardware/01-genodebs/>



II. TESTBED 1 (5 VM)

❖ Build Open5GS

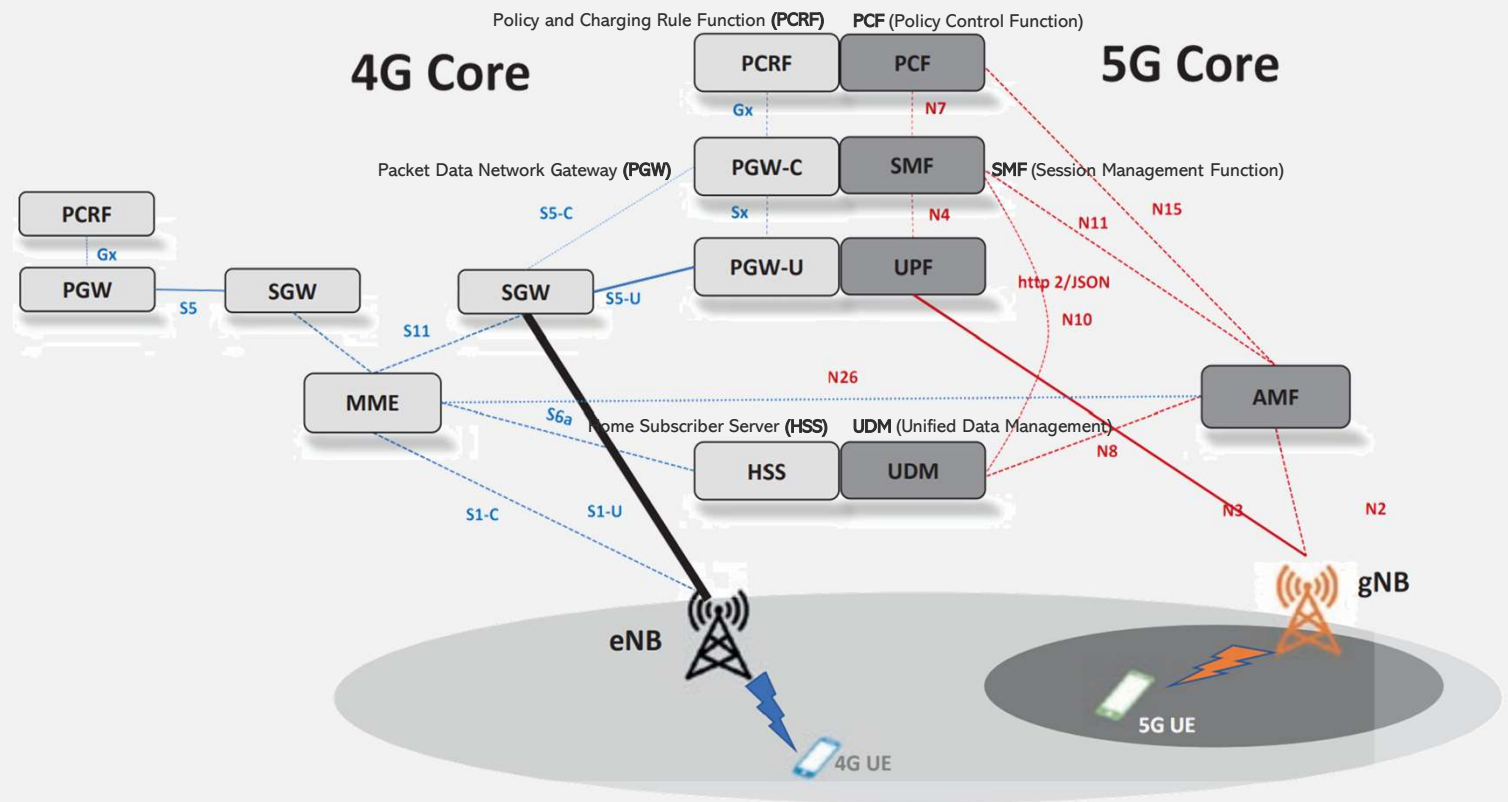
- NSA (4G Core)
- SA (5G Core)



II. TESTBED 1 (5 VM)

❖ Build Open5GS

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



II. TESTBED 1 (5 VM)

❖ VMware ESXi (Type 1 Hypervisor) 실행

The screenshot displays the VMware ESXi management interface. The top navigation bar shows the user 'root@192.168.1.100' and a search bar. The left sidebar contains a 'Navigator' with sections for Host, Virtual Machines (6), Storage (1), and Networking (2). The main area is titled 'VM Network' and provides summary statistics: Accessible (Yes), Virtual machines (6), Virtual switch (vSwitch0), VLAN ID (0), and Active ports (7). Below this is a 'vSwitch topology' diagram showing the 'VM Network' connected to 'Physical adapters' (vmmnic1 and vmmnic0, 1000 Mbps). A list of 'Virtual Machines (6)' is shown: vm4 ueransim ran, vm5 ueransim ua, vm2 u-plane 1, vm3 u-plane 2, vm1 c-plane, and pfsense 0. On the right, three policy sections are visible: 'Security policy' (Allow promiscuous mode: Yes, Allow forged transmits: Yes, Allow MAC changes: Yes), 'NIC teaming policy' (Notify switches: Yes, Policy: Route based on originating port ID, Reverse policy: Yes, Failback: Yes), and 'Shaping policy' (Enabled: No). An inset window shows the 'vm1 c-plane' VM details, including its state (Powered off), configuration file path, and hardware compatibility (Workstation 11x virtual machine).



II. TESTBED 1 (5 VM)

❖ VMware ESXi (Type 1 Hypervisor) 실행

The screenshot displays a terminal window in 'Multi-execution mode' for a VMware ESXi environment. The interface includes a sidebar with 'User sessions' for five VMs: 192.168.0.111 (vm1), 192.168.0.112 (vm2), 192.168.0.113 (vm3), 192.168.0.131 (vm4), and 192.168.0.132 (vm5). The main terminal area shows network configuration commands and logs for each VM. For example, vm1 and vm2 show 'ogstun' and 'ogstun2' configurations with various IP addresses and scopes. vm3 and vm4 show similar configurations with different IP ranges. vm5 shows a configuration for 'uesimtu0' and 'uesimtu1'. The logs include messages from the Network Access Server (NAS) such as 'Registration accept received', 'UE switches to state [MM-REGIST]', and 'PDU Session Establishment is success'. A status bar at the bottom indicates the time as 17/08/2022 02:19:29 and the current directory as /home/mobaxterm.

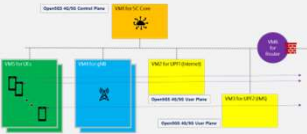
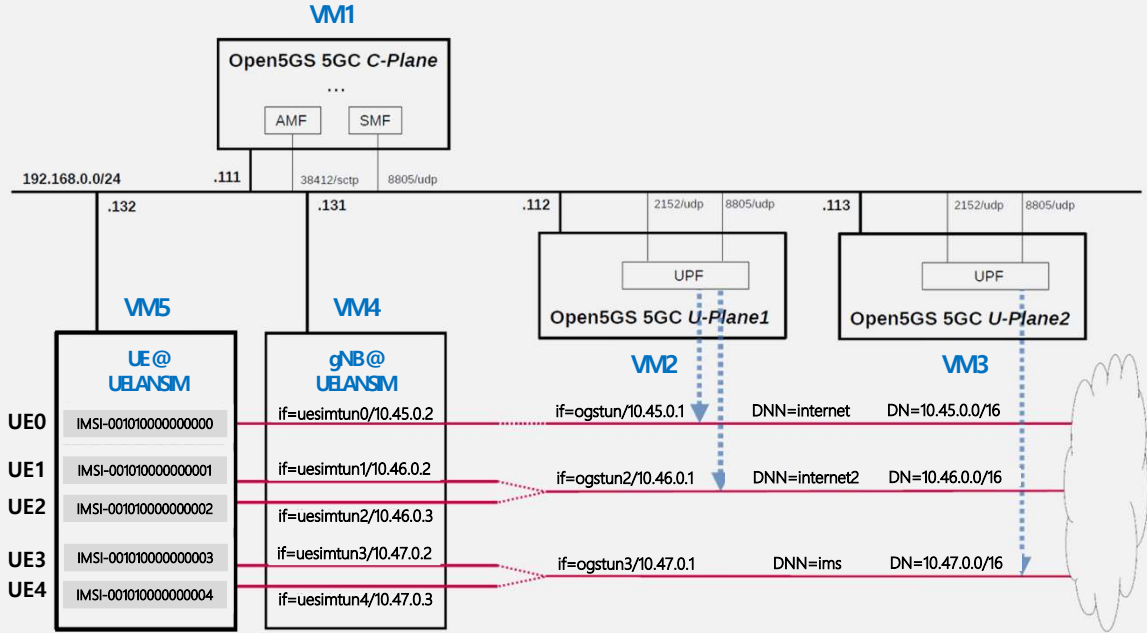


II. TESTBED 1 (5 VM)

❖ 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

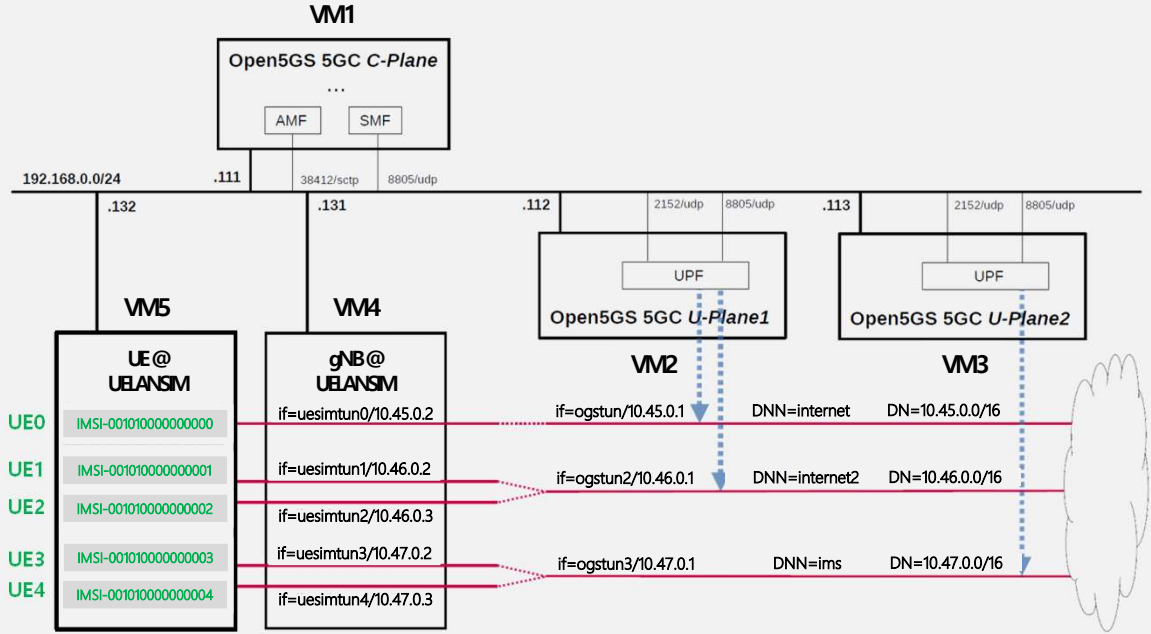
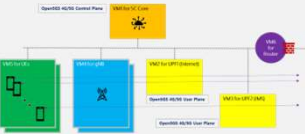


II. TESTBED 1 (5 VM)

❖ Overview of Open5GS 5GC Simulation Mobile Network

- 5 UEs @ VM5
 - C-Plane have multiple U-Planes.
 - U-Plane have multiple DN.
 - 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



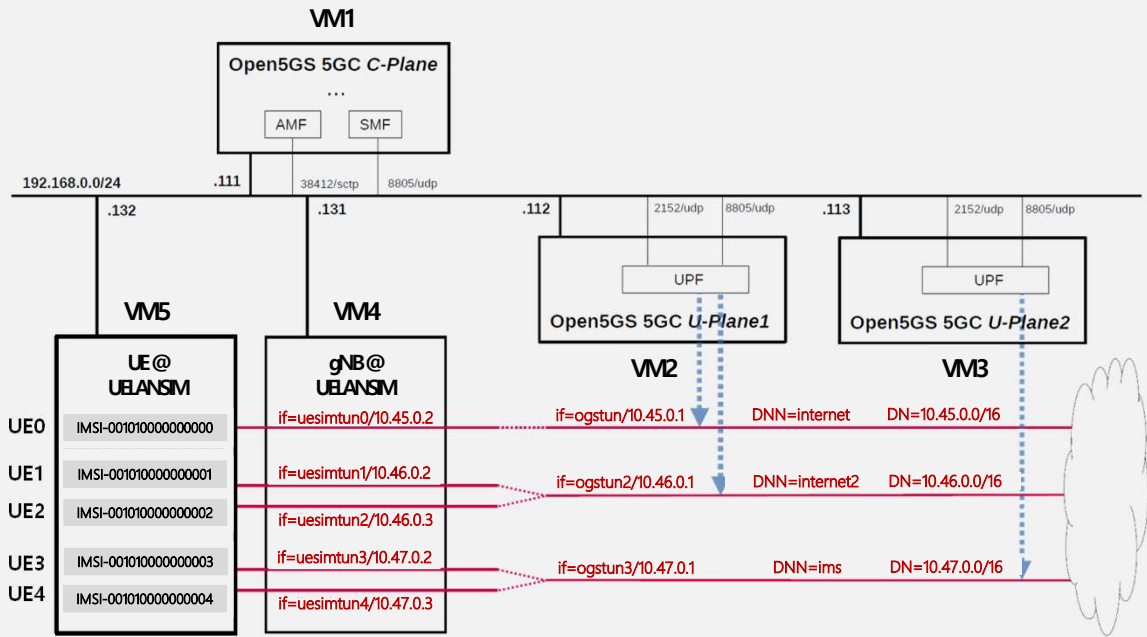
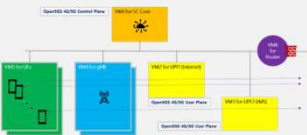
II. TESTBED 1 (5 VM)

❖ Overview of Open5GS 5GC Simulation Mobile Network

- 3 DN 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:
```

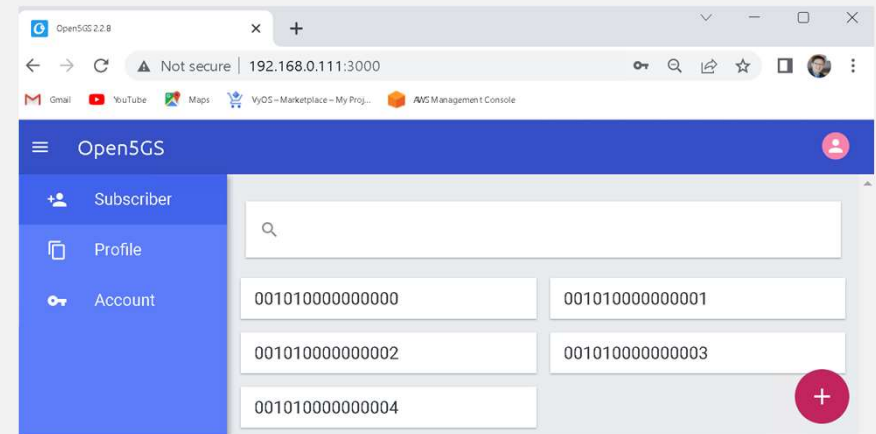
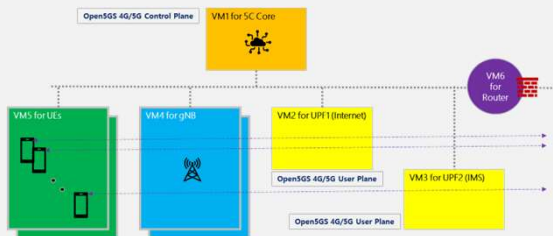
```
curl -fsSL https://open5gs.org/open5gs/assets/webui/uninstall | sudo -E bash -
```



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

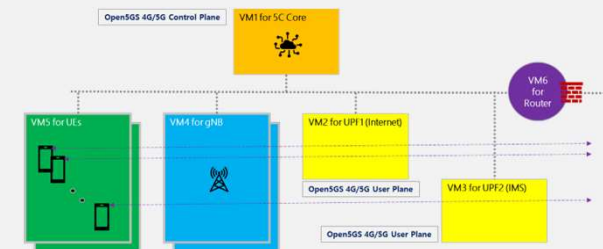
• configure the TUNnel interface and NAPT. (sudo -i) @ User Plane 1 (vm2)

- 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)

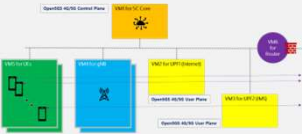


II. TESTBED 1 (5 VM)

❖ Open5GS WebUI

Username : admin
Password : 1423

The screenshot shows a web browser window with the Open5GS WebUI. The browser tabs include KubeSphere, Hubble UI, free5GC Web C, and Open5GS 2.2.8. The address bar shows the URL 192.168.0.111:3000. The interface has a blue header with the Open5GS logo and a user profile icon. A sidebar on the left contains three menu items: Subscriber, Profile, and Account. The main content area features a search bar and five input fields containing binary strings: 001010000000000, 001010000000001, 001010000000002, 001010000000003, and 001010000000004.



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-00101000000000'
# Mobile Country Code value of HPLMN
mcc: '001'
# Mobile Network Code value of HPLMN (2 or 3 digits)
mnc: '01'

# Permanent subscription key
key: '465B5CE8B199B49FAA5FOA2EE238A6BC'
# 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
  class1: 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

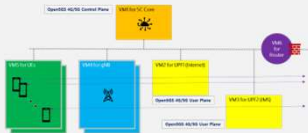
# Default Configured NSSAI for this UE
default-nssai:
  - sst: 1
```



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` # Ping @ vm5 - UE0
 - `ping -I uesimtun1 google.com` # Ping @ vm5 - UE1
 - `ping -I uesimtun2 google.com` # Ping @ vm5 - UE2
 - `ping -I uesimtun3 google.com` # Ping @ vm5 - UE3
 - `sudo tcpdump -i ogstun` # Data Capture @ vm2 - UPF1
 - `sh nr-binder 10.45.0.2 curl google.com` # UE0 @ vm5 - UERANSIM/build/
 - `sh nr-binder 10.45.0.3 ping google.com` # UE1 @ vm5 - UERANSIM/build/
 - `sh nr-binder 10.47.0.3 ping google.com` # UE1 @ vm5 - UERANSIM/build/

```

sudo tcpdump -i ogstun @ vm2 upf1
sudo tcpdump -i ogstun2 @ vm2 upf1
sudo tcpdump -i ogstun2 @ vm2 upf1
sudo tcpdump -i ogstun3 @ vm3 upf2
sudo tcpdump -i ogstun2 @ vm2 upf1
sudo tcpdump -i ogstun2 @ vm2 upf1
sudo tcpdump -i ogstun2 @ vm2 upf1

```

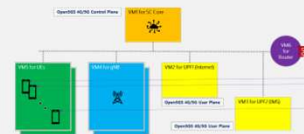


II. TESTBED 1 (5 VM)

❖ 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>



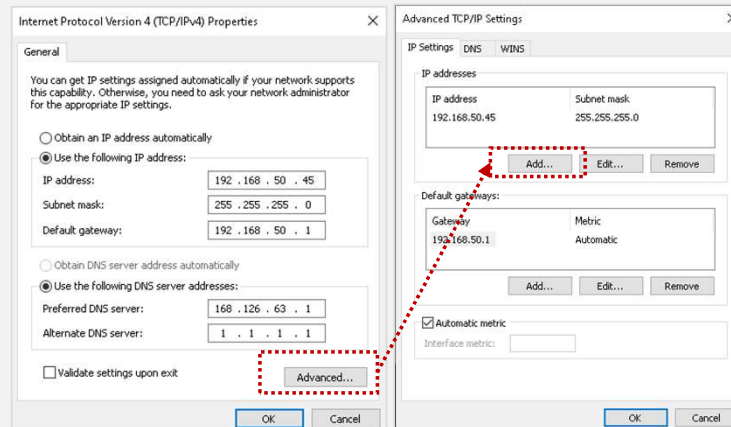
III. Testbed 2 (1 for 2 VMs)



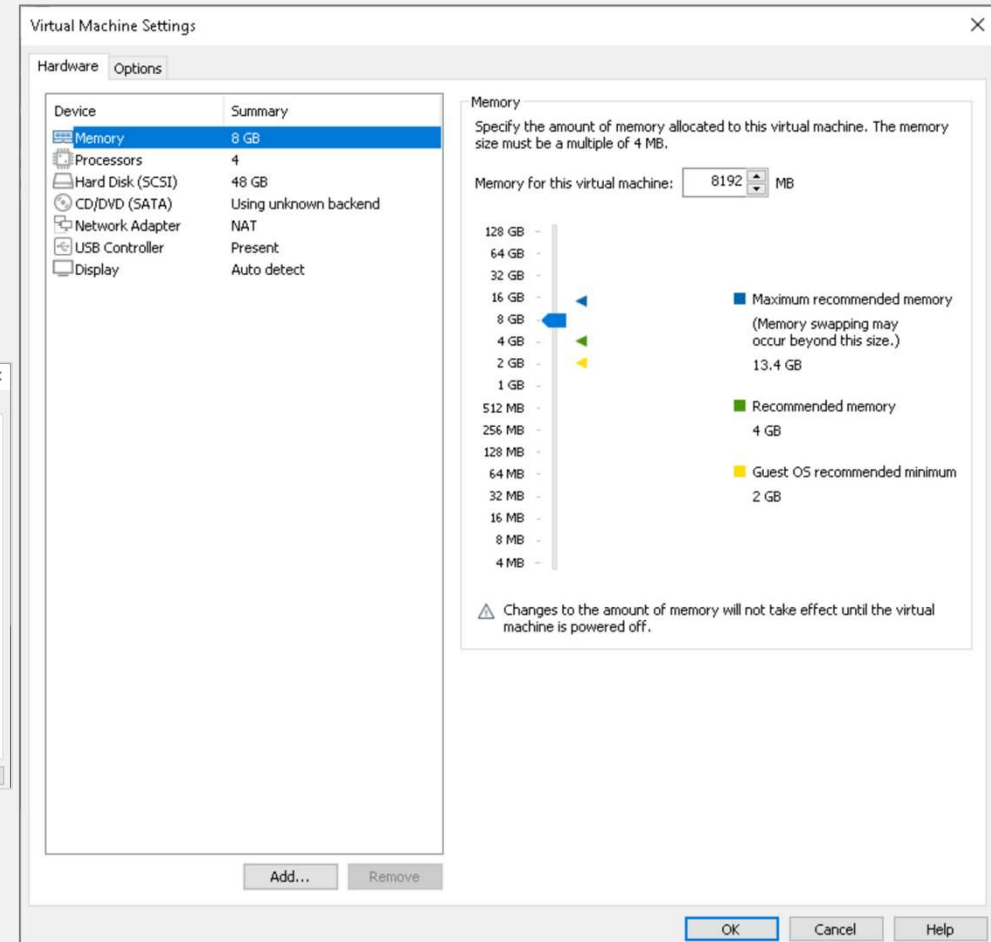
III. TESTBED 2 (2 VM)

❖ 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

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

Free5GC

UERANSIM

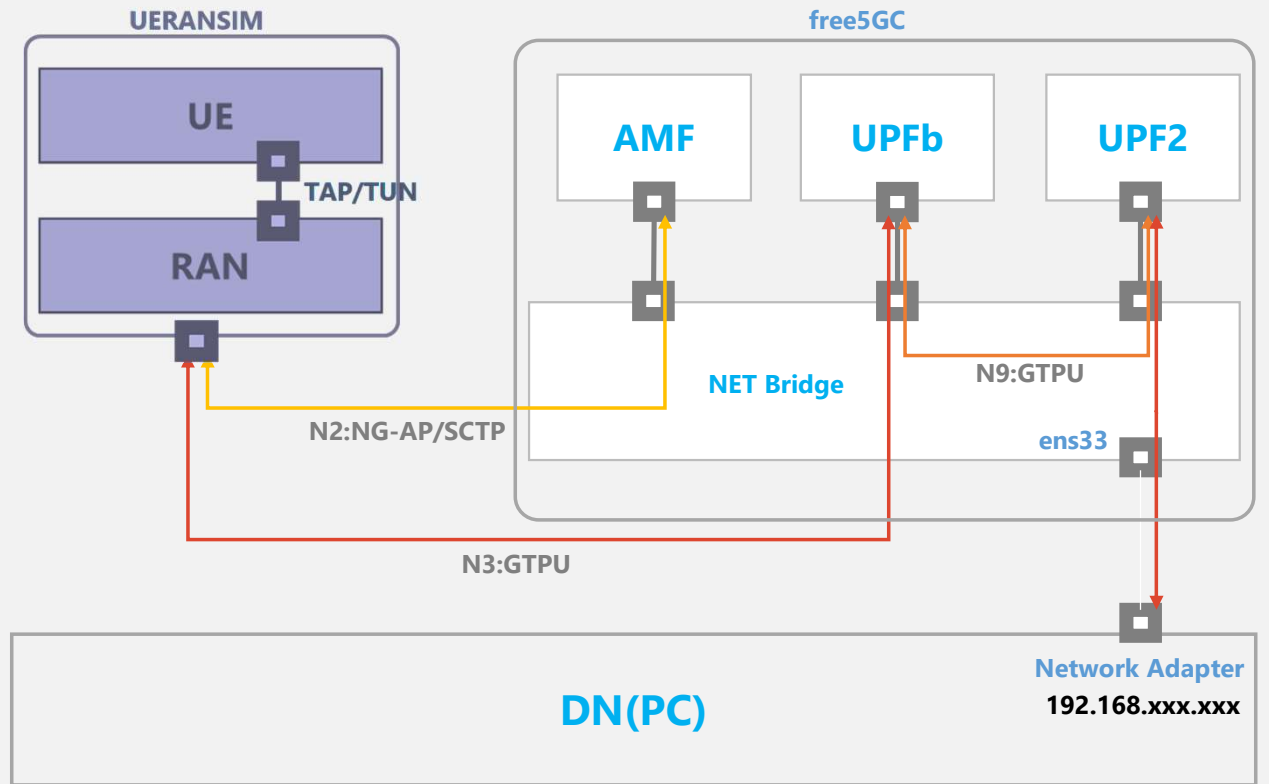
```
# This is the network config written by 'subiquity'  
network:  
  ethernets:  
    ens33:  
      dhcp4: false  
      addresses: [192.168.220.129/24]  
      gateway4: 192.168.220.2  
      nameservers:  
        addresses: [1.1.1.1, 8.8.8.8]  
    ens34:  
      dhcp4: true  
  version: 2
```

```
# 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
```



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
auto ens160
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)

Registered UEs

SUPI --	Status --	Details
imsi-208930000000003	CONNECTED	Show Info

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-8e67-6f7bae34b37
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

Edit Subscriber

Subscriber data number (auto-increased with SUPI)*
1

PLMN ID*
20893

SUPI (IMSI)*
208930000000003

Authentication Method*
5G_AKA

K*
8ba473f2f8fd09487cccbd7097c6862

Operator Code Type*
OP

Operator Code Value*
8e27b6af0e692e750f32667a3b14605d

SQN*
16f3b3f70fc4

S-NSSAI Configuration

snsai [dropdown]

SST*
1

SD*
010203

Default S-NSSAI



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

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

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

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
```



```
jslab@ubuntu:~$ 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
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: ens33: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 00:0c:29:09:8e:b5 brd ff:ff:ff:ff:ff:ff
    altname eno253
    inet 192.168.0.133/24 brd 192.168.0.255 scope global noprefixroute ens33
        valid_lft forever preferred_lft forever
    inet 192.168.50.14/24 brd 192.168.50.255 scope global noprefixroute ens33
        valid_lft forever preferred_lft forever
    inet6 fe80::7dcd:d601:2d00:b305/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
3: uesimtun0: <POINTOPOINT,MULTICAST,NOARP,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UNKNOWN group default qlen 500
    link/none
    inet 60.60.0.2/32 scope global uesimtun0
        valid_lft forever preferred_lft forever
    inet6 fe80::4642:799f:79e5:427d/64 scope link stable-privacy
        valid_lft forever preferred_lft forever
jslab@ubuntu:~$
jslab@ubuntu:~$
ns1: [2022-08-17 05:43:30.507] [nas] [debug] Derived kNasEnc[7a21aECFEF27002501EBDFAB5C05616] kNasInt[C6648D74F797095167821CA73C1114E]
[2022-08-17 05:43:30.532] [nas] [debug] TSS2 started with int[3600]
[2022-08-17 05:43:30.532] [nas] [info] UE switches to state: MM-REGISTERED/NORMAL-SERVICE
[2022-08-17 05:43:30.532] [nas] [info] Initial registration is successful
[2022-08-17 05:43:30.532] [nas] [info] Initial PDU sessions are establishing [18]
[2022-08-17 05:43:30.532] [nas] [debug] Sending PDU session establishment request
[2022-08-17 05:43:30.782] [nas] [info] PDU Session establishment is successful PSI[1]
[2022-08-17 05:43:30.822] [app] [info] connection setup for PDU session[1] is successful, TUN interface[uesimtun0, 60.60.0.2] is up
ns2: [2022-08-17 05:41:22.149] [ngap] [debug] Initial NAS message received from UE 4
[2022-08-17 05:41:23.949] [nr] [info] A UE disconnected from gNB. Total number of UEs is now: 1
[2022-08-17 05:43:30.481] [nr] [info] New UE connected to gNB. Total number of UEs is now: 2
[2022-08-17 05:43:30.482] [rrc] [debug] Sending RRC Setup for UE[5]
[2022-08-17 05:43:30.482] [ngap] [debug] Initial NAS message received from UE 5
[2022-08-17 05:43:30.532] [ngap] [debug] Initial Context Setup Request received
[2022-08-17 05:43:30.781] [ngap] [info] PDU session resource is established for UE[5] count[1]
[2022-08-17 05:43:31.530] [nr] [info] A UE disconnected from gNB. Total number of UEs is now: 1
```



IV. Testbed 3 (Cloud Native)



IV. TESTBED 3 (CLOUD NATIVE)

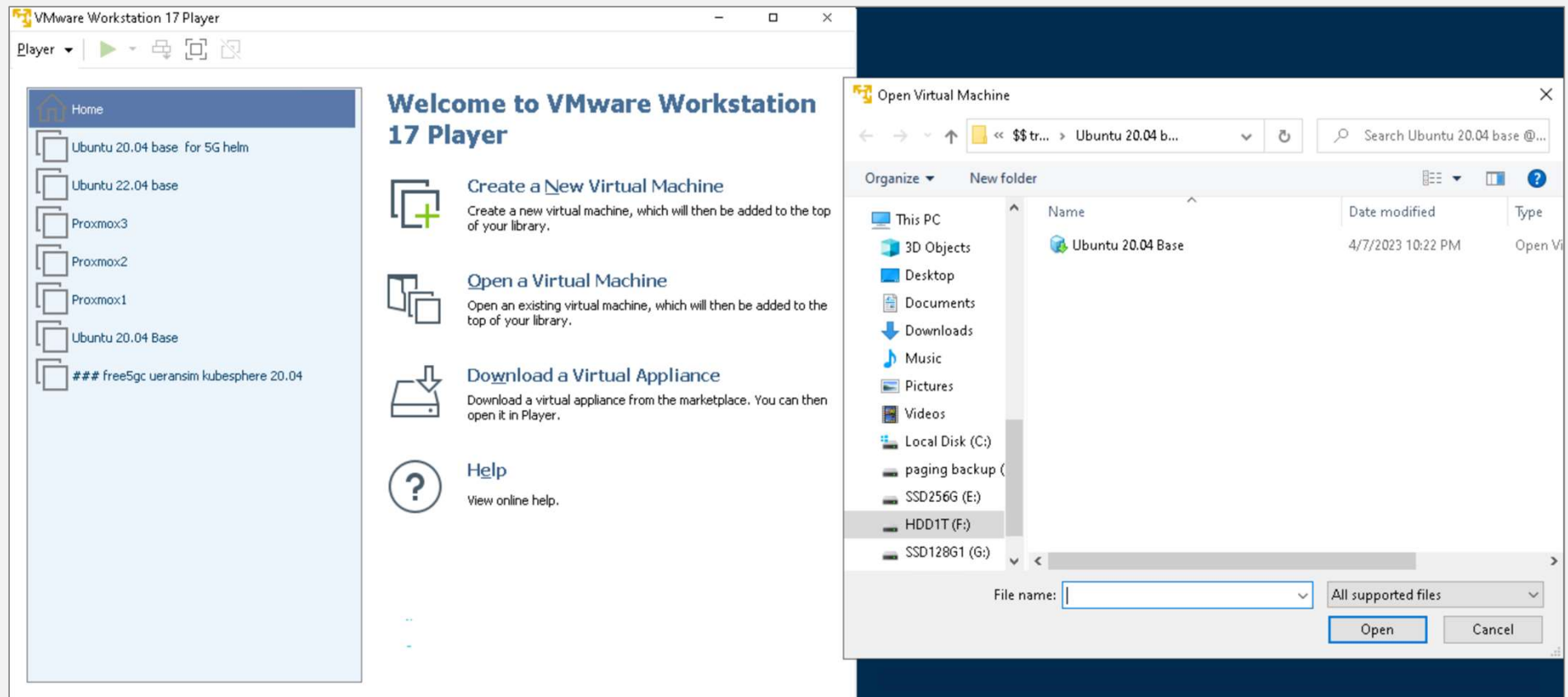
- ❖ Prerequisites for Setup free5gc on one single one
 - A Kubernetes cluster supporting **SCTP**
 - Kubernetes worker nodes with **kernel 5.0.0-23-generic** and containing gtp5g kernel module (required for the Free5GC **UPF** element).
 - Multus-CNI.
 - **Helm3**.
 - Kubectl (optional).
 - A Persistent 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)

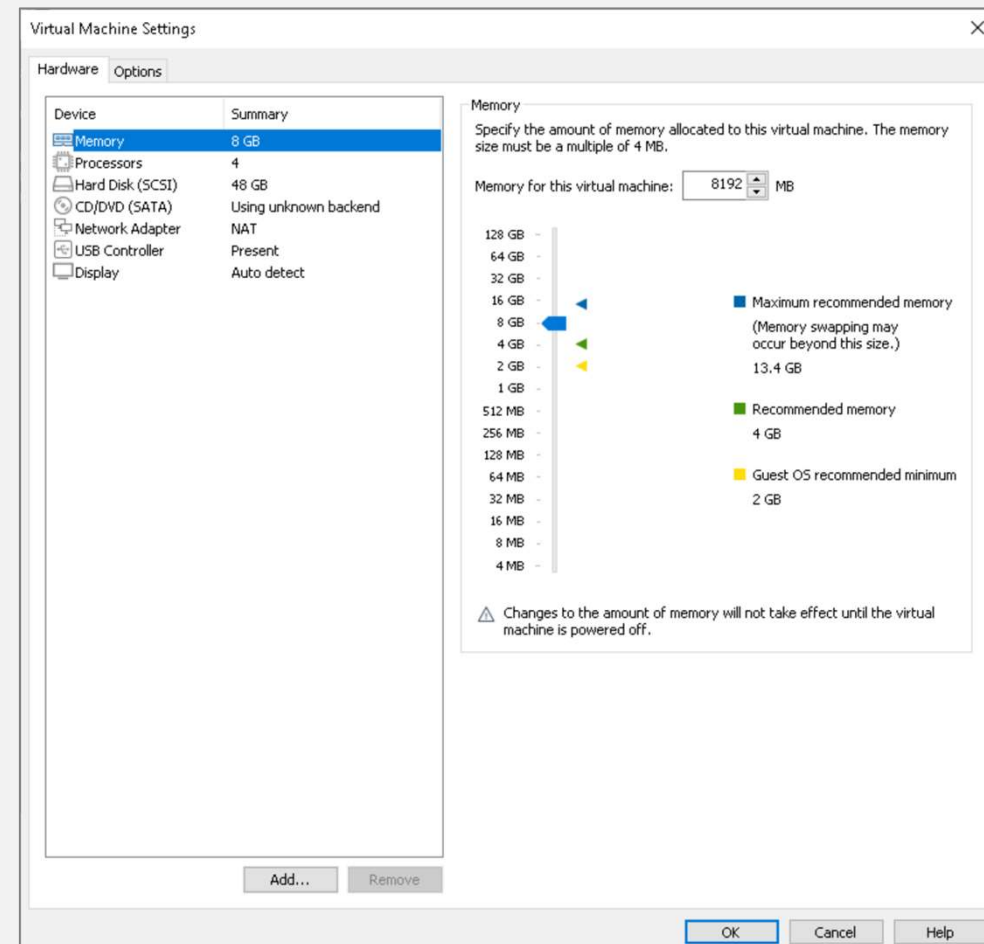
❖ Open a Virtual Machine



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>

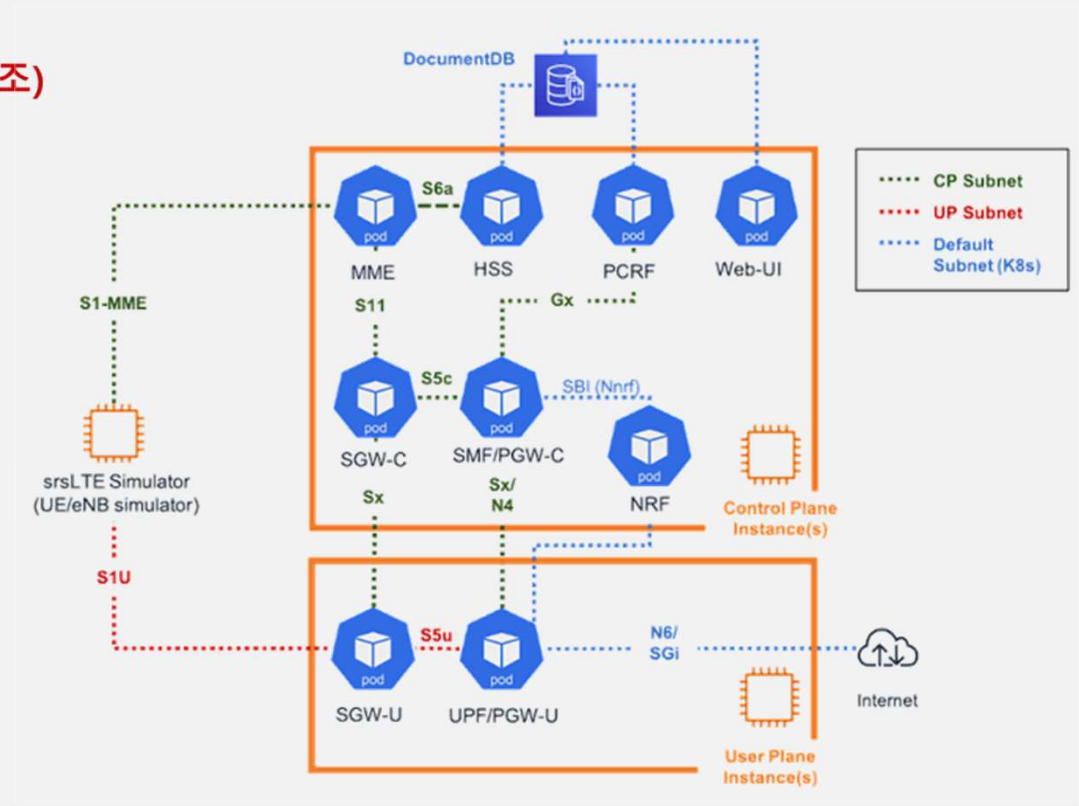
Source: <https://qiita.com/wzm/items/5c8a9ca811c146b0142c>



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

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://gradient.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`

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

Add vNIC(host only adapter) for WebUI

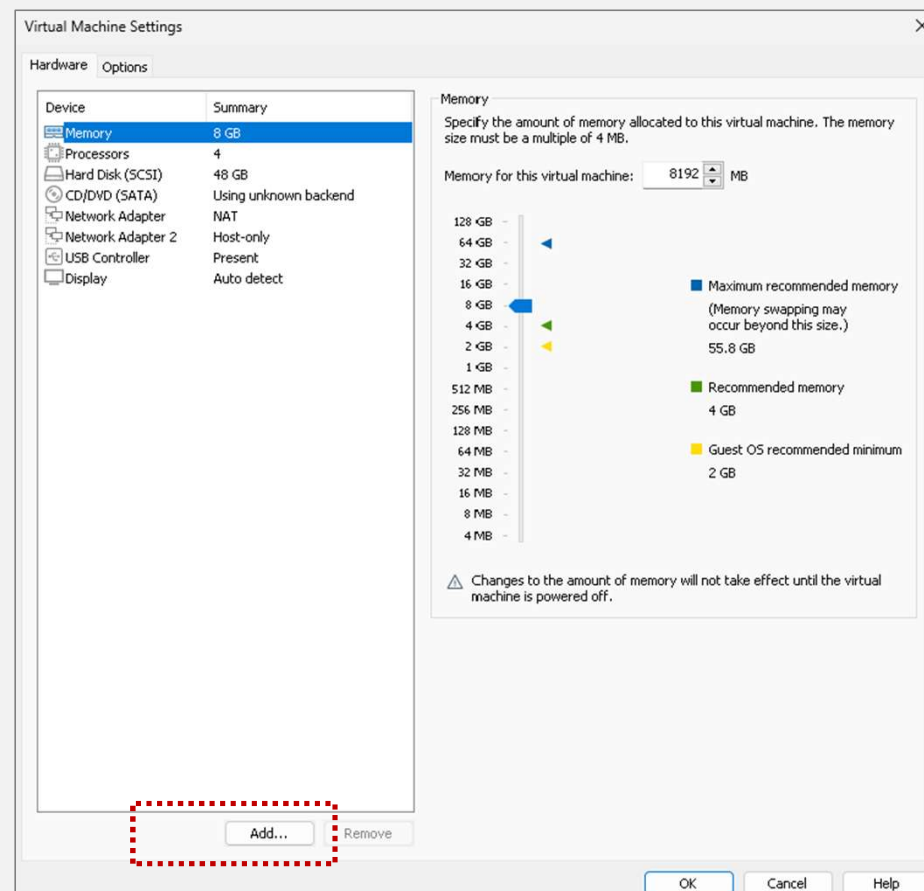


IV. TESTBED 3 (CLOUD NATIVE)

❖ 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
```




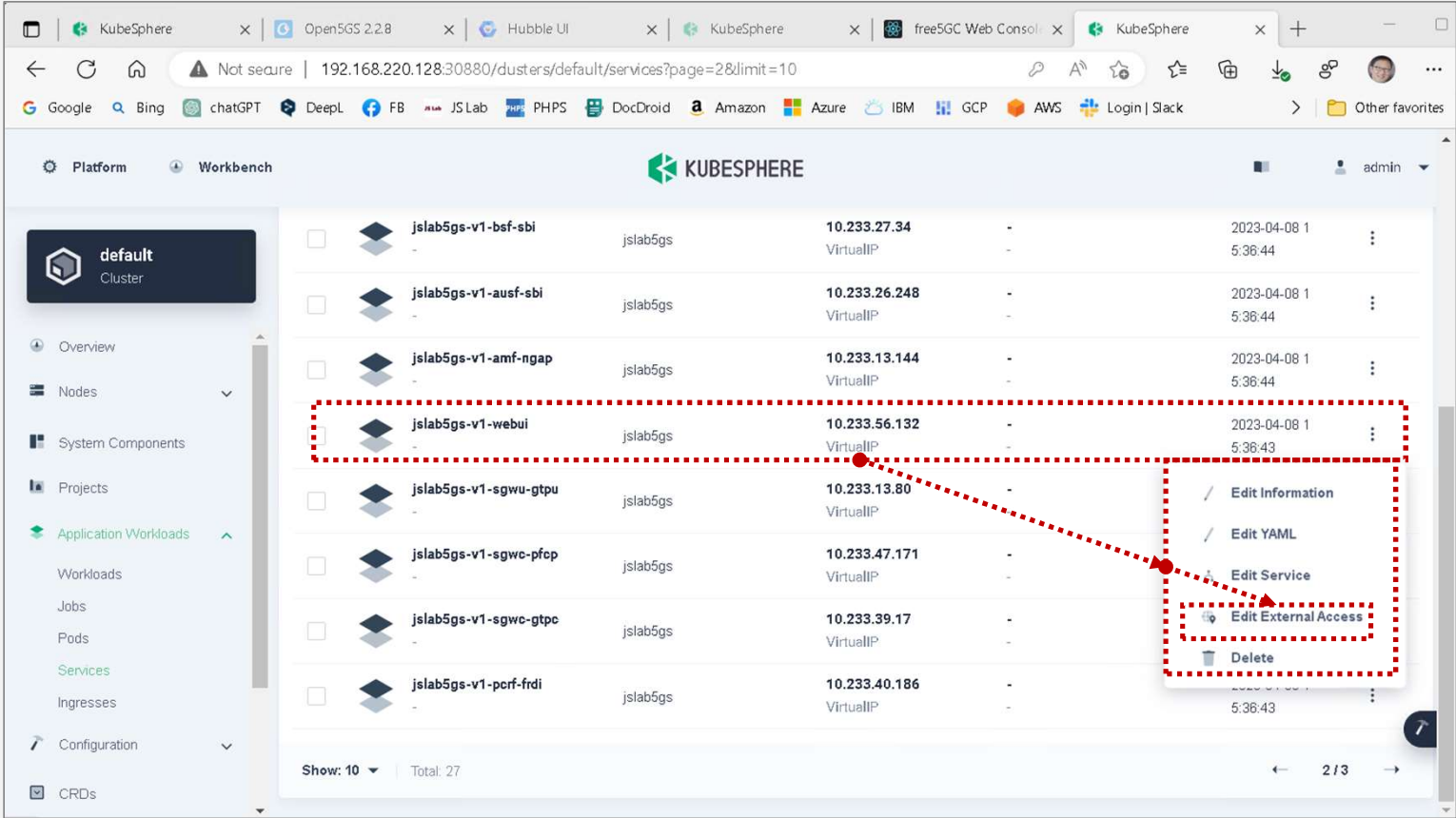
IV. TESTBED 3 (CLOUD NATIVE)

❖ External WebUI

- 1. WebUI
- 2. Extension
- 3. Exit External Access (NodePort)

Username : admin
Password : 1423





Service Name	Namespace	IP Address	Port	Created At
jslab5gs-v1-bsf-sbi	jslab5gs	10.233.27.34	-	2023-04-08 15:36:44
jslab5gs-v1-ausf-sbi	jslab5gs	10.233.26.248	-	2023-04-08 15:36:44
jslab5gs-v1-amf-ngap	jslab5gs	10.233.13.144	-	2023-04-08 15:36:44
jslab5gs-v1-webui	jslab5gs	10.233.56.132	-	2023-04-08 15:36:43
jslab5gs-v1-sgwu-gtpu	jslab5gs	10.233.13.80	-	-
jslab5gs-v1-sgwc-pfcp	jslab5gs	10.233.47.171	-	-
jslab5gs-v1-sgwc-gtpc	jslab5gs	10.233.39.17	-	-
jslab5gs-v1-pcrf-frdi	jslab5gs	10.233.40.186	-	2023-04-08 15:36:43



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

Name	Project	Internal Access	External Access	Creation Time
ueransim-gnb	jslab	None Headless	-	2022-07-10 21:2 0:00
open5gs-webui	jslab	10.233.8.44 Virtual IP	32428/TCP Ports	2022-07-10 21:1 1:58
open5gs-upf	jslab	10.233.63.188 Virtual IP	-	
open5gs-udr	jslab	10.233.42.141 Virtual IP	-	
open5gs-udm	jslab	10.233.30.202 Virtual IP	-	
open5gs-smf	jslab	10.233.15.193 Virtual IP	-	
open5gs-sgwu	jslab	10.233.8.141 Virtual IP	-	2022-07-10 21:1 1:58
open5gs-sgwc	jslab	10.233.27.40 Virtual IP	-	2022-07-10 21:1 1:58
open5gs-pcrf	jslab	10.233.9.152 Virtual IP	-	2022-07-10 21:1 1:58
open5gs-pcf	jslab	10.233.59.194 Virtual IP	-	2022-07-10 21:1 1:58

External Access
Set the method for accessing the service from outside the cluster.

Access Mode

- None
Internal access is not supported. The service can be accessed only within the cluster.
- NodePort**
Use a port of the cluster nodes to access the service. ✓
- LoadBalancer
Use a load balancer to access the service.

Buttons: Cancel, OK



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/...)

Name	Node	Pod IP address	CPU	Memory
ueransim-v1-ue-784f76f55-kd...	5g (192.168.5...)	10.233.95.107	CPU 1 m	Memory 7.96 Mi
ueransim-v1-gnb-6fd9c7f79c-...	5g (192.168.5...)	10.233.95.106...	CPU 0 m	Memory 5.96 Mi
mongodb-0	5g (192.168.5...)	10.233.95.78	CPU 14 m	Memory 208.59 Mi
free5gc-v1-free5gc-webui-we...	5g (192.168.5...)	10.233.95.77	CPU 1 m	Memory 9.96 Mi
free5gc-v1-free5gc-upf-upf-7...	5g (192.168.5...)	10.233.95.83...	CPU 0 m	Memory 65.13 Mi
free5gc-v1-free5gc-udr-udr-5...	5g (192.168.5...)	10.233.95.79	CPU 0 m	Memory 9.12 Mi

free5gc

Status: **Active**

Cluster: default

Workspace: -

Creation Time: 2022-07-01 01:37:09

Creator: -

Resource Status

Resource Type	Count
Pods	13
Deployments	12
Statefulset	1
Daemonsets	0
Jobs	0
Cronjobs	0
Persistent Volume Claim	1
Services	11
Routes	0

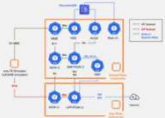
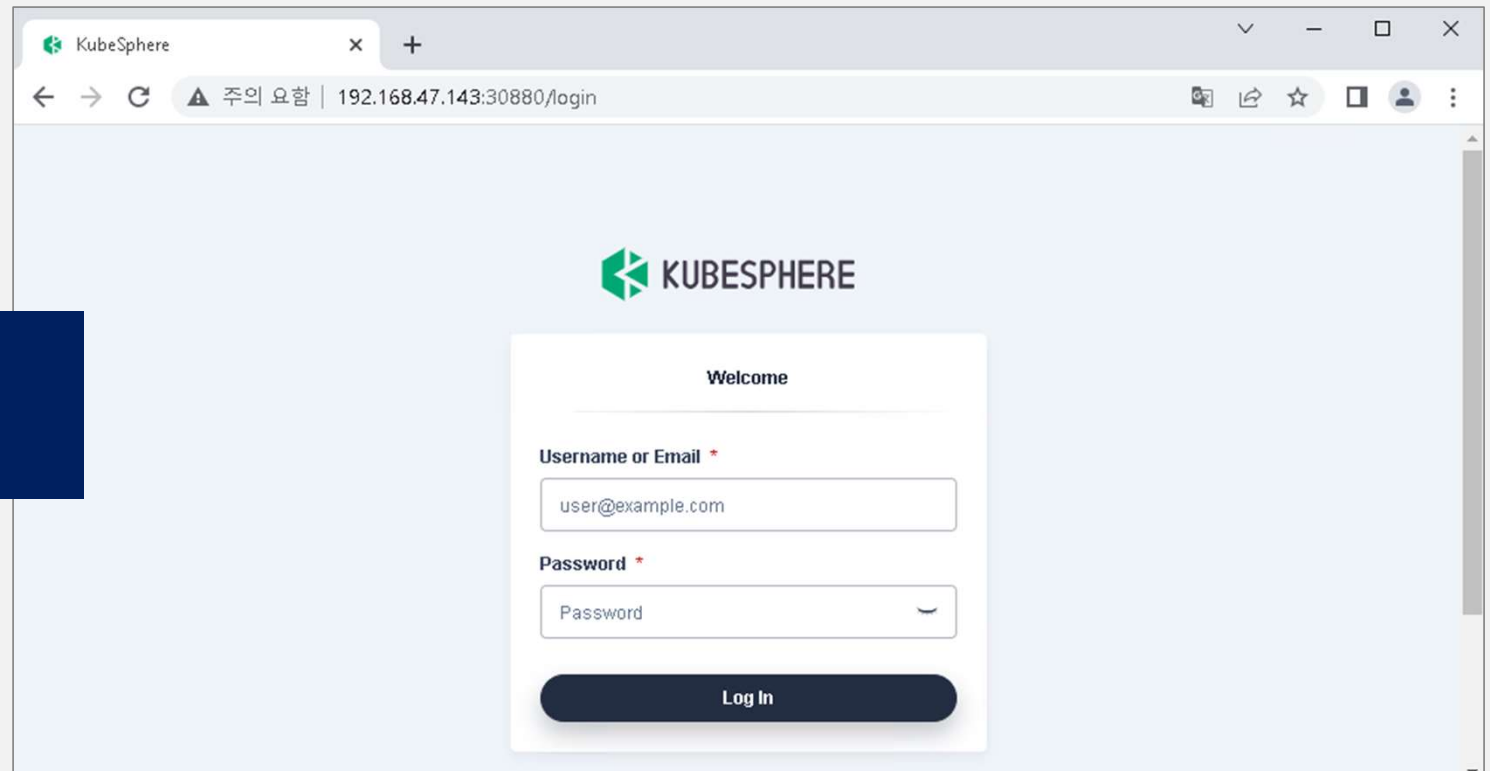


IV. TESTBED 3 (CLOUD NATIVE)

❖ 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

The screenshot displays the KubeSphere Workloads page for the 'default' cluster. The page title is 'Workloads' and it includes a sub-header: 'Workloads are used to handle service requests and can contain one or more pods. System functions such as logging and monitoring are also implemented by workloads. [Learn More](#)'. Below the title, there are tabs for 'Deployments', 'Statefulsets', and 'Daemonssets', with 'Deployments' selected. A search bar contains the text 'free5gc'. A 'Create' button is visible in the top right corner of the table area. The table lists several deployments, all with a status of 'Running'.

Name	Status	Project	Update Time
lcransim-v1-ue	Running (1/1)	free5gc	2022-08-17 18:40:31
lcransim-v1-gnb	Running (1/1)	free5gc	2022-08-17 18:40:15
free5gc-v1-free5gc-smf-smf	Running (2/2)	free5gc	2022-08-17 15:20:24
free5gc-v1-free5gc-nssf-nssf	Running (1/1)	free5gc	2022-08-17 15:14:20
free5gc-v1-free5gc-udm-udm	Running (1/1)	free5gc	2022-08-17 15:14:18
free5gc-v1-free5gc-pcf-pcf	Running (1/1)	free5gc	2022-08-17 15:14:13
free5gc-v1-free5gc-udr-udr	Running (1/1)	free5gc	2022-08-17 15:14:11
free5gc-v1-free5gc-amf-amf	Running (1/1)	free5gc	2022-08-17 15:14:08
free5gc-v1-free5gc-ausf-ausf	Running (1/1)	free5gc	2022-08-17 15:14:06
free5gc-v1-free5gc-nrf-nrf	Running (1/1)	free5gc	2022-08-17 15:14:01



IV. TESTBED 3 (CLOUD NATIVE)

❖ Cloud Native @ KubeSphere

The screenshot displays the KubeSphere Workbench interface. The browser address bar shows the URL: `192.168.50.200:30880/clusters/default/projects/free5gc/pods/ueransim-v1-ue-6b7bf76f56-v2xhb/resource-status`. The interface includes a navigation menu with 'Platform' and 'Workbench' options. The main content area is titled 'Pods' and shows details for a specific pod: `ueransim-v1-ue-6b7bf76f56-v...`. The pod is in a 'Running' state. The 'Containers' section shows one container named 'ue' with the image `towards5gs/ueransim-ue:v3.2.6`. The 'Volumes' section lists several volumes: `ue-volume` (configmap), `ue-configmap` (configmap), `ue` (mounting `/ueransim/config`), `kube-api-access-jt7d8` (Persistent Volume Claim), and `ue` (mounting `/var/run/secrets/kubernetes.io/serviceaccount`).

Containers	Status	Restarts	Ports
ue Image: towards5gs/ueransim-ue:v3.2.6	Running	0	-

Volumes	Mount Path	Permissions
ue-volume Volume type: configmap		
ue-configmap Configmap		
ue	/ueransim/config	(read and write)
kube-api-access-jt7d8 Storage class: -		
ue	/var/run/secrets/kubernetes.io/serviceaccount	(read-only)



IV. TESTBED 3 (CLOUD NATIVE)

❖ 노출 포트 지정

The screenshot shows the KubeSphere console interface. On the left sidebar, the 'Projects' menu item is highlighted with a red dashed box and labeled 'Namespace'. The main area displays a table of services in the 'default' namespace. The first row, 'webui-service', has its IP address '10.233.35.142' and port '30500/TCP' highlighted with a red dashed box and labeled '노출 Port'. A context menu is open over the 'pcf-npcf' service, with the 'Edit External Access' option highlighted by a red dashed box and labeled '노출 Port 지정'.

Service	Namespace	IP Address	Port	Created
webui-service	free5gc	10.233.35.142	30500/TCP	2022-07-01 01:38:08
udr-nudr	free5gc	10.233.2.107	-	2022-07-01 01:38:08
udm-nudm	free5gc	10.233.48.151	-	2022-07-01 01:38:08
smf-nsmf	free5gc	10.233.49.167	-	-
pcf-npcf	free5gc	10.233.61.116	-	-
nssf-nssf	free5gc	10.233.34.190	-	2022-07-01 01:38:08



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 parameters

```

```

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 override the
## global value
## Current available global Docker image parameters

## @param kubeVersion Override Kubernetes version
##
kubeVersion: ""

## @param nameOverride String to override the component name
##
nameOverride: ""

## @param fullnameOverride String to override the component full name
##
fullnameOverride: ""

## @param commonLabels Labels to add to all objects
##
commonLabels: {}

## @param commonAnnotations Annotations to add to all objects
##
commonAnnotations: {}

## @param clusterDomain Kubernetes cluster domain
##
clusterDomain: cluster.local

## @param extraDeploy Array of extra manifests to deploy with the release
##
extraDeploy: []

## @section Common parameters
##
kubeVersion: ""

## @param nameOverride String to override the component name
##
nameOverride: ""

## @param fullnameOverride String to override the component full name
##
fullnameOverride: ""

## @param commonLabels Labels to add to all objects
##
commonLabels: {}

## @param commonAnnotations Annotations to add to all objects
##
commonAnnotations: {}

## @param clusterDomain Kubernetes cluster domain
##
clusterDomain: cluster.local

## @param extraDeploy Array of extra manifests 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-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: []

```

sudo su - root
(return with ctrl-d)

configured to use the
datastore

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-clgl                       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-54ccb7c9d-51j66                    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-hrkkd                   1/1     Running   0           22m
jslab5gs       jslab5gs-v1-smf-c7bf5b64c-gl6mw                     1/1     Running   0           22m
jslab5gs       jslab5gs-v1-udm-66b9c856b4-7h4s2                    1/1     Running   0           22m
jslab5gs       jslab5gs-v1-udr-7c775f4fbc-fnce2                    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-6699d7bdb9-5lbf5                       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-qhmkd                             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-lsqtq                                     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
kubernetes-system default-http-backend-5bf68ff9b8-trg78                1/1     Running   2 (34m ago) 3h16m
kubernetes-system kubectl-admin-6dbcb94855-k966g                       1/1     Running   2 (33m ago) 3h7m
kubernetes-monitoring-system alertmanager-main-0                                  2/2     Running   4 (34m ago) 3h11m
kubernetes-monitoring-system kube-state-metrics-687d66b747-g8xfv                   3/3     Running   6 (34m ago) 3h12m
kubernetes-monitoring-system node-exporter-tsgtg                                    2/2     Running   4 (34m ago) 3h12m
kubernetes-monitoring-system notification-manager-deployment-78664576cb-2b78s 2/2     Running   4 (33m ago) 3h9m
kubernetes-monitoring-system notification-manager-operator-7d44854f54-nzgxg 2/2     Running   4 (34m ago) 3h10m
kubernetes-monitoring-system prometheus-k8s-0                                       2/2     Running   4 (34m ago) 3h11m
kubernetes-monitoring-system prometheus-operator-8955bbd98-x9fbh                   2/2     Running   4 (34m ago) 3h12m
kubernetes-system ks-apiserver-576fbd5df4-vpssv                       1/1     Running   2 (34m ago) 3h16m
kubernetes-system ks-console-5c9fcbc67b-hzdn7                    1/1     Running   2 (34m ago) 3h16m
kubernetes-system ks-controller-manager-f8dfd55c8-2t4v5    1/1     Running   2 (34m ago) 3h16m
kubernetes-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-qbxm    1/1     Running
jslab5gs-v1-bsf-75854784b-clgc       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-54ccb7c9d-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-6699d7bdb9-5lbf5       0/1     CrashLoopBackOff
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 chart to deploy Free5GC
towards5gs/free5gc-ausf 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-n3iwf 0.2.1          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-nrf 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-nssf 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-pcf 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-smf 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-udm 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-udr 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-upf 0.2.1          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-webui 0.1.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gcControlPlane 0.1.2          v3.0.5      DEPRECATED
towards5gs/free5gcN3iwf 0.1.2          v3.0.5      DEPRECATED
towards5gs/free5gcUserPlane 0.1.2          v3.0.5      DEPRECATED
towards5gs/networks5g 0.1.2          0.1.2       DEPRECATED
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'

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

```

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"

```



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-uersanim-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              uersanim-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

```

jslab@5g:~$ sudo su - root
[sudo] password for jslab:
root@5g:~# helm show values openverso/open5gs
# Default values for open5gs
# This is a YAML-formatted file.
# Declare variables to be passed into your templates

# image - The base image
# for default see https://
image:
  registry: docker.io
  repository: openverso/
  tag: 2.4.4
  # Specify a imagePullPolicy
  # Defaults to 'Always' if
  # not present.
  # ref: http://kubernetes
  pullPolicy: IfNotPresent
  # Optionally specify a
  # secret name.
  # ref: https://kubernetes
  pullSecrets: []

# imageCredentials:
# registry:
# username:
# password:
# email:

# ingress
# For a full ingress
# ref: https://kubernetes.io/docs/concepts/services-networking/ingress/
# If certManager is enabled
# annotations:
#   kubernetes.io/ingress.class: nginx
#   nginx.ingress.kubernetes.io/ssl-redirect: 'true'
# Enable TLS termination
# TLS certificates are
# managed by certManager
# You can use the
# default secret name, or
# specify one.
# ref: https://cert-manager.io/docs/usage/ingress/#
tls: false
# db_uri -- default is
# mongodb -- password
# mongodb.enabled --
# mongodb.auth.enabled
# securityPolicy --
securityPolicy:
  enabled: false

# Set to true to enable
# certManager: false

# Ingress Path type
pathType: ImplementationSpecific

# When the ingress is enabled, a hostPath pointing to /etc/hosts will be created
# If empty, defaults to .Release.Name-.Release.Namespace.ingress.lab5g.gradiant.org
hostname: ""

# The Path to open5gs webui. You may need to set this to '/' in order to use this
# with ALB ingress controllers.
path: /

webui:
  image:
    registry: docker.io
    repository: openverso/
    tag: 2.3.3
    # Specify a imagePullPolicy
    # Defaults to 'Always' if
    # not present.
    # ref: http://kubernetes
    pullPolicy: IfNotPresent
    # Optionally specify a
    # secret name.
    # ref: https://kubernetes
    pullSecrets: []
  ingress:
    # Set to true to enable
    enabled: true

amf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
    sst: 1
    sd: "ffffff"
  externalService:
    enabled: false
    advertiseDomain: "ext.
type: LoadBalancer
    # @param service.loadBalancerSourceRanges
    # e.g.:
    # - 0.0.0.0/0
  loadBalancerSourceRanges:
    # @param service.loadBalancerIP
    # ref: http://kubernetes
    loadBalancerIP:
    # external advertise
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

ausf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
    sst: 1
    sd: "ffffff"
  externalService:
    enabled: false
    type: LoadBalancer
    # @param service.loadBalancerSourceRanges
    # e.g.:
    # - 0.0.0.0/0
  loadBalancerSourceRanges:
    # @param service.loadBalancerIP
    # ref: http://kubernetes
    loadBalancerIP:
    # external advertise
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

mme:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
  externalService:
    enabled: false
    type: LoadBalancer
    # @param service.loadBalancerSourceRanges
    # e.g.:
    # - 0.0.0.0/0
  loadBalancerSourceRanges:
    # @param service.loadBalancerIP
    # ref: http://kubernetes
    loadBalancerIP:
    # external advertise
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

nrf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
  externalService:
    enabled: false
    type: LoadBalancer
    # @param service.loadBalancerSourceRanges
    # e.g.:
    # - 0.0.0.0/0
  loadBalancerSourceRanges:
    # @param service.loadBalancerIP
    # ref: http://kubernetes
    loadBalancerIP:
    # external advertise
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

nsmf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
  externalService:
    enabled: false
    type: LoadBalancer
    # @param service.loadBalancerSourceRanges
    # e.g.:
    # - 0.0.0.0/0
  loadBalancerSourceRanges:
    # @param service.loadBalancerIP
    # ref: http://kubernetes
    loadBalancerIP:
    # external advertise
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

nssf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
  externalService:
    enabled: false
    type: LoadBalancer
    # @param service.loadBalancerSourceRanges
    # e.g.:
    # - 0.0.0.0/0
  loadBalancerSourceRanges:
    # @param service.loadBalancerIP
    # ref: http://kubernetes
    loadBalancerIP:
    # external advertise
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

pcf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
  externalService:
    enabled: false
    type: LoadBalancer
    # @param service.loadBalancerSourceRanges
    # e.g.:
    # - 0.0.0.0/0
  loadBalancerSourceRanges:
    # @param service.loadBalancerIP
    # ref: http://kubernetes
    loadBalancerIP:
    # external advertise
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

pcf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
  externalService:
    enabled: false
    type: LoadBalancer
    # @param service.loadBalancerSourceRanges
    # e.g.:
    # - 0.0.0.0/0
  loadBalancerSourceRanges:
    # @param service.loadBalancerIP
    # ref: http://kubernetes
    loadBalancerIP:
    # external advertise
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

pcrf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
  externalService:
    enabled: false
    type: LoadBalancer
    # @param service.loadBalancerSourceRanges
    # e.g.:
    # - 0.0.0.0/0
  loadBalancerSourceRanges:
    # @param service.loadBalancerIP
    # ref: http://kubernetes
    loadBalancerIP:
    # external advertise
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

sgwc:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
  externalService:
    enabled: false
    type: LoadBalancer
    # @param service.loadBalancerSourceRanges
    # e.g.:
    # - 0.0.0.0/0
  loadBalancerSourceRanges:
    # @param service.loadBalancerIP
    # ref: http://kubernetes
    loadBalancerIP:
    # external advertise
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

smf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
  externalService:
    enabled: false
    type: LoadBalancer
    # @param service.loadBalancerSourceRanges
    # e.g.:
    # - 0.0.0.0/0
  loadBalancerSourceRanges:
    # @param service.loadBalancerIP
    # ref: http://kubernetes
    loadBalancerIP:
    # external advertise
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

sgw:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
  externalService:
    enabled: false
    type: LoadBalancer
    # @param service.loadBalancerSourceRanges
    # e.g.:
    # - 0.0.0.0/0
  loadBalancerSourceRanges:
    # @param service.loadBalancerIP
    # ref: http://kubernetes
    loadBalancerIP:
    # external advertise
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

udm:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
  externalService:
    enabled: false
    type: LoadBalancer
    # @param service.loadBalancerSourceRanges
    # e.g.:
    # - 0.0.0.0/0
  loadBalancerSourceRanges:
    # @param service.loadBalancerIP
    # ref: http://kubernetes
    loadBalancerIP:
    # external advertise
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

udr:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
  externalService:
    enabled: false
    type: LoadBalancer
    # @param service.loadBalancerSourceRanges
    # e.g.:
    # - 0.0.0.0/0
  loadBalancerSourceRanges:
    # @param service.loadBalancerIP
    # ref: http://kubernetes
    loadBalancerIP:
    # external advertise
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

upf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
  externalService:
    enabled: false
    type: LoadBalancer
    # @param service.loadBalancerSourceRanges
    # e.g.:
    # - 0.0.0.0/0
  loadBalancerSourceRanges:
    # @param service.loadBalancerIP
    # ref: http://kubernetes
    loadBalancerIP:
    # external advertise
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

```

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 secret names (comma separated)
## @param global.storageClass Global StorageClass for PersistentVolumes (if not set to 'storageClassName')
global:
  imageRegistry:
  ## E.g.
  ## imagePullSecrets:
  ## - myRegistryKeySecretName
  imagePullSecrets: []
  storageClass:

## @section Common parameters

## @param kubeVersion Override Kubernetes version
##
kubeVersion:
## @param nameOverride String to partially override common.namespaces
##
nameOverride:
## @param fullnameOverride String to fully override common.namespaces
##
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: "0xfffff"
tac: '0001'

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

ues:
  enabled: false
  count: 1
  initialMSISDN: '0000000001'
  key: 465B5CE8B199B49FAA5FOA2EE238A6BC
  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 under the terms of the Apache License
# the text of which is available at https://www.apache.org/licenses/LICENSE-2.0
# or see the "LICENSE" file for more details.
#
# Author: Abderaouf KHICHANE, Ilhem KHICHANE
# Software description: An open-source 5G RAN/UE testbed
#
# Default values for ueransim-chart.
# This is a YAML-formatted file.
# Declare variables to be passed into your templates.

global:
  multiCluster: false
  #Global network parameters
  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: |-
  mnc: '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
  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
  # 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-20893000000003" # IMSI number
  mnc: '208' # Mobile Country Code value
  mnc: '93' # Mobile Network Code value (2 or 3 digits)
  key: "8baf473f2f8fd09487ccbd7097c6862" # 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 the UE
  imeiSv: '4370816125816151' # 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-
      volume:
        name: connectivity-test-volume
        mount: /scripts
        ttlseconds: 50
  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

```

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: |-
mnc: '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
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
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-20893000000003" # IMSI number
mnc: '208' # Mobile Country Code value
mnc: '93' # Mobile Network Code value (2 or 3 digits)
key: "8baf473f2f8fd09487ccbd7097c6862" # 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 the UE
imeiSv: '4370816125816151'
UAC Access Identities Configuration
uacAcc:
mps: false
mcs: false
UAC Access Control Class
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-
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
#
# 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

imsi-208930000000003

```

root@5g:~# helm show values towards5gs/ueransim
#
# Software Name : towards5gs-helm
# SPDX-FileCopyrightText: Copyright (c) 2022 OpenVerse
# SPDX-License-Identifier: Apache-2.0
#
# This software is distributed under the terms of the Apache License, Version 2.0
# the text of which is available at https://www.apache.org/licenses/LICENSE-2.0
# or see the "LICENSE" file for more details
#
# Author: Abderaouf KHICHANE, Ilhem FAJJAJ
# Software description: An open-source project for 5G RAN/UE deployment
#
# Default values for ueransim-chart.
# This is a YAML-formatted file.
# Declare variables to be passed into your templates

global:
  multiCluster: false
  #Global network parameters
  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" # This
  # A script that will be run after the UE creation. It
  # is 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: "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
  # either 'OP' or 'OPC'
  amf: '8000' # Authentication Management Field (AMF) value
  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

```

```

# 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

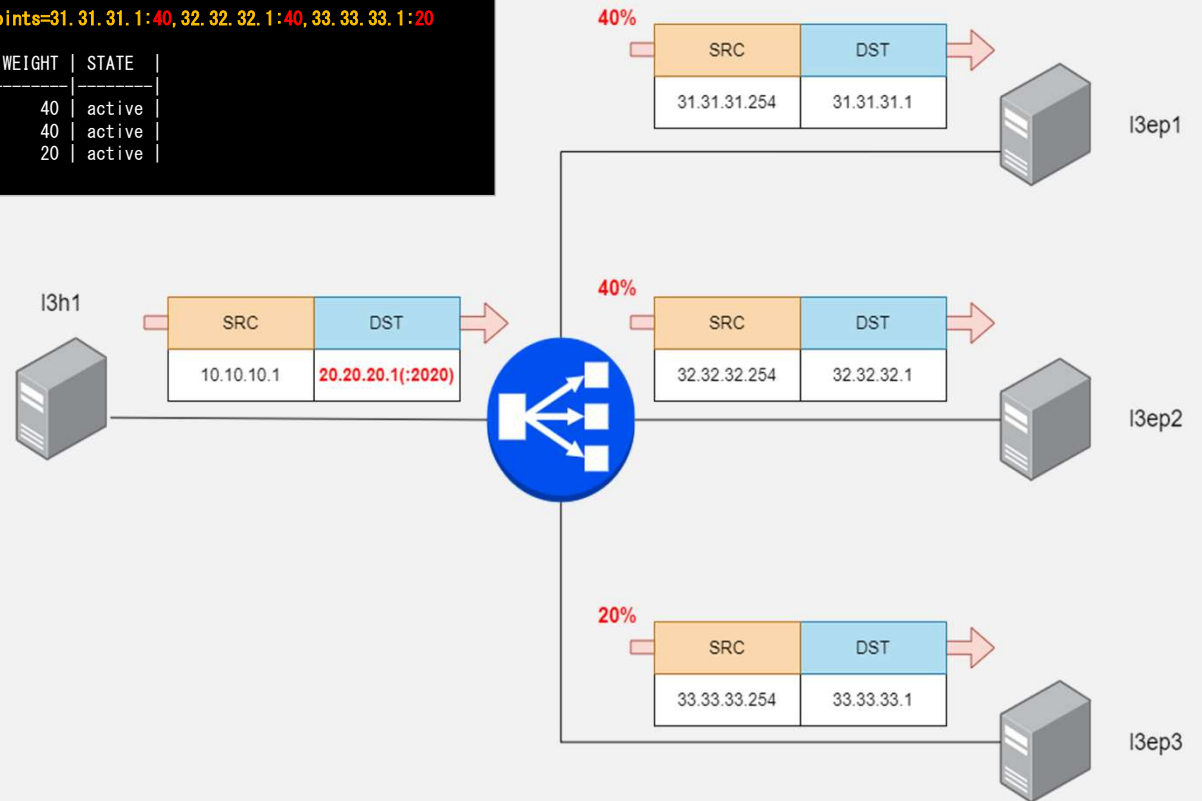
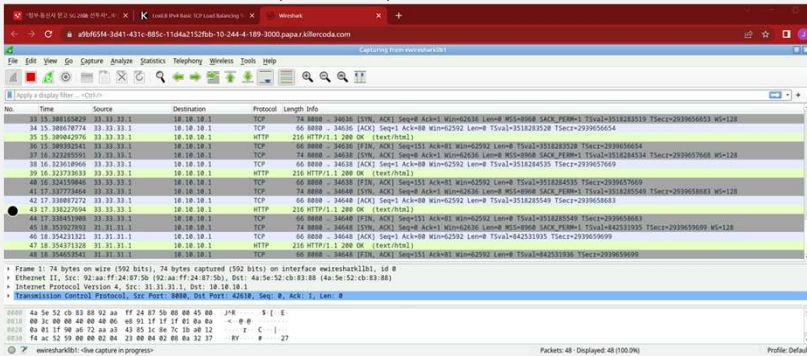
❖ IPv4 Basic TCP Load Balancing Test with WRR(Weighted Round Robin) Algorithm

- o 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 와이어샷(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:late  "/init"                 About a minute 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 l1b1
ubuntu $ docker exec -it l1b1 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.

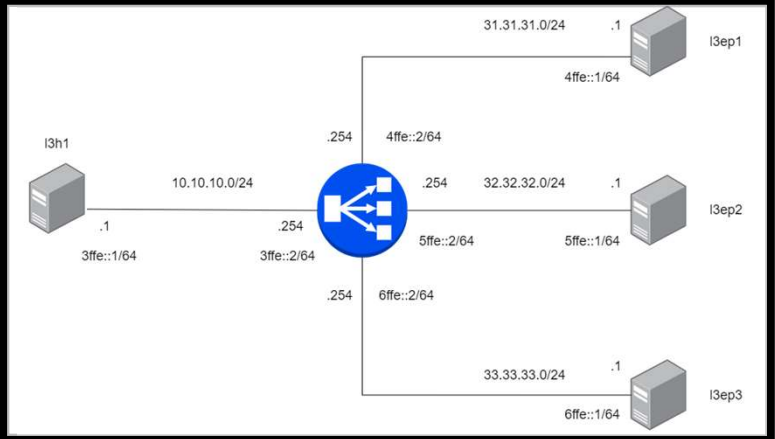
Usage:
  loxicmd [command]

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-wrrtcp1b>



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	el1b1l3h1
31.31.31.0	0.0.0.0	255.255.255.0	U	0	0	0	el1b1l3ep1
32.32.32.0	0.0.0.0	255.255.255.0	U	0	0	0	el1b1l3ep2
33.33.33.0	0.0.0.0	255.255.255.0	U	0	0	0	el1b1l3ep3
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
```

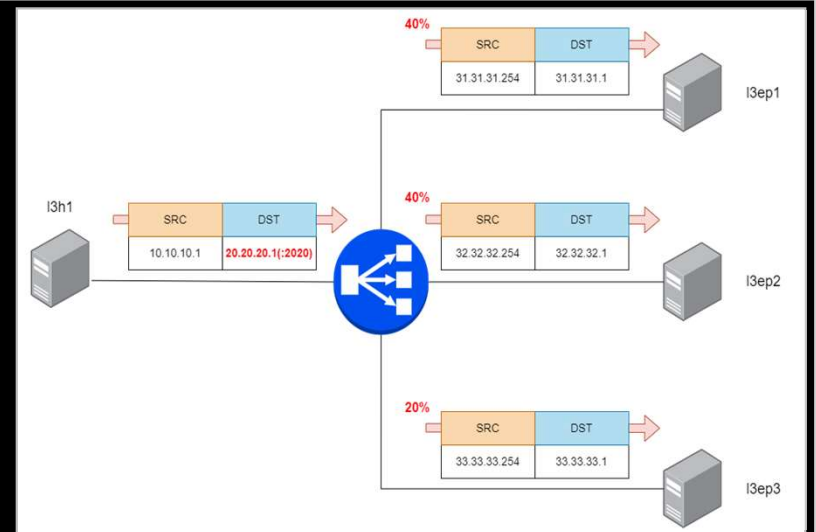
```
#####
```

```
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-wrrtcp1b>



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-wrrtcp1b1
server1 UP
server2 UP
server3 UP
server1
server1
server1
server1
server1
server1
server1
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-wrrtcp1b2 [OK]
```

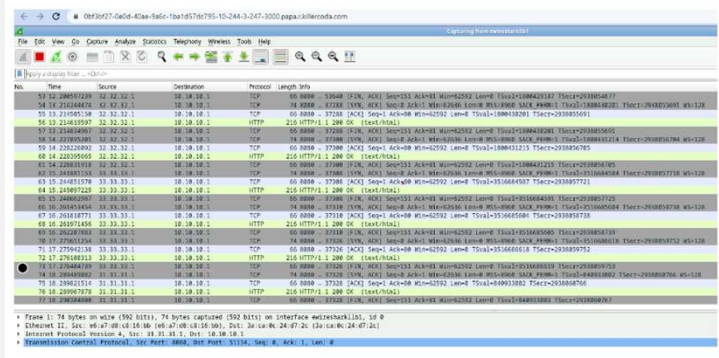
```
source ./common.sh
connect_docker_hosts_default_ns llb1 wireshark

./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 ewireshark11b1 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-wrrtcp1b>



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.

The screenshot shows a Wireshark interface with a capture filter set to 'ewiresharkllb1'. The packet list pane displays a series of network packets:

No.	Time	Source	Destination	Protocol	Length	Info
33	15.308165029	33.33.33.1	10.10.10.1	TCP	74	8080 → 34636 [SYN, ACK] Seq=0 Ack=1 Win=62636 Len=0 MSS=8960 SACK_PERM=1 TSval=3518283519 TSecr=2939656653 WS=128
34	15.308670774	33.33.33.1	10.10.10.1	TCP	66	8080 → 34636 [ACK] Seq=1 Ack=80 Win=62592 Len=0 TSval=3518283520 TSecr=2939656654
35	15.309042976	33.33.33.1	10.10.10.1	HTTP	216	HTTP/1.1 200 OK (text/html)
36	15.309392541	33.33.33.1	10.10.10.1	TCP	66	8080 → 34636 [FIN, ACK] Seq=151 Ack=81 Win=62592 Len=0 TSval=3518283520 TSecr=2939656654
37	16.323285591	33.33.33.1	10.10.10.1	TCP	74	8080 → 34638 [SYN, ACK] Seq=0 Ack=1 Win=62636 Len=0 MSS=8960 SACK_PERM=1 TSval=3518284534 TSecr=2939657668 WS=128
38	16.323610966	33.33.33.1	10.10.10.1	TCP	66	8080 → 34638 [ACK] Seq=1 Ack=80 Win=62592 Len=0 TSval=3518284535 TSecr=2939657669
39	16.323733633	33.33.33.1	10.10.10.1	HTTP	216	HTTP/1.1 200 OK (text/html)
40	16.324159046	33.33.33.1	10.10.10.1	TCP	66	8080 → 34638 [FIN, ACK] Seq=151 Ack=81 Win=62592 Len=0 TSval=3518284535 TSecr=2939657669
41	17.337773464	33.33.33.1	10.10.10.1	TCP	74	8080 → 34640 [SYN, ACK] Seq=0 Ack=1 Win=62636 Len=0 MSS=8960 SACK_PERM=1 TSval=3518285549 TSecr=2939658683 WS=128
42	17.338087272	33.33.33.1	10.10.10.1	TCP	66	8080 → 34640 [ACK] Seq=1 Ack=80 Win=62592 Len=0 TSval=3518285549 TSecr=2939658683
43	17.338227694	33.33.33.1	10.10.10.1	HTTP	216	HTTP/1.1 200 OK (text/html)
44	17.338451908	33.33.33.1	10.10.10.1	TCP	66	8080 → 34640 [FIN, ACK] Seq=151 Ack=81 Win=62592 Len=0 TSval=3518285549 TSecr=2939658683
45	18.353927893	31.31.31.1	10.10.10.1	TCP	74	8080 → 34648 [SYN, ACK] Seq=0 Ack=1 Win=62636 Len=0 MSS=8960 SACK_PERM=1 TSval=842531935 TSecr=2939659699 WS=128
46	18.354231321	31.31.31.1	10.10.10.1	TCP	66	8080 → 34648 [ACK] Seq=1 Ack=80 Win=62592 Len=0 TSval=842531935 TSecr=2939659699
47	18.354371328	31.31.31.1	10.10.10.1	HTTP	216	HTTP/1.1 200 OK (text/html)
48	18.354653541	31.31.31.1	10.10.10.1	TCP	66	8080 → 34648 [FIN, ACK] Seq=151 Ack=81 Win=62592 Len=0 TSval=842531936 TSecr=2939659699

The packet details pane for the selected packet (No. 48) shows:

- Frame 1: 74 bytes on wire (592 bits), 74 bytes captured (592 bits) on interface ewiresharkllb1, id 0
- Ethernet II, Src: 92:aa:ff:24:87:5b (92:aa:ff:24:87:5b), Dst: 4a:5e:52:cb:83:88 (4a:5e:52:cb:83:88)
- Internet Protocol Version 4, Src: 31.31.31.1, Dst: 10.10.10.1
- Transmission Control Protocol, Src Port: 8080, Dst Port: 42610, Seq: 0, Ack: 1, Len: 0

The packet bytes pane shows the raw hex and ASCII data for the captured frame.

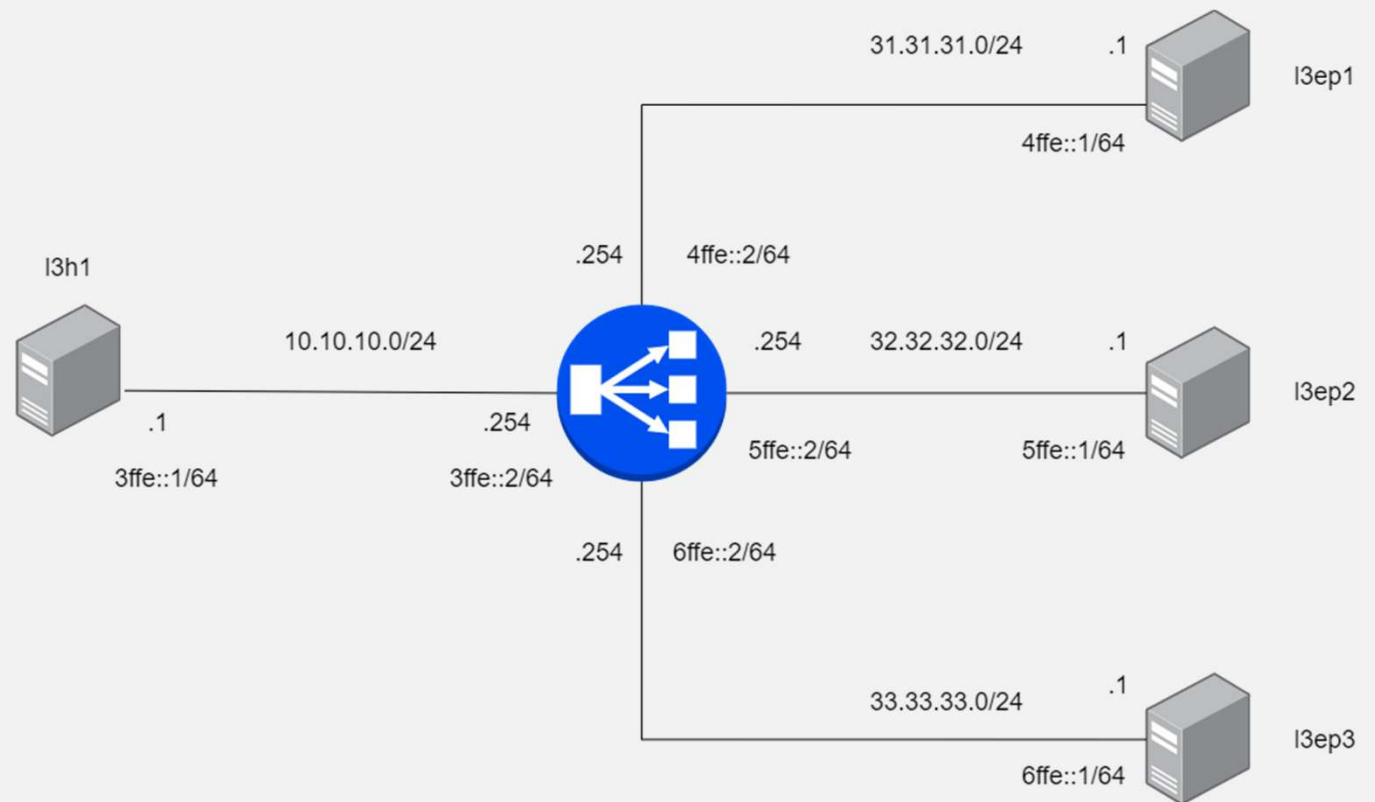
Source: <https://killercoda.com/netlox/scenario/loxilb-wrrtcpb>



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



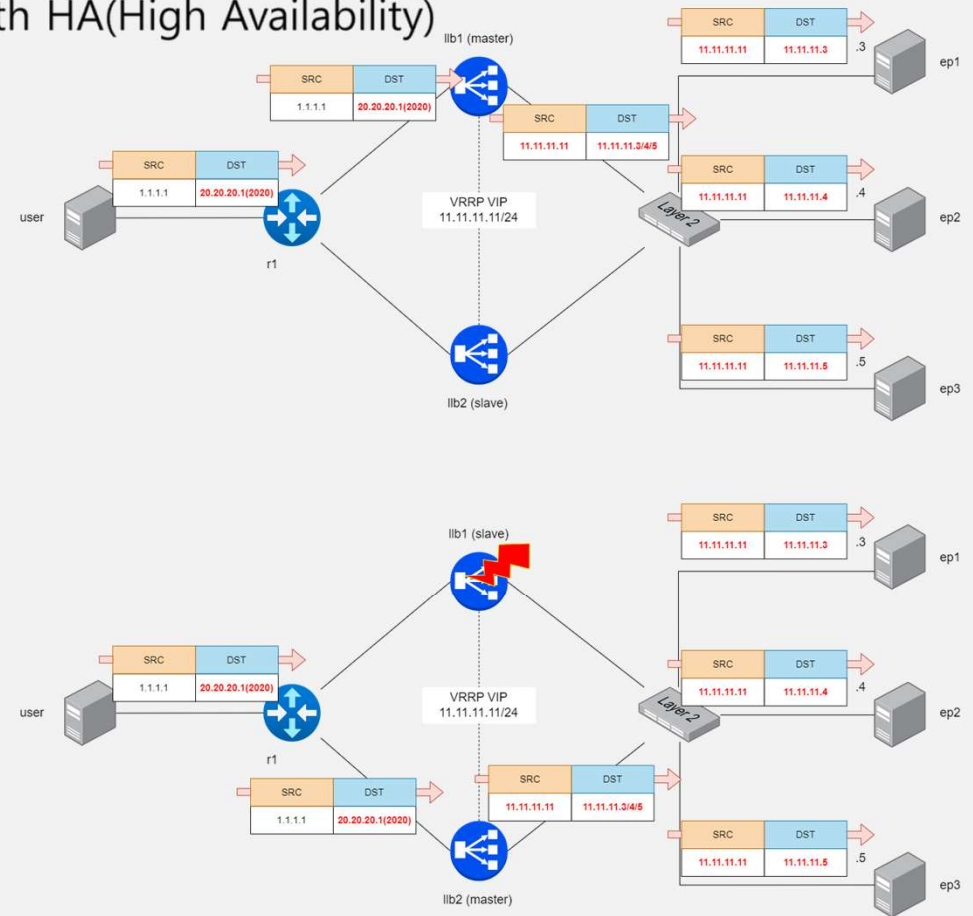
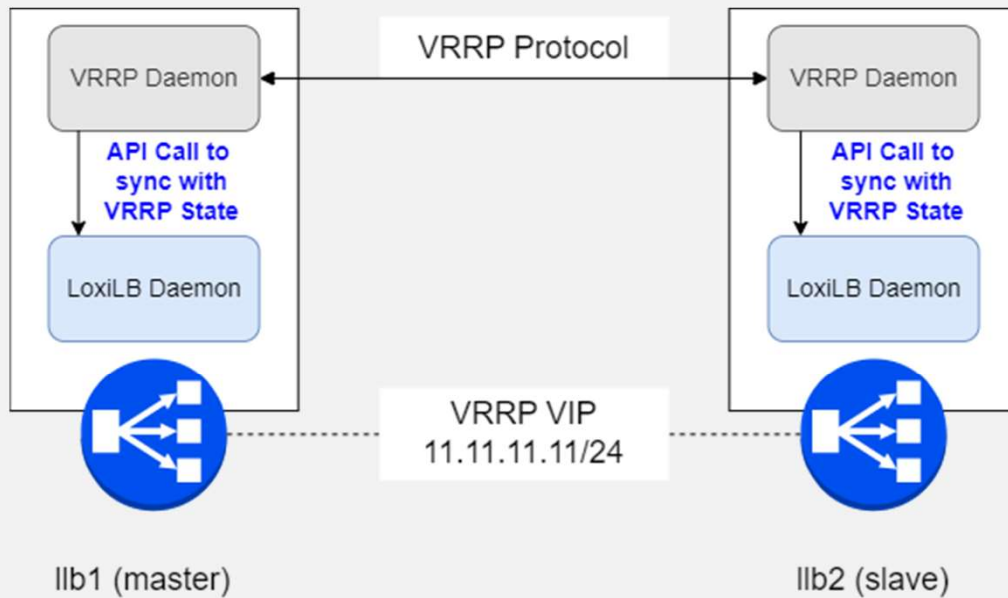
Source: <https://killercoda.com/netlox>



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)



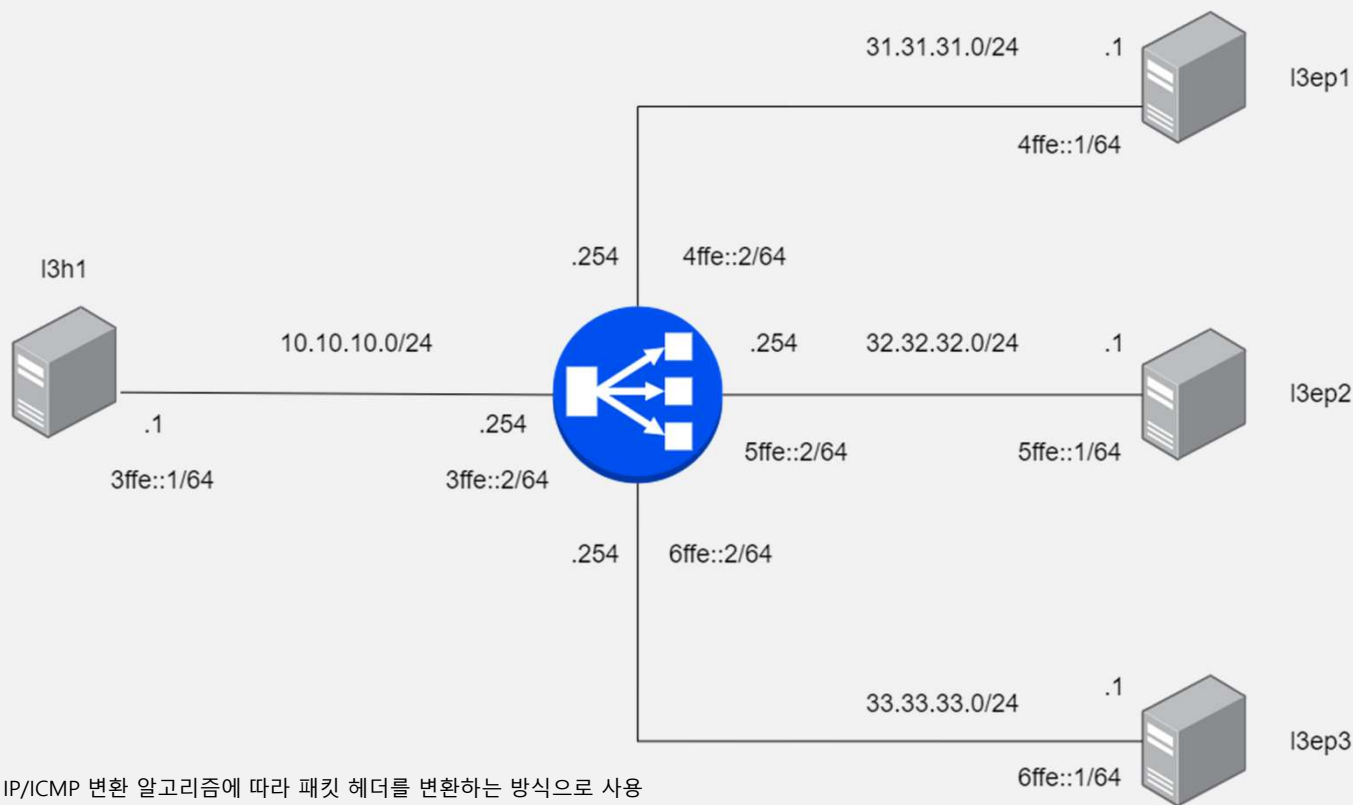
Source: <https://killercoda.com/netlox>



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

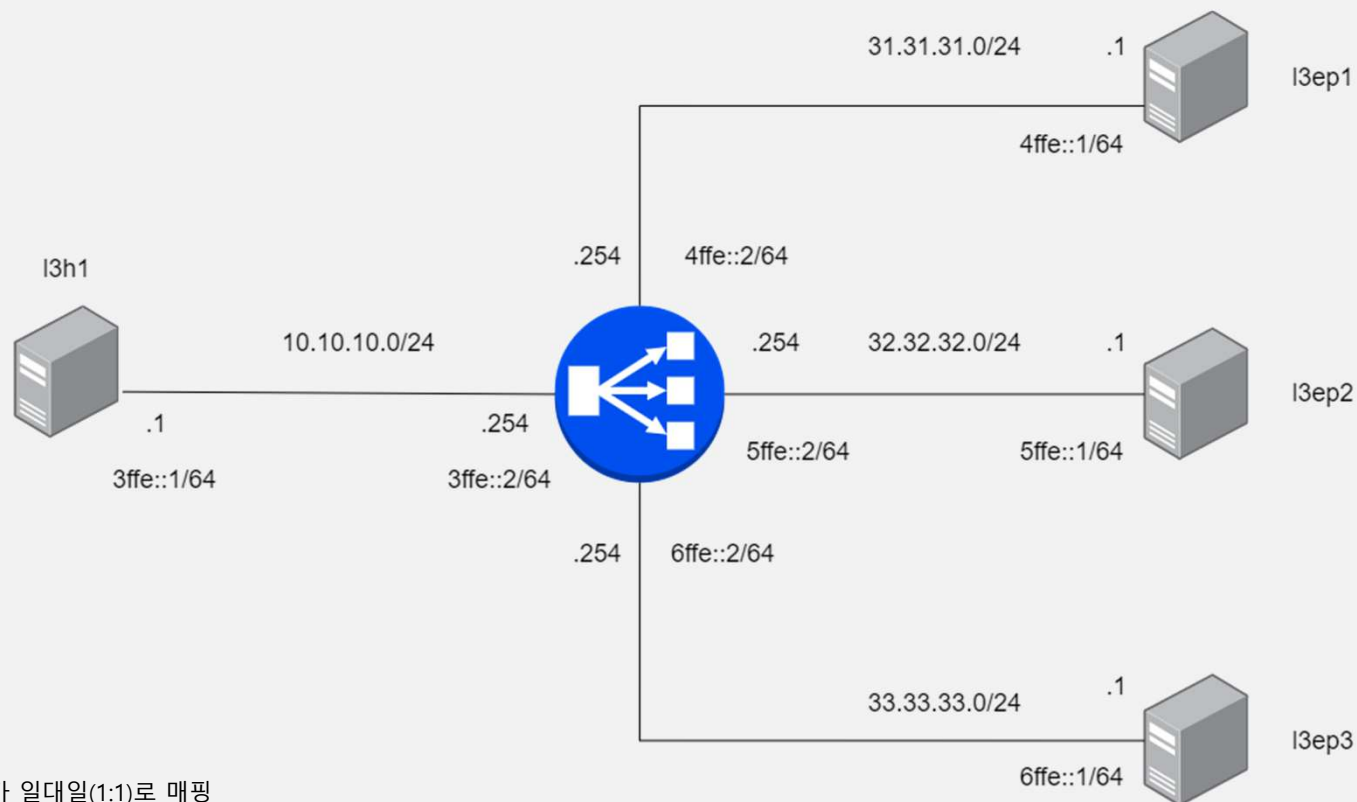
Source: <https://killercoda.com/netlox>



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

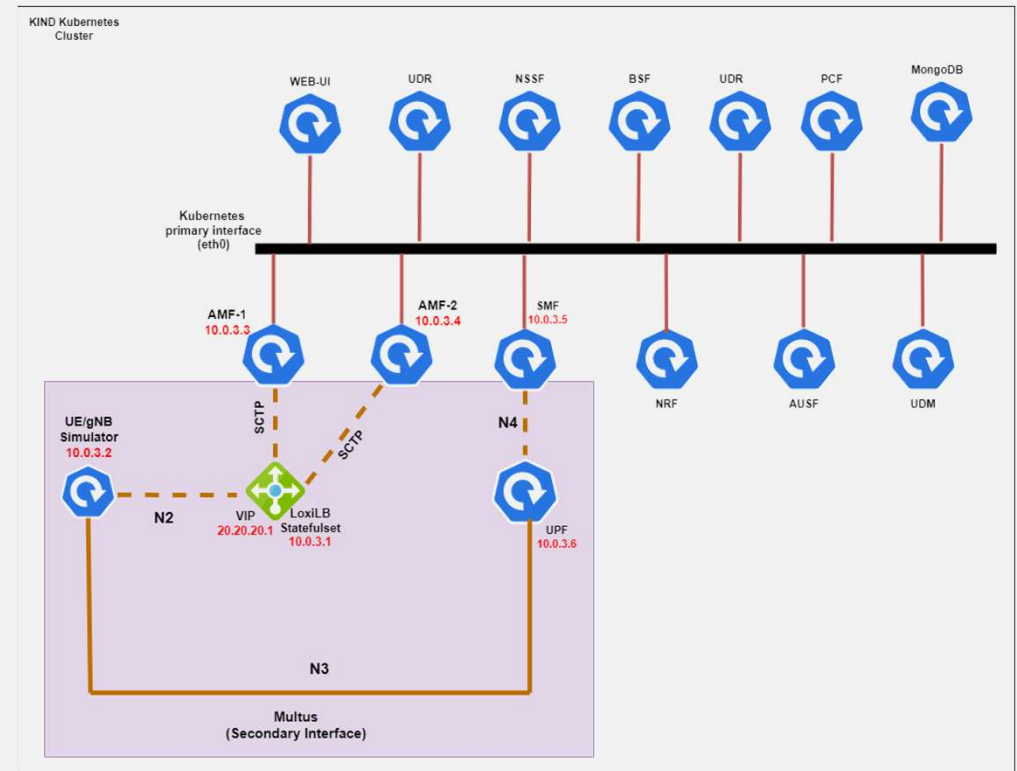
Source: <https://killercoda.com/netlox>



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>

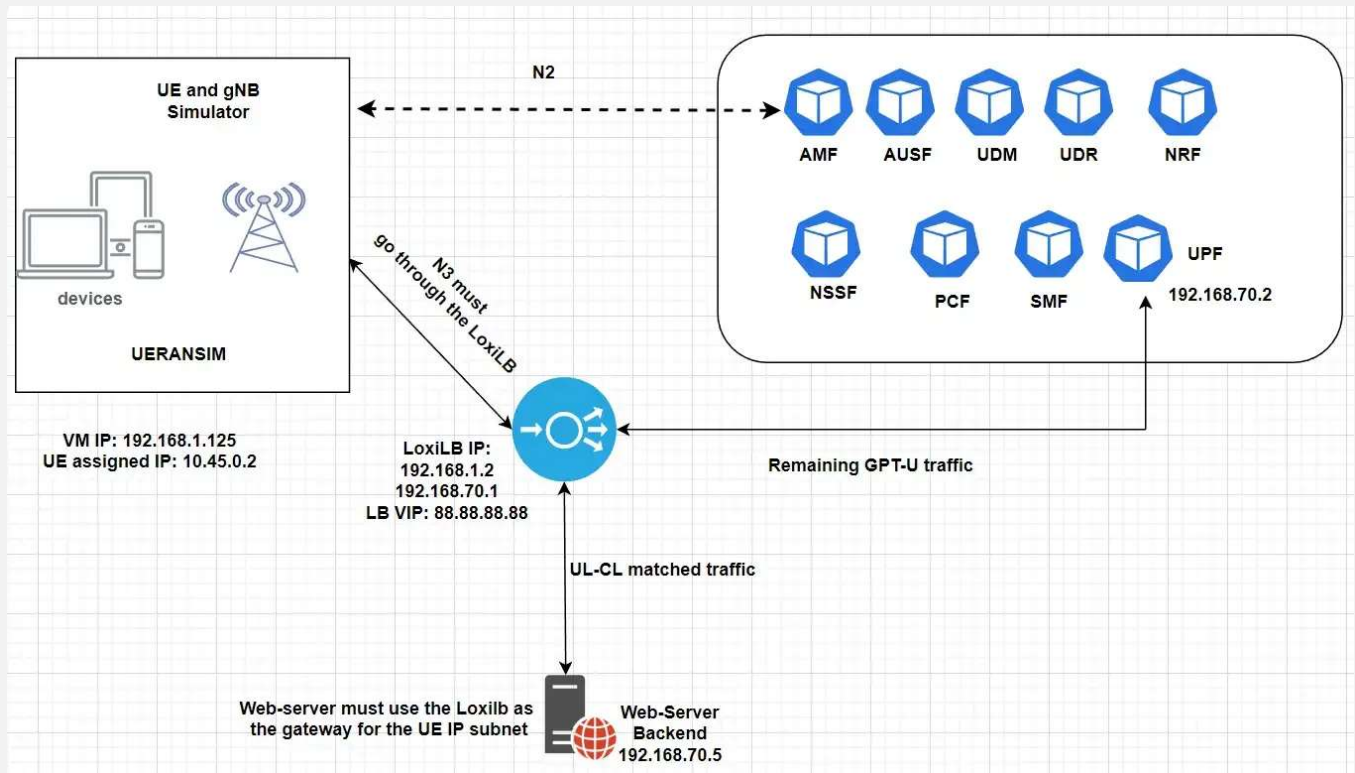
Source: <https://futuredon.medium.com/5g-sctp-loadbalancer-using-loxilb-b525198a9103>



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>

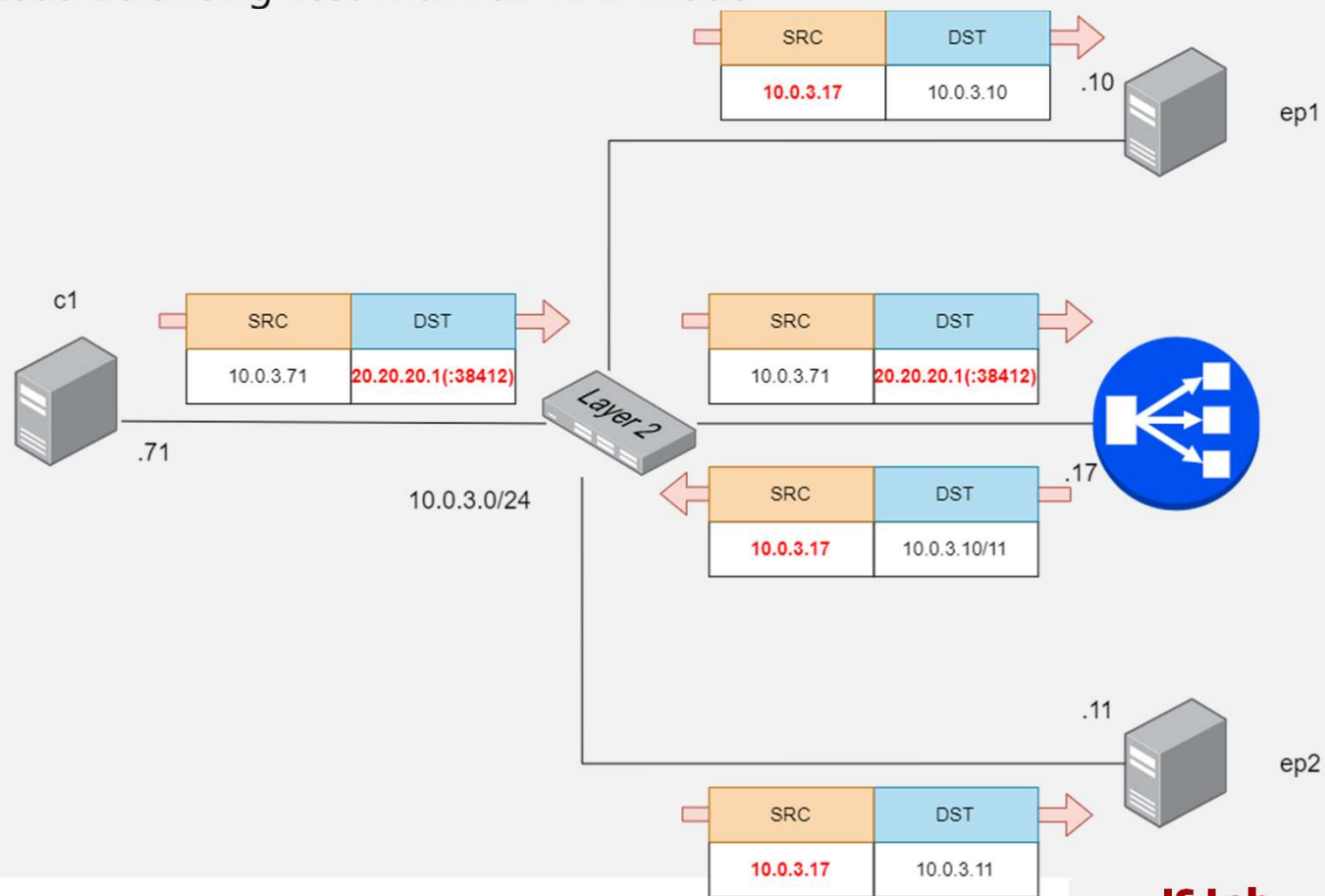
Source: <https://futuredon.medium.com/5g-uplink-classifier-using-loxilb-7593a4d66f4c>



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



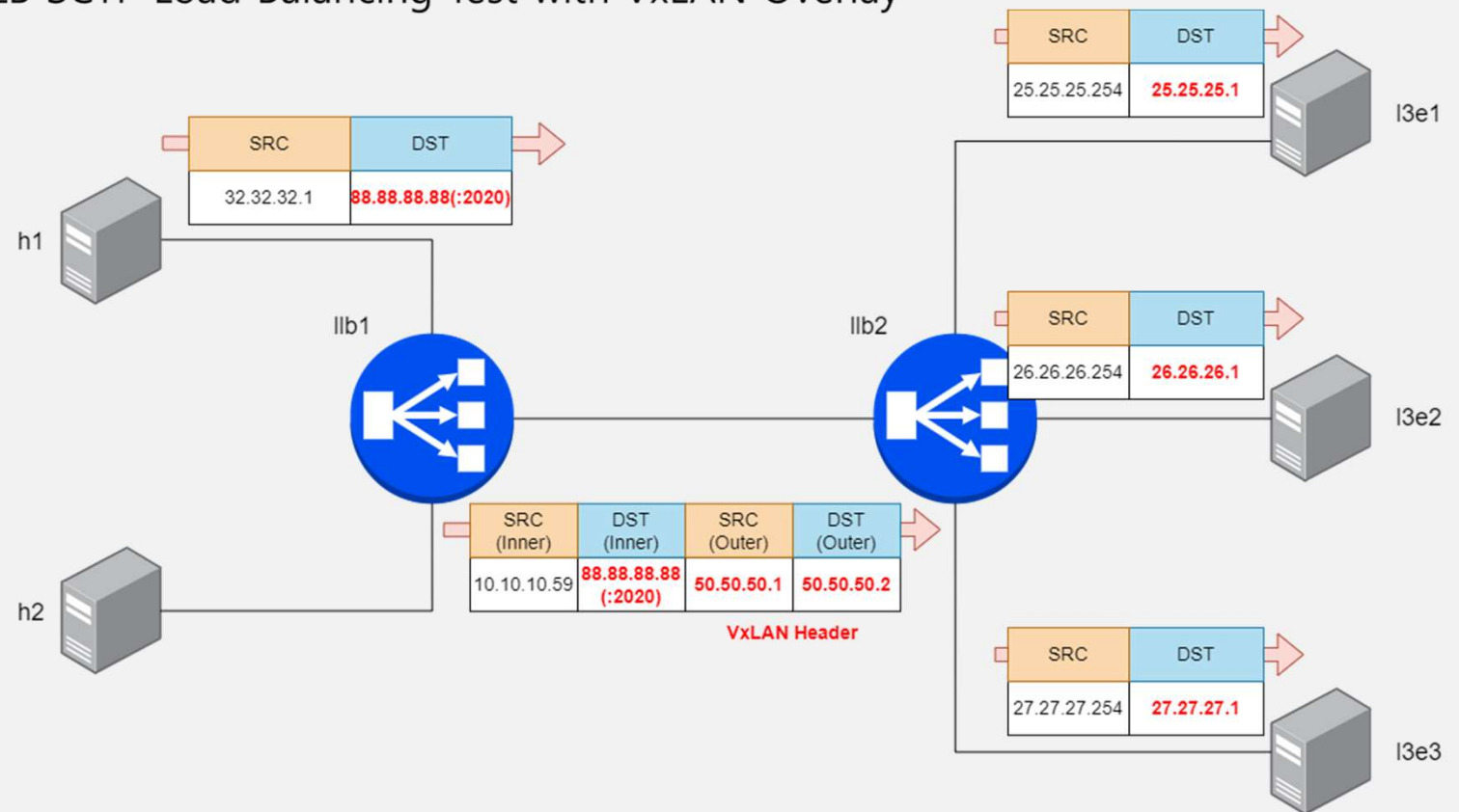
Source: <https://killercoda.com/netlox>



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



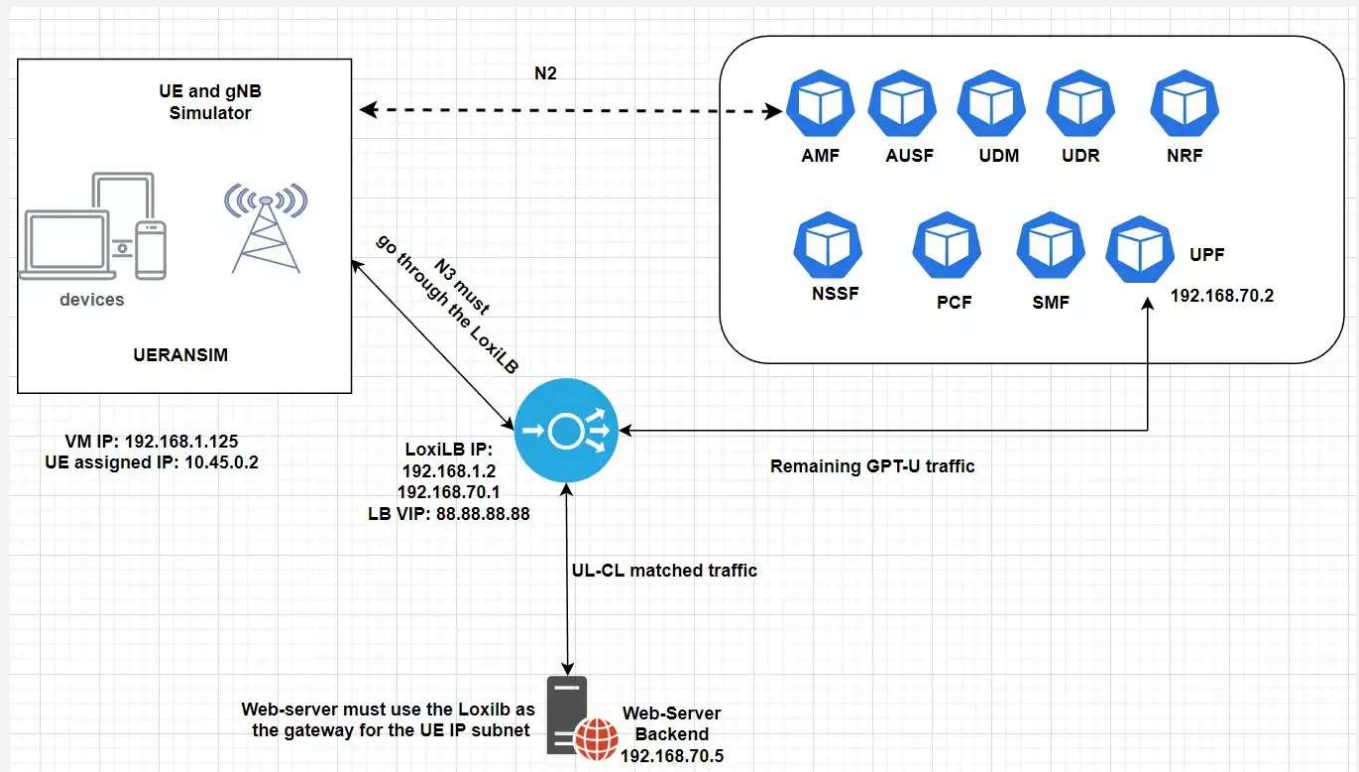
Source: <https://killercoda.com/netlox>



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>

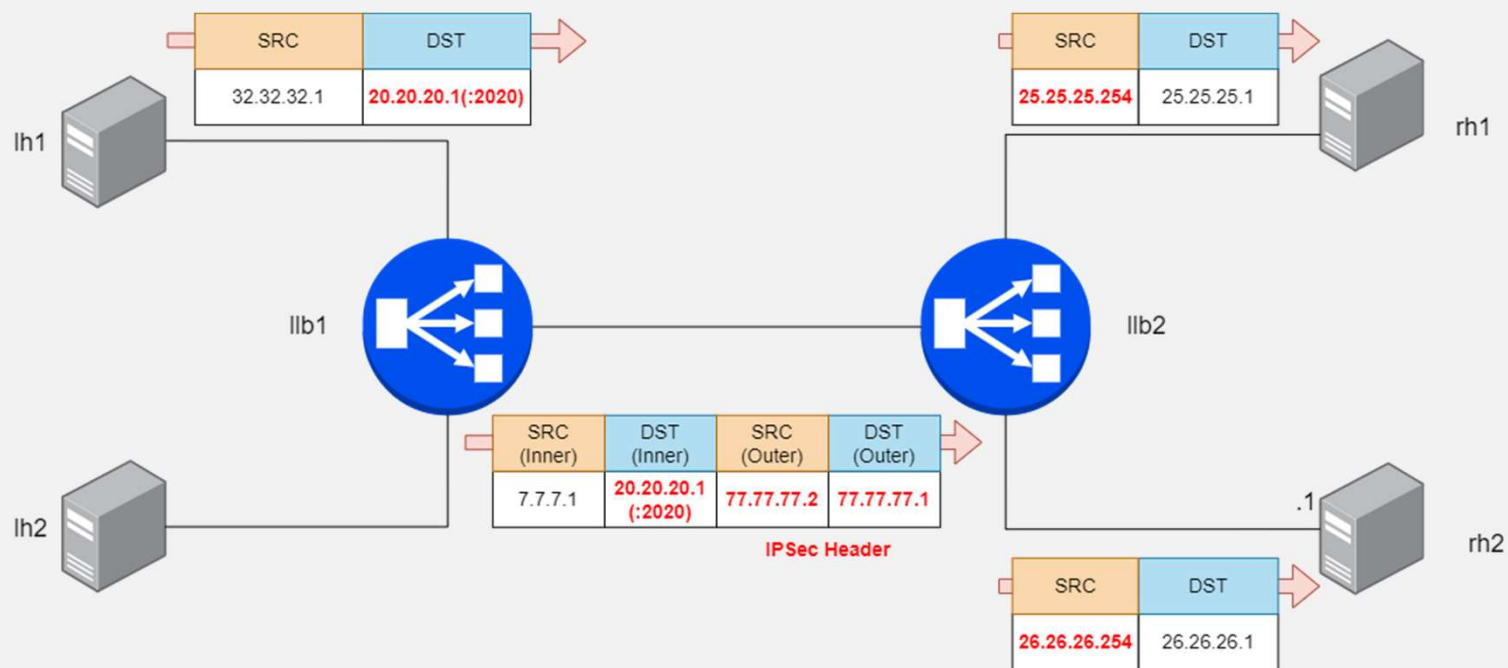
Source: <https://futuredon.medium.com/5g-uplink-classifier-using-loxilb-7593a4d66f4c>



V. 5G EDGE LB VIRTUAL LAB

❖ TCP Load Balancing Test with IPsec

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

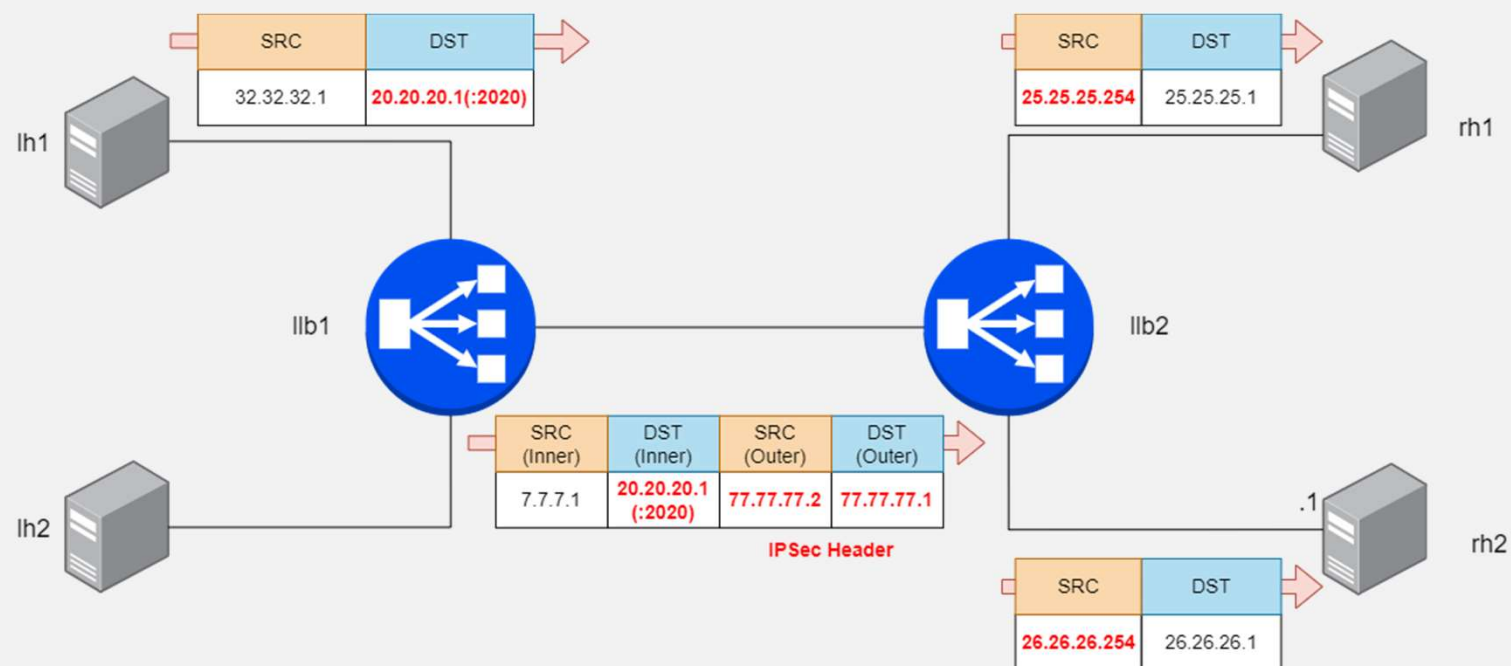


Source: <https://killercoda.com/netlox>

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



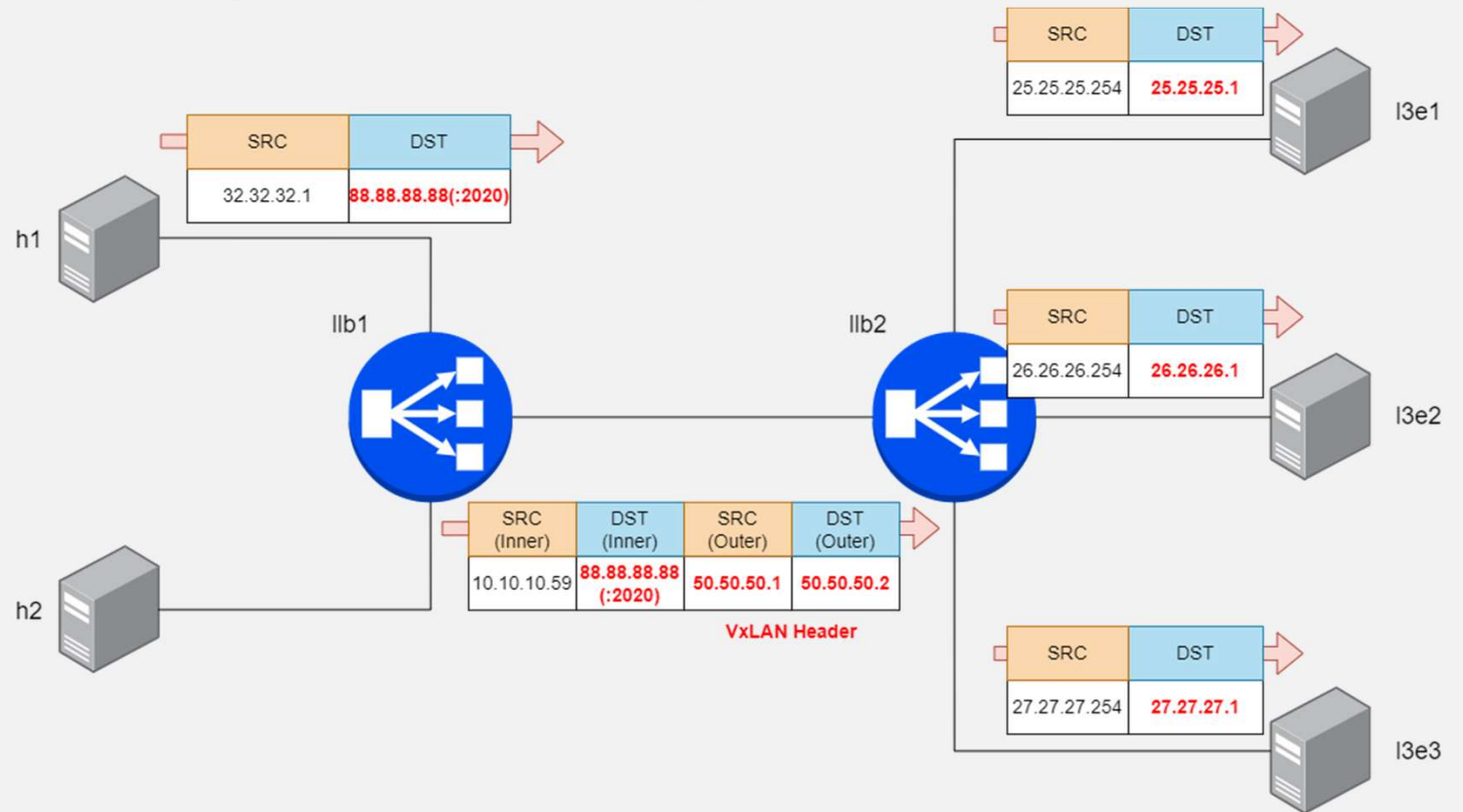
strongSwan: Open-source, modular and portable IPsec-based VPN solution

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>

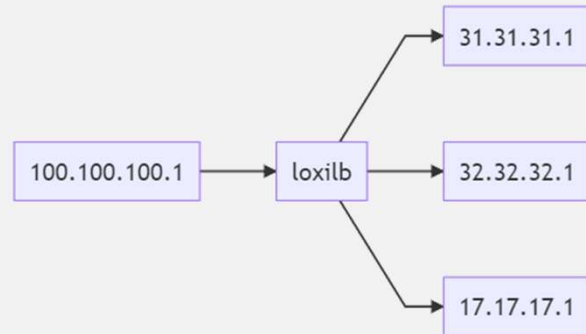


V. 5G EDGE LB VIRTUAL LAB

❖ 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 take 5 - 10 minutes =====
===== It will take 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 네임스페이스는 lo 인터페이스만 가지고 있으며 다른 네임스페이스와 통신할 수 없는 영역
l3e3
l3e2
l3e1
loxiLB (id: 0)
```

```
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 : [172.17.0.1/8 - Primary] IPv6 : []	IsPVID: true VID : 3801
2	vlan3801	aa:bb:cc:dd:ee:ff	true/true	Routed: false IPv4 : [] IPv6 : []	IsPVID: false VID : 3801
3	llb0	d2:ed:85:74:ba:db	true/true	Routed: false IPv4 : [] IPv6 : []	IsPVID: true VID : 3803
4	vlan3803	aa:bb:cc:dd:ee:ff	true/true	Routed: false IPv4 : [] IPv6 : []	IsPVID: false VID : 3803
5	eth0	02:42:ac:11:00:02	true/true	Routed: true IPv4 : [172.17.0.2/16 - Primary] IPv6 : []	IsPVID: true VID : 3805
6	vlan3805	aa:bb:cc:dd:ee:ff	true/true	Routed: false IPv4 : [] IPv6 : []	IsPVID: false VID : 3805
7	enp1	9e:c9:54:8b:c7:0c	true/true	Routed: true IPv4 : [31.31.31.254/24 - Primary] IPv6 : []	IsPVID: true VID : 3807
8	vlan3807	aa:bb:cc:dd:ee:ff	true/true	Routed: false IPv4 : [] IPv6 : []	IsPVID: false VID : 3807
9	enp2	3e:d4:bc:31:35:75	true/true	Routed: true IPv4 : [32.32.32.254/24 - Primary] IPv6 : []	IsPVID: true VID : 3809
10	vlan3809	aa:bb:cc:dd:ee:ff	true/true	Routed: false IPv4 : [] IPv6 : []	IsPVID: false VID : 3809
11	enp3	a6:63:01:10:1b:b7	true/true	Routed: true IPv4 : [17.17.17.254/24 - Primary] IPv6 : []	IsPVID: true VID : 3811

```
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
./server

sudo ip netns exec l3e2 bash
./server

sudo ip netns exec l3e3 bash
./server

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

```

Tab1

Tab2

Tab3

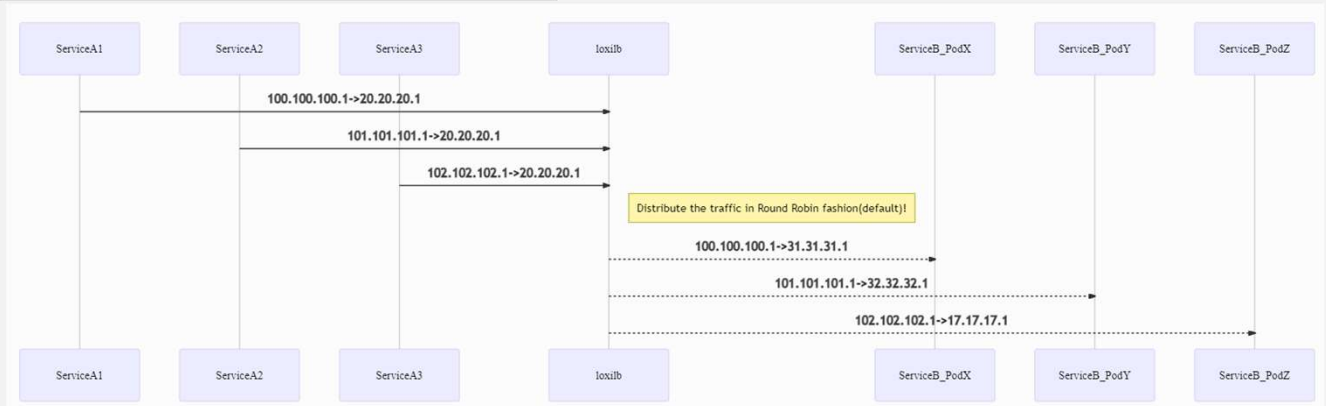
Tab4

```

Editor Tab1 Tab2 Tab3 Tab4
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



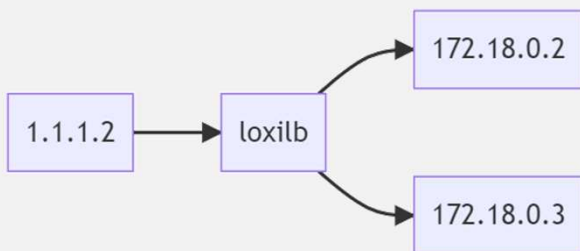
Source: <https://killercoda.com/netlox/scenario/loxilb-3node-1client-lb>



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

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

- Compile & Build LoxiLB Command from source code

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

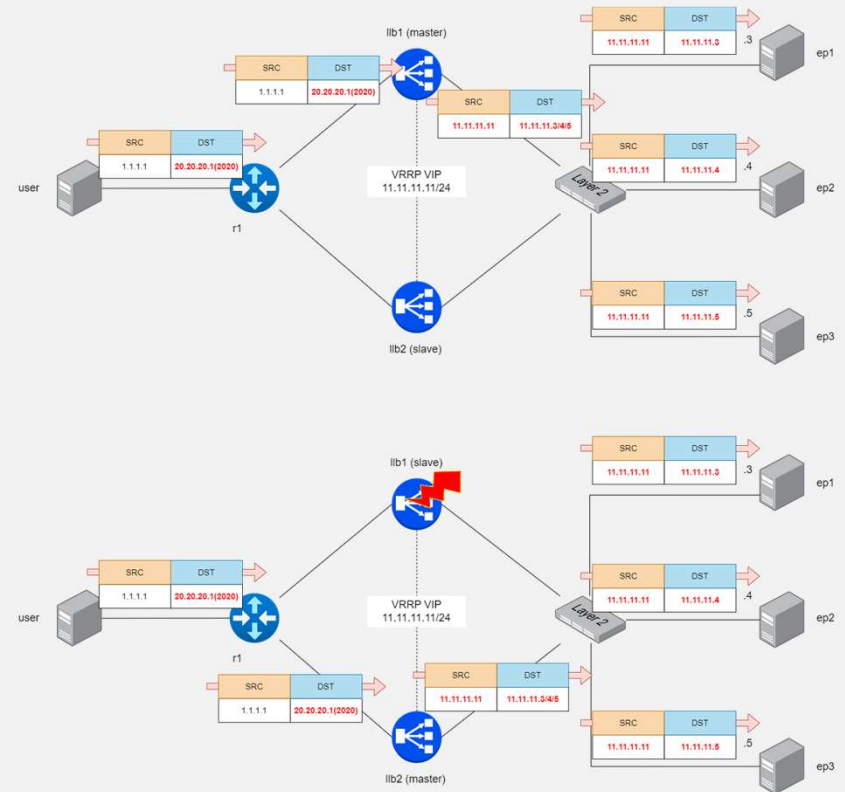
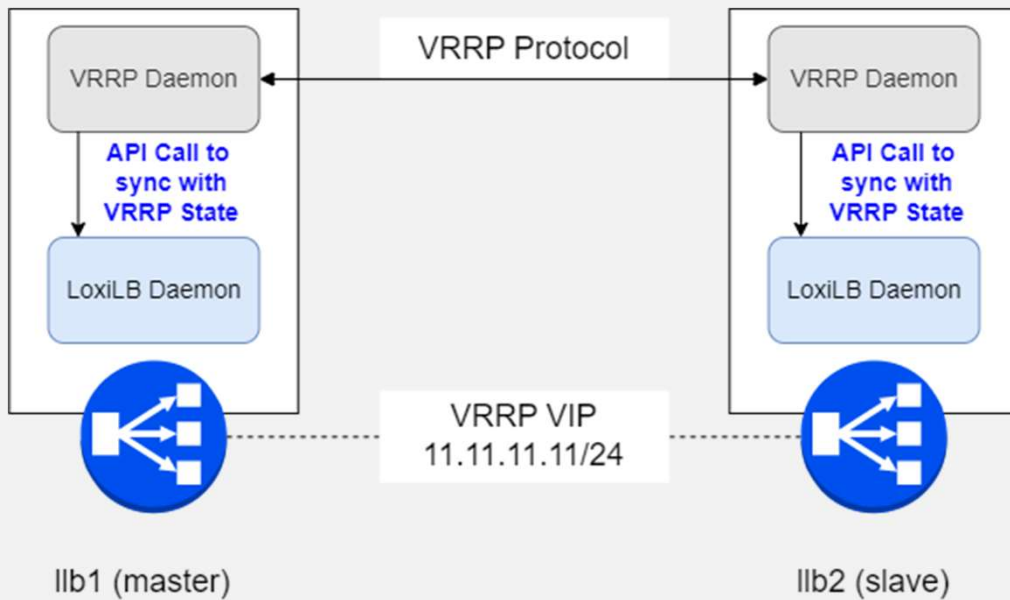
Source: <https://killercoda.com/netlox/scenario/loxilb-ccm>



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)



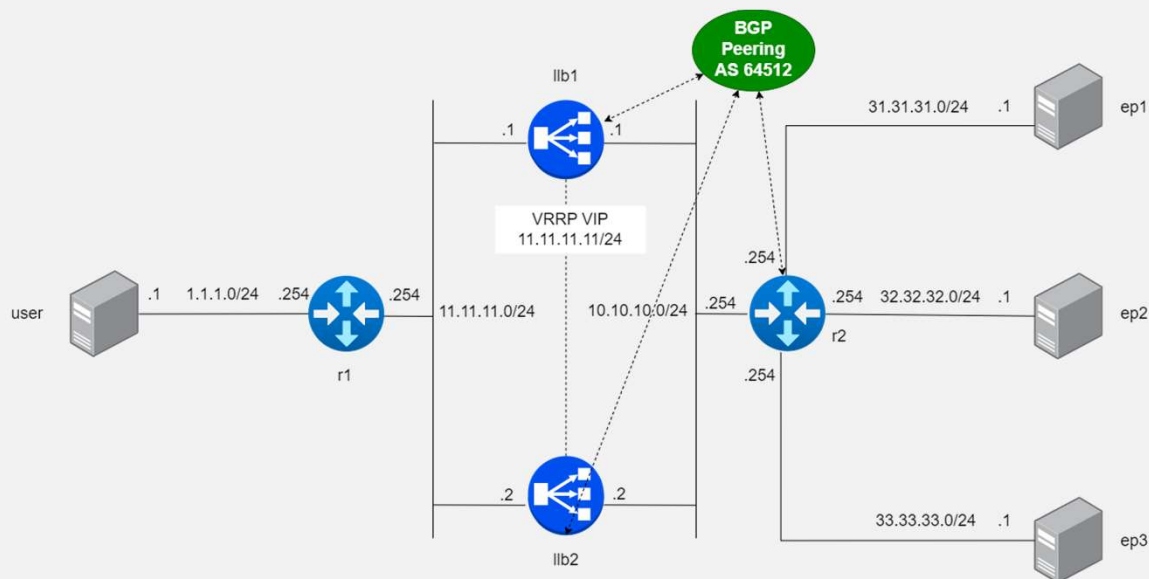
Source: <https://killercoda.com/netlox/scenario/loxilb-cluster1>



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
```

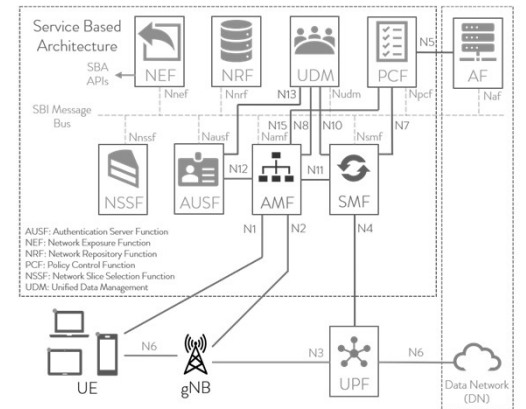
```
ip netns exec llb1 ping 11.11.11.254 -c 5
ip netns exec llb1 ping 10.10.10.254 -c 5
ip netns exec llb2 ping 11.11.11.254 -c 5
ip netns exec llb2 ping 10.10.10.254 -c 5
ip netns exec r1 ping 1.1.1.1 -c 5
ip netns exec r2 ping 31.31.31.1 -c 5
ip netns exec r2 ping 32.32.32.1 -c 5
ip netns exec r2 ping 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).
- Kubectl: 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

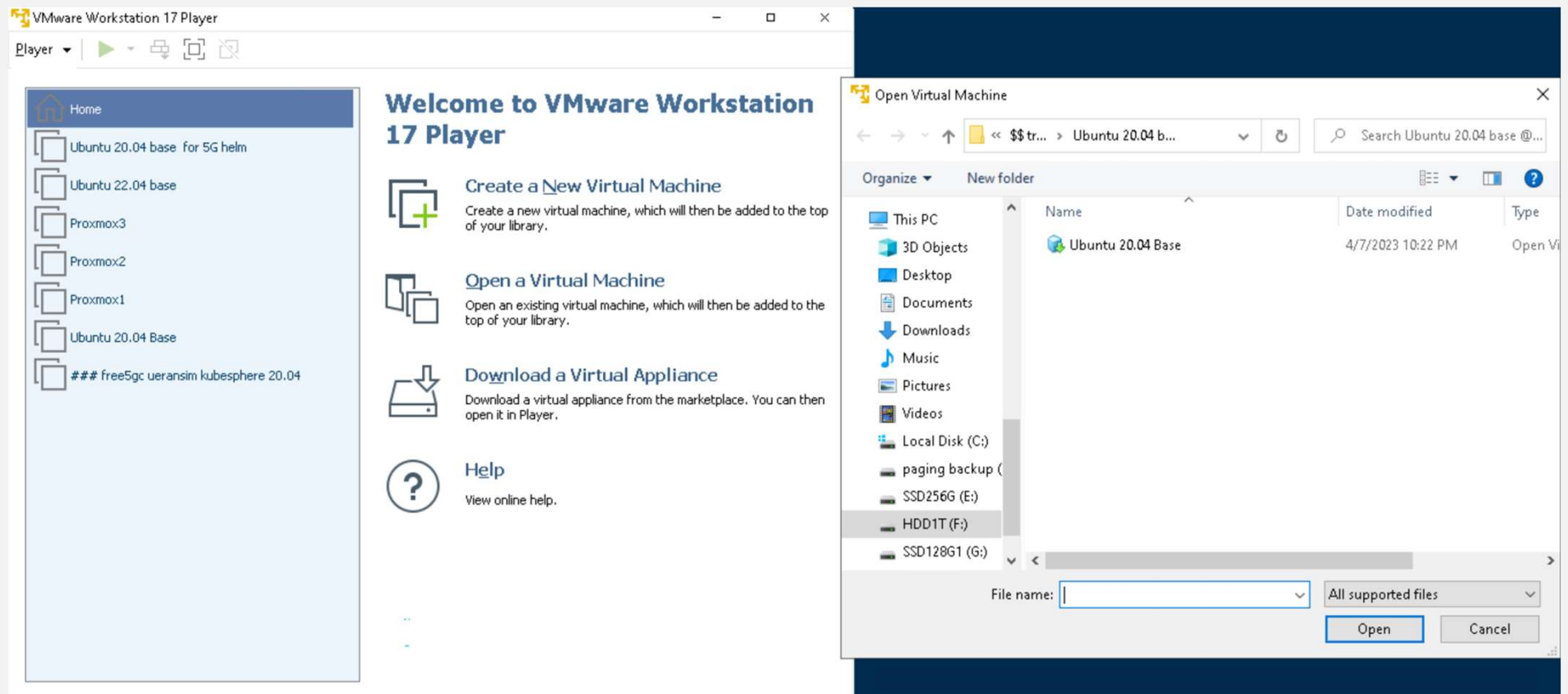
• Cloud-based solutions:

- 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 통해서도 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 \geq 1.18	Kubernetes Version $<$ 1.18
<code>socat</code>	Required	Optional but recommended
<code>conntrack</code>	Required	Optional but recommended
<code>ebtables</code>	Optional but recommended	Optional but recommended
<code>ipset</code>	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
auto ens160
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 -sL 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 -sL 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	iptables	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
a05fe001771   kubernetes/notification-tenant-sidecar  "/tenant-sidecar"      10 minutes ago Up 10 minutes          k8s_tenant_notification_manager-deployment-78664576cb-5r1j.kubernetes-monitoring-system_15763065-cae1-4d8d-b718-c263d644ba6e_0
8f16c89285d3   kubernetes/notification-manager        "/notification-manag..." 10 minutes ago Up 10 minutes          k8s_notification_manager_notification_manager-deployment-78664576cb-5r1j.kubernetes-monitoring-system_15763065-cae1-4d8d-b718-c263d644ba6e_0
a83e2370d637   763de88523a                          "/bin/prometheus-con..." 10 minutes ago Up 10 minutes          k8s_config-reloader_prometheus-k8s-0_kubernetes-monitoring-system_e89a45c-f61d-4f0e-a711-b3a7d2d3dd7_0
f39470e450c   prom/prometheus                       "/bin/prometheus --w..." 10 minutes ago Up 10 minutes          k8s_prometheus_prometheus-k8s-0_kubernetes-monitoring-system_e89a45c-f61d-4f0e-a711-b3a7d2d3dd7_0
b892986d0a66   kubernetes/kubectl                    "entrypoint.sh"        11 minutes ago Up 11 minutes          k8s_kubectl_kubectl-admin-6dbcb94855-tdp76.kubernetes-control-system_486a6989-d758-49d3-aea4-b044622ba6c4_0
c3e97c9b3f69   kubernetes/pause:3.5                  "/pause"                11 minutes ago Up 11 minutes          k8s_POD_notification_manager-deployment-78664576cb-5r1j.kubernetes-monitoring-system_15763065-cae1-4d8d-b718-c263d644ba6e_0
c6bca84f9b9f   kubernetes/notification-manager-operator  "/notification-manag..." 11 minutes ago Up 11 minutes          k8s_notification_manager_operator_notification_manager-operator-7d44854f54-jhsv.kubernetes-monitoring-system_bb3a4b74-c07f-4a8f-9210-6bd843711a4e_0
b166fa2f643a   kubernetes/prometheus-config-reloader  "/bin/prometheus-con..." 12 minutes ago Up 12 minutes          k8s_config-reloader_alermanager-main-0_kubernetes-monitoring-system_525cca8c-c070-4638-a627-fa9add3d5396_0
7c330f2a227b   kubernetes/ks-apiserver                "ks-apiserver --logt..." 12 minutes ago Up 12 minutes          k8s_ks_apiserver_ks-apiserver-576fbd5d4f-vbmdp.kubernetes-system_36002958-913b-439a-a7c3-578fd48ba3e_0
e6d2af027d41   kubernetes/pause:3.5                  "/pause"                13 minutes ago Up 13 minutes          k8s_POD_kubectl-admin-6dbcb94855-tdp76.kubernetes-control-system_486a6989-d758-49d3-aea4-b044622ba6c4_0
660cb24b6967   kubernetes/ks-controller-manager       "controller-manager ..." 13 minutes ago Up 13 minutes          k8s_ks-controller-manager_ks-controller-manager-f8df455c8-fn8c8.kubernetes-system_52342f81-elc5-4bd6-9402-561cf1c9873a_0
7ea7920b0e4e   2958949d78d                          "/usr/local/bin/kube..." 13 minutes ago Up 13 minutes          k8s_kube-rbac-proxy-self_kube-state-metrics-687d66b747-6rpb8.kubernetes-monitoring-system_05827a75-382d-4b90-9d6b-d74ae83fcec_0
40f9c2673946   kubernetes/kube-rbac-proxy            "/usr/local/bin/kube..." 13 minutes ago Up 13 minutes          k8s_kube-rbac-proxy_node-exporter-dw8lr.kubernetes-monitoring-system_1c92ab61-elc4-4d4d-8f10-74f9586279bc_0
3f0789ea4183   kubernetes/kube-rbac-proxy            "/usr/local/bin/kube..." 13 minutes ago Up 13 minutes          k8s_kube-rbac-proxy_notification_manager-operator-7d44854f54-jhsv.kubernetes-monitoring-system_bb3a4b74-c07f-4a8f-9210-6bd843711a4e_0
f1c676113031   kubernetes/kube-rbac-proxy            "/usr/local/bin/kube..." 13 minutes ago Up 13 minutes          k8s_kube-rbac-proxy_notification_manager-operator-7d44854f54-jhsv.kubernetes-monitoring-system_bb3a4b74-c07f-4a8f-9210-6bd843711a4e_0
eb2f0f6f8f44   kubernetes/pause:3.5                  "/pause"                14 minutes ago Up 14 minutes          k8s_POD_prometheus-k8s-0_kubernetes-monitoring-system_e89a45c-f61d-4f0e-a711-b3a7d2d3dd7_0
8f5ff7de5503   prom/alertmanager                     "/bin/alertmanager ..." 14 minutes ago Up 14 minutes          k8s_alertmanager_alertmanager-main-0_kubernetes-monitoring-system_525cca8c-c070-4638-a627-fa9add3d5396_0
4ab33d303c92   kubernetes/pause:3.5                  "/pause"                14 minutes ago Up 14 minutes          k8s_POD_ks-apiserver-576fbd5d4f-vbmdp.kubernetes-system_36002958-913b-439a-a7c3-578fd48ba3e_0
4c7eb210ebb    kubernetes/pause:3.5                  "/pause"                14 minutes ago Up 14 minutes          k8s_POD_ks-controller-manager-f8df455c8-fn8c8.kubernetes-system_52342f81-elc5-4bd6-9402-561cf1c9873a_0
f6c5e598c0be   kubernetes/kube-rbac-proxy            "/usr/local/bin/kube..." 15 minutes ago Up 15 minutes          k8s_kube-rbac-proxy_prometheus-operator-8955bbd98-srvph.kubernetes-monitoring-system_34aa1551-bd52-4dc1-a9fc-b161caeae8980_0
a82bc04e6597   kubernetes/kube-state-metrics         "/kube-state-metrics..." 15 minutes ago Up 15 minutes          k8s_kube-state-metrics_kube-state-metrics-687d66b747-6rpb8.kubernetes-monitoring-system_05827a75-382d-4b90-9d6b-d74ae83fcec_0
30108943c0bc   prom/node-exporter                    "/bin/node_exporter ..." 15 minutes ago Up 15 minutes          k8s_node-exporter_node-exporter-dw8lr.kubernetes-monitoring-system_1c92ab61-elc4-4d4d-8f10-74f9586279bc_0
1002eae830c    kubernetes/pause:3.5                  "/pause"                16 minutes ago Up 16 minutes          k8s_POD_notification_manager-operator-7d44854f54-jhsv.kubernetes-monitoring-system_bb3a4b74-c07f-4a8f-9210-6bd843711a4e_0
11e30c1a192    kubernetes/pause:3.5                  "/pause"                16 minutes ago Up 16 minutes          k8s_POD_alertmanager-main-0_kubernetes-monitoring-system_525cca8c-c070-4638-a627-fa9add3d5396_0
37a08ba49331   kubernetes/prometheus-operator        "/bin/operator --kub..." 16 minutes ago Up 16 minutes          k8s_prometheus-operator_prometheus-operator-8955bbd98-srvph.kubernetes-monitoring-system_34aa1551-bd52-4dc1-a9fc-b161caeae8980_0
613041e16104   kubernetes/pause:3.5                  "/pause"                16 minutes ago Up 16 minutes          k8s_POD_kube-state-metrics-687d66b747-6rpb8.kubernetes-monitoring-system_05827a75-382d-4b90-9d6b-d74ae83fcec_0
6013c8398bf    kubernetes/pause:3.5                  "/pause"                16 minutes ago Up 16 minutes          k8s_POD_node-exporter-dw8lr.kubernetes-monitoring-system_1c92ab61-elc4-4d4d-8f10-74f9586279bc_0
ec16286b809    kubernetes/pause:3.5                  "/pause"                16 minutes ago Up 16 minutes          k8s_POD_prometheus-operator-8955bbd98-srvph.kubernetes-monitoring-system_34aa1551-bd52-4dc1-a9fc-b161caeae8980_0
1c5b4f3d3f7b   mirror/google_containers/defaultbackend-amd64  "server"                18 minutes ago Up 18 minutes          k8s_default-http-backend_default-http-backend-5bf68f7908-cxppp.kubernetes-control-system_dc102db7-c887-4cd3-a161-f5f4ebf4db6d_0
7d86c4d0683d   kubernetes/ks-console                  "docker-entrypoint s..." 19 minutes ago Up 18 minutes          k8s_ks-console_ks-console-e59f4bc67b9-9bdjc.kubernetes-system_8d8f42ce-eddc-445c-8668-15030c229772_0
20c8a5783847   kubernetes/pause:3.5                  "/pause"                19 minutes ago Up 19 minutes          k8s_POD_ks-console-e59f4bc67b9-9bdjc.kubernetes-system_8d8f42ce-eddc-445f-8668-15030c229772_0
8501a97f183f   kubernetes/pause:3.5                  "/pause"                19 minutes ago Up 19 minutes          k8s_POD_default-http-backend-5bf68f7908-cxppp.kubernetes-control-system_dc102db7-c887-4cd3-a161-f5f4ebf4db6d_0
9e5740e096d2   csipulgin/snapshot-controller        "/snapshot-controlle..." 21 minutes ago Up 21 minutes          k8s_snapshot-controller_snapshot-controller-0_kube-system_35d6f2d0-2258-4444-b510-812fa90ff830_0
8d0d2e135d57   kubernetes/pause:3.5                  "/pause"                21 minutes ago Up 21 minutes          k8s_POD_snapshot-controller-0_kube-system_35d6f2d0-2258-4444-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   kubernetes/ks-installer                "shell-operator sta..." 22 minutes ago Up 22 minutes          k8s_installer_ks-installer-85d6fb8c97-jj7n5.kubernetes-system_4bdea3ba-27a9-4204-a852-a1f795206217_0
7bb75826333a   ec95788d0772                          "/usr/bin/kube-contr..." 22 minutes ago Up 22 minutes          k8s_calico-kube-controller_calico-kube-controller-69d878584c-r519c.kube-system_9a4fa59-7907-445a-8f4c-edf482e05af8_0
dd171912210e   2986bd503be2                          "coredns -conf /etc..." 22 minutes ago Up 22 minutes          k8s_coredns_coredns-b5648d655-tjzn5.kube-system_e801844c-02a8-47a9-9dc0-e535673ab499_0
505850c36ca8   2986bd503be2                          "coredns -conf /etc..." 22 minutes ago Up 22 minutes          k8s_coredns_coredns-b5648d655-trxn.kube-system_28338401-3bb1-43ab-965b-70b3ae6550f_0
5377f64dc64d   kubernetes/pause:3.5                  "/pause"                22 minutes ago Up 22 minutes          k8s_POD_calico-kube-controller-69d878584c-r519c.kube-system_9a4fa59-7907-445a-8f4c-edf482e05af8_0
b47ce9600340   kubernetes/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   kubernetes/pause:3.5                  "/pause"                22 minutes ago Up 22 minutes          k8s_POD_coredns-b5648d655-tjzn5.kube-system_e801844c-02a8-47a9-9dc0-e535673ab499_0
55887a9e6040   kubernetes/pause:3.5                  "/pause"                22 minutes ago Up 22 minutes          k8s_POD_coredns-b5648d655-trxn.kube-system_28338401-3bb1-43eb-965b-70b3ae6550f_0
3701ad08f0    kubernetes/pause:3.5                  "/pause"                22 minutes ago Up 22 minutes          k8s_POD_ks-installer-85d6fb8c97-jj7n5.kubernetes-system_4bdea3ba-27a9-4204-a852-a1f795206217_0
6461ae32c87   a3447b26d32c                          "start_runit"          22 minutes ago Up 22 minutes          k8s_calico-node_calico-node-w6294.kube-system_3fcd0749-740c-436e-934e-22924125a545_0
765f6b01023d   5340ba194e99                          "node-cache -locali..." 22 minutes ago Up 22 minutes          k8s_node-cache_nodeocal_dns-jp87q.kube-system_3bc7242f-926f-4151-8a92-79ab1511e35d_0
1749b4366c5f   kubernetes/pause:3.5                  "/pause"                22 minutes ago Up 22 minutes          k8s_POD_nodeocal_dns-jp87q.kube-system_3bc7242f-926f-4151-8a92-79ab1511e35d_0
642e4eae831   7618176989d2                          "/usr/local/bin/kube..." 22 minutes ago Up 22 minutes          k8s_kube-proxy_kube-proxy-z6b7l.kube-system_9b9a9b6-e92e-4eee-9eb8-34d37f642b1_0
43f607ae55bc   kubernetes/pause:3.5                  "/pause"                22 minutes ago Up 22 minutes          k8s_POD_kube-proxy-z6b7l.kube-system_9b9a9b6-e92e-4eee-9eb8-34d37f642b1_0
bf2c27c27f4d   kubernetes/pause:3.5                  "/pause"                22 minutes ago Up 22 minutes          k8s_POD_calico-node-w6294.kube-system_3fcd0749-740c-436e-934e-22924125a545_0
dd750e263fc   f9ef4d6e30ee                          "kube-controller-man..." 23 minutes ago Up 23 minutes          k8s_kube-controller-manager_kube-controller-manager-jslab.kubernetes-system_898d827bd77c9d67f14c4461cf3d731_0
8828b10e562c   5ee90014579c                          "kube-scheduler --au..." 23 minutes ago Up 23 minutes          k8s_kube-scheduler_jslab.kube-system_98c5c78d9268c3e7e256d48b9671226_0
3af41c1fabac   d922296a8b85                          "kube-apiserver --ad..." 23 minutes ago Up 23 minutes          k8s_kube-apiserver_kube-apiserver-jslab.kube-system_aea9f56a432607153b25f2b9ad2f05b_0
2ba3dc06291   kubernetes/pause:3.5                  "/pause"                23 minutes ago Up 23 minutes          k8s_POD_kube-scheduler-jslab.kube-system_98c5c78d9268c3e7e256d48b9671226_0
ab73c3e58326   kubernetes/pause:3.5                  "/pause"                23 minutes ago Up 23 minutes          k8s_kube-controller-manager_jslab.kube-system_898d827bd77c9d67f14c4461cf3d731_0
77eedb3770cb   kubernetes/pause:3.5                  "/pause"                23 minutes ago Up 23 minutes          k8s_POD_kube-apiserver-jslab.kube-system_aea9f56a432607153b25f2b9ad2f05b_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:3CGZ:OVXQ:JOZY:QXLO:JL5Z:KELY:15F3:5PFP: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           22m
```



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@kubernetes:~/k8s# kubectl get all --all-namespaces
NAMESPACE      NAME                                     READY   STATUS    RESTARTS   AGE
kube-system     pod/calico-node-6xv5g                  1/1     Running   0           12m
kube-system     pod/calico-node-6xv5g                  1/1     Running   0           12m
kube-system     pod/coredns-5548665440-rt4qp           1/1     Running   0           12m
kube-system     pod/coredns-5548665440-rt4qp           1/1     Running   0           12m
kube-system     pod/kube-apiserver-kubernetes           1/1     Running   0           12m
kube-system     pod/kube-controller-manager-kubepher   1/1     Running   0           12m
kube-system     pod/kube-proxy-89w4k                   1/1     Running   0           12m
kube-system     pod/kube-scheduler-kubepher            1/1     Running   0           12m
kube-system     pod/nodemaster-2z2hs                    1/1     Running   0           11m
kube-system     pod/nodemaster-2z2hs                    1/1     Running   0           11m
kube-system     pod/heapster-controller-0               1/1     Running   0           11m
kube-system     pod/default-backend-6d6ff86b-2iffr      1/1     Running   0           9m7s
kube-system     pod/kubectl-admin-6667746b-ffelp        1/1     Running   0           10m
kube-system     pod/kube-state-metrics-554166d6c-9xvut  2/2     Running   0           10m
kube-system     pod/kube-state-metrics-554166d6c-9xvut  2/2     Running   0           10m
kube-system     pod/notifications-controller-2866478cb-p2ak  2/2     Running   0           9m49s
kube-system     pod/prometheus-operator-565b7946-821sl  2/2     Running   0           10m
kube-system     pod/prometheus-operator-565b7946-821sl  2/2     Running   0           10m
kube-system     pod/k8s-console-65f44428-4n0jt          1/1     Running   0           11m
kube-system     pod/k8s-controller-manager-756d9f97-35waf  1/1     Running   0           9m35s
kube-system     pod/k8s-installer-370db0f86-kjvvn       1/1     Running   0           12m

NAMESPACE      NAME                                     TYPE          CLUSTER-IP   EXTERNAL-IP   PORT(S)          AGE
kube-system     service/kubernetes                       ClusterIP     10.233.0.1    <none>         443/TCP          12m
kube-system     service/coredns                           ClusterIP     10.233.0.3    <none>         53/UDP,53/TCP,8153/TCP  12m
kube-system     service/kube-controller-manager-svc       ClusterIP     <none>        <none>         10259/TCP        10m
kube-system     service/kube-scheduler-svc               ClusterIP     <none>        <none>         10259/TCP        10m
kube-system     service/kubectl                           ClusterIP     <none>        <none>         <none>           10m
kube-system     service/default-http-backend              ClusterIP     10.233.1.227  <none>         80/TCP           11m
kube-system     service/alertmanager-main                 ClusterIP     10.233.45.12  <none>         9093/TCP,9094/TCP,9094/UDP  11m
kube-system     service/kube-state-metrics                ClusterIP     <none>        <none>         8443/TCP,8443/TCP  10m
kube-system     service/kube-scheduler                    ClusterIP     <none>        <none>         19000/TCP        9m56s
kube-system     service/notifications-controller-metrics  ClusterIP     10.233.12.2   <none>         8443/TCP         10m
kube-system     service/notifications-controller-webhook  ClusterIP     10.233.18.81  <none>         443/TCP          9m56s
kube-system     service/prometheus-k8s                    ClusterIP     10.233.1.156  <none>         9090/TCP         10m
kube-system     service/prometheus-operator               ClusterIP     <none>        <none>         4443/TCP         10m
kube-system     service/k8s-apiserver                      ClusterIP     10.233.2.12   <none>         80/TCP           11m
kube-system     service/k8s-console                        NodePort     10.233.18.52  <none>         80/HTTP,80/TCP  11m
kube-system     service/k8s-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           <none>           12m
kube-system     daemonset.apps/kube-proxy                1         1         1         1             1           <none>           12m
kube-system     daemonset.apps/kubelet                    1         1         1         1             1           <none>           12m

NAMESPACE      NAME                                     READY   UP-TO-DATE   AVAILABLE   AGE
kube-system     deployment.apps/calico-kube-controllers  1/1      1              1           12m
kube-system     deployment.apps/coredns                   2/2      2              2           12m
kube-system     deployment.apps/openshift-local-provisioner  1/1      1              1           12m
kube-system     deployment.apps/default-http-backend      1/1      1              1           11m
kube-system     deployment.apps/kubectl-admin              1/1      1              1           9m7s
kube-system     deployment.apps/kube-state-metrics        1/1      1              1           10m
kube-system     deployment.apps/notifications-controller  1/1      1              1           9m49s
kube-system     deployment.apps/notifications-controller-deployment  1/1      1              1           10m
kube-system     deployment.apps/prometheus-k8s            1/1      1              1           10m
kube-system     deployment.apps/prometheus-operator        1/1      1              1           10m
kube-system     deployment.apps/k8s-apiserver              0         0              0           11m
kube-system     deployment.apps/k8s-apiserver-9921f999b0  0         0              0           11m
kube-system     deployment.apps/k8s-apiserver-937d44689   1         1              1           11m
kube-system     deployment.apps/k8s-console-65f44428      1         1              1           11m
kube-system     deployment.apps/k8s-controller-manager-756d9f97  1         1              1           9m35s
kube-system     deployment.apps/k8s-controller-manager-96c0c997  0         0              0           9m35s
kube-system     deployment.apps/k8s-installer-370db0f86    1         1              1           12m

NAMESPACE      NAME                                     DESIRED   CURRENT   READY   AGE
kube-system     pod/localed.apps/calico-kube-controllers-4605f884  1         2         1           12m
kube-system     pod/localed.apps/coredns-5548665440-rt4qp        1         2         1           12m
kube-system     pod/localed.apps/openshift-local-provisioner-50f67894  1         1         1           12m
kube-system     pod/localed.apps/default-http-backend-5686ff9a     1         1         1           11m
kube-system     pod/localed.apps/kubectl-admin-6667746b-ffelp     1         1         1           9m7s
kube-system     pod/localed.apps/kube-state-metrics-554166d6c-9xvut  1         1         1           10m
kube-system     pod/localed.apps/notifications-controller-2866478cb-p2ak  1         1         1           9m49s
kube-system     pod/localed.apps/prometheus-operator-565b7946-821sl  1         1         1           10m
kube-system     pod/localed.apps/k8s-apiserver-9921f999b0         0         0         0           11m
kube-system     pod/localed.apps/k8s-apiserver-937d44689          1         1         1           11m
kube-system     pod/localed.apps/k8s-console-65f44428             1         1         1           11m
kube-system     pod/localed.apps/k8s-controller-manager-756d9f97  1         1         1           9m35s
kube-system     pod/localed.apps/k8s-controller-manager-96c0c997  0         0         0           9m35s
kube-system     pod/localed.apps/k8s-installer-370db0f86          1         1         1           12m

NAMESPACE      NAME                                     READY   AGE
kube-system     statefulset.apps/heapster-controller           1/1      11m
kube-system     statefulset.apps/alertmanager-main            1/1      10m
kube-system     statefulset.apps/prometheus-k8s               1/1      10m
root@kubernetes:~/k8s#
```



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      0 127.0.0.1:53          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:~$
```

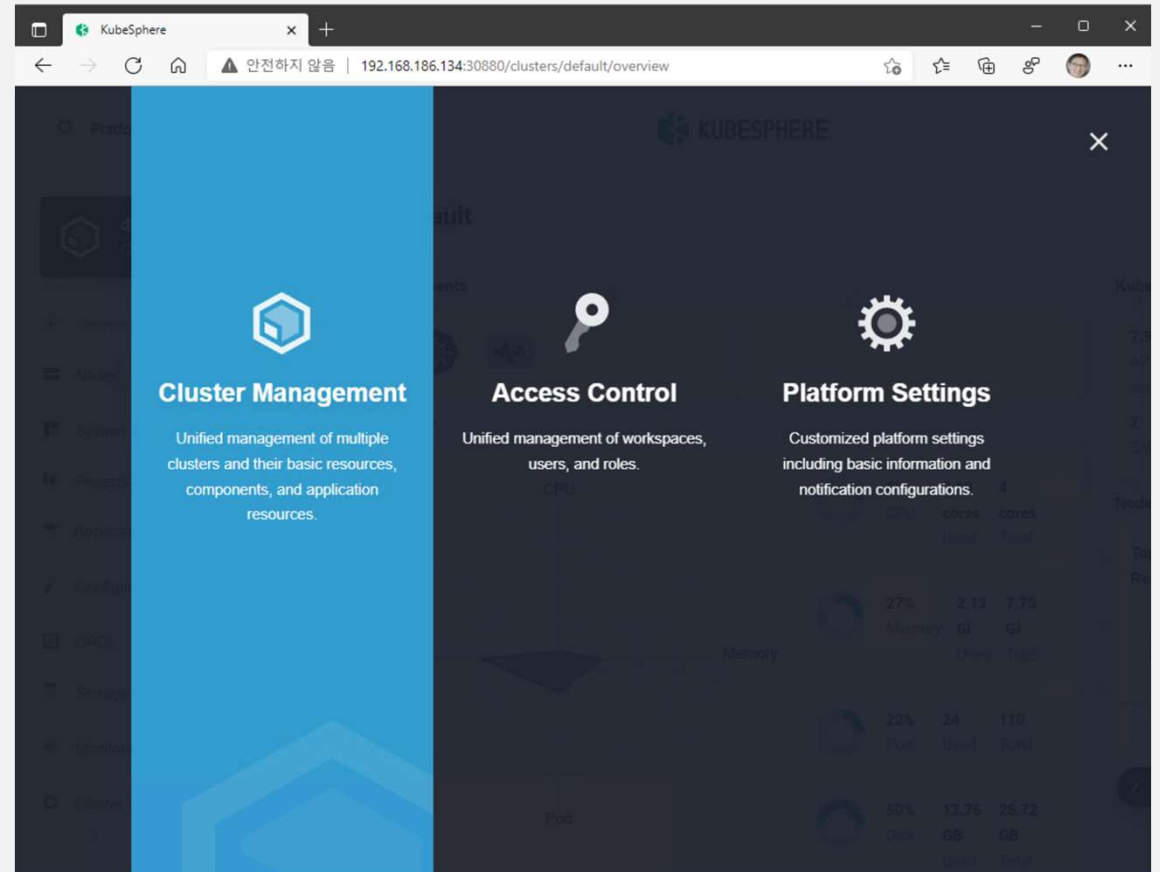


부록 1. KUBERNETES 설치

❖ 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

The screenshot displays the KubeSphere dashboard for a 'default' cluster. The interface includes a navigation sidebar on the left with options like Overview, Nodes, System Components, Projects, Application Workloads, Configuration, CRDs, Storage, Monitoring & Alerting, and Cluster Settings. The main content area is divided into several sections:

- System Components:** Shows icons for Kubernetes, Prometheus, and Grafana.
- Resource Usage:** A central radar chart and four summary cards showing usage for CPU, Memory, Pod, and Disk. The data is as follows:

Resource	Used	Total
CPU	0.22 cores	4 cores
Memory	2.15 Gi	7.73 Gi
Pod	24	110
Disk	13.85 GB	26.16 GB
- Kubernetes Status:** Displays '7.567 times/s' for API requests per second and '2.17 ms' for API request latency. It also shows 'Scheduling operations' and 'Scheduling failures'.
- Nodes:** A section titled 'Top 5 for Resource Usage' sorted by CPU usage. The top node is 'jslab Control plane' with 6% CPU usage.
- Tools:** A section at the bottom with descriptions for 'kubectl' (Command line tool used to control the current cluster) and 'kubeconfig' (File used to configure the access information about the current cluster).



부록 1. KUBERNETES 설치

❖ Cluster Management

The screenshot displays the KubeSphere dashboard for a 'default' cluster. The interface includes a navigation bar with 'Platform' and 'Workbench' tabs, and a user profile 'admin'. The main content area is divided into several sections:

- default Cluster:** A dark blue button with a cluster icon.
- System Components:** A section with icons for KubeSphere, Kubernetes, and Prometheus.
- Resource Usage:** A radar chart showing CPU, Memory, Disk, and Pod usage. The chart has concentric circles representing usage levels from 0 to 100. The current usage is shown as a shaded area.
- Toolbox:** A dark blue box with a hammer icon, stating 'Provides cluster analysis and control tools.'
- Analysis Tools:** A section with a folder icon and the text 'Resource Consumption Statistics' and 'View resource consumption of clusters and workspac...'
- kubeconfig:** A section with a document icon and the text 'View or download the kubeconfig file of the current clu...'
- Control Tool:** A section with a terminal icon and the text 'kubect!' and 'Command line tool used to control the current cluster.'

On the left side, there is a 'kubect!' terminal window with a dark background and a prompt '/ #'. Below it is a sidebar with a list of commands and operations:

- Customized Output:**
 - View more information about a pod: `kubect! get pod <pod-name> -o wide`
 - View pod details in YAML format: `kubect! get pod <pod-name> -o yaml`
- Operations:**
 - Create Resources:**
 - Create a service by using a YAML configuration file: `kubect! create -f my-service.yaml`
 - Create resources by using all YAML, YML, and JSON files in a directory: `kubect! create -f <directory>`
 - View Resources:**
 - View all pods: `kubect! get pods`
 - View all services: `kubect! get services`
 - View Resource Details:** `Hide Help Information`

At the bottom of the dashboard, there are two tool cards:

- kubect!:** Command line tool used to control the current cluster.
- kubeconfig:** File used to configure the access information about the current cluster.

A purple dashed box highlights the 'kubect!' tool card in the 'Control Tool' section and the terminal window. A purple arrow points from the 'kubect!' tool card to the terminal window. A note at the bottom right of the dashboard says: 'Press "shift+left click" to open kubect! in a new browser window.'



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
```

```

TASK [ks-core/prepare : KubeSphere | Generating kubeconfig-admin] *****
skipping: [localhost]

PLAY RECAP *****
localhost      : ok=25  changed=19  unreachable=0    failed=0    skipped=22   rescued=0    ignored=0

Start installing monitoring
Start installing multicluster
Start installing openpitrix
Start installing network
*****
Waiting for all tasks to be completed ...
task network status is successful (1/4)
task openpitrix status is successful (2/4)
task multicluster status is successful (3/4)
task monitoring status is successful (4/4)
*****
Collecting installation results ...
#####
###      Welcome to KubeSphere!      ###
#####

Console: http://192.168.42.100:30880
Account: admin
Password: P@88@0rd
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      2023-04-07 10:22:58
#####

```



부록 2. Helm Operations



부록 2. HELM OPERATIONS

- ❖ Rancher (예)
- Helm3-library

The screenshot displays the Rancher Helm3-library interface. A central modal window titled 'Catalogs' is open, showing a table of installed catalogs. The table has columns for State, Scope, Name, Catalog URL, and Branch. The 'helm3-library' catalog is highlighted in blue.

State	Scope	Name	Catalog URL	Branch
<input type="checkbox"/>	Project	free5gc	https://raw.githubusercontent.com/Orange-OpenSource/towards5gs-helm/main/repo/	master
<input checked="" type="checkbox"/>	Global	helm3-library	https://git.rancher.io/helm3-charts	master
<input checked="" type="checkbox"/>	Global	library	https://git.rancher.io/charts	master
<input checked="" type="checkbox"/>	Project	open5gs	https://gradiant.github.io/openverso-charts/	master
<input checked="" type="checkbox"/>	Global	system-library	https://git.rancher.io/system-charts	release-v2.5

The background shows a grid of various Helm charts, including 'alicide-advisor-cronjob', 'aws-event-sources', 'cloudcasa', 'dynatrace-oneagent-operator', 'kong', 'mariadb', 'artifactory-ha', 'artifactory-jcr', 'citrix-adc-istio-ingress-gateway', 'citrix-api-gateway', 'citrix-k8s-ingress-controller', 'cockroachdb', 'kubecost', 'cost-analyzer', 'datadog', 'docker-registry', and 'drone'. Many charts are marked as 'PARTNER'.



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-kubernetes-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/gradient-openverso/u... 0.2.1          3.2.6        ueransim for 5G RAN simulation
https://hub.helm.sh/charts/gradient-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/gradient-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	node-local-dns-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
kubernetes-controls-system	default-http-backend-5bf68ff9b8-tjc2v	1/1	Running	1 (2d22h ago)	2d23h
kubernetes-controls-system	kubectl-admin-6dbcb94855-fljcj	1/1	Running	1 (2d22h ago)	2d23h
kubernetes-monitoring-system	alertmanager-main-0	2/2	Running	2 (2d22h ago)	2d23h
kubernetes-monitoring-system	kube-state-metrics-687d66b747-jspd9	3/3	Running	3 (2d22h ago)	2d23h
kubernetes-monitoring-system	node-exporter-gpwrj	2/2	Running	2 (2d22h ago)	2d23h
kubernetes-monitoring-system	notification-manager-deployment-78664576cb-ntdhn	2/2	Running	2 (2d22h ago)	2d23h
kubernetes-monitoring-system	notification-manager-operator-7d44854f54-4qp9h	2/2	Running	2 (2d22h ago)	2d23h
kubernetes-monitoring-system	prometheus-k8s-0	2/2	Running	2 (2d22h ago)	2d23h
kubernetes-monitoring-system	prometheus-operator-8955bbd98-hpgwn	2/2	Running	2 (2d22h ago)	2d23h
kubernetes-system	ks-apiserver-6cd95fb98f-b8qkj	1/1	Running	1 (2d22h ago)	2d23h
kubernetes-system	ks-console-7d9857b6c-wpzzl	1/1	Running	1 (2d22h ago)	2d23h
kubernetes-system	ks-controller-manager-5958b94c9c-5gr74	1/1	Running	1 (2d22h ago)	2d23h
kubernetes-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`

`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`

```
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#
```



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-nssf	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 "ucl"
  nrf:
    service:
      name: nrf-nnrf
      type: ClusterIP
      port: "3000"
      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)

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`

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

`helm show values towards5gs/free5gc`

Source: <https://medium.com/rahasak/deploying-5g-core-network-with-free5gc-kubernetes-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-cnif# 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 License
# 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 running:
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-cnif#

```

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 parameters
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
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"
```

```
# 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 under the terms of the license
# the text of which is available at https://www.apache.org/licenses/LICENSE-2.0
# or see the "LICENSE" file for more details.
#
# Author: Abderaouf KHICHANE. Ithac@orange.com
# Software description: An open-source 5G RAN/UE simulator
#
# Default values for ueransim-chart:
# This is a YAML-formatted file.
# Declare variables to be passed into your templates.

global:
  multiCluster: false
#Global network parameters
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:
      name: 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
  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 container
  # 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-20893000000003" # IMSI number
  mcc: '208' # Mobile Country Code value
  mnc: '93' # Mobile Network Code value (2 or 3 digits)
  key: "8baf473f2f8fd09487ccbd7097c6862" # 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 the UE
  imeiSv: '4370816125816151' # 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-
      volume:
        name: connectivity-test-volume
        mount: /scripts
        ttlseconds: 50
  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
  configuredNssai:
    - sst: 0x01
      sd: 0x010203
  # Default Configured NSSAI for this UE
  defaultNssai:
    - sst: 1
      sd: 1
```



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-5c548c9dca-q9mzg          1/1     Running   0           30m
jslab5gc           jslab5gc-v1-free5gc-ausf-ausf-5774d545f9-xf1mm        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-a86k8              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-r-j29r                                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       node-local-dns-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-6dbc94855-f1jcj                        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-gpwrp                                  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-zzfmr -- ip a`

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

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

```
jslab@jslab:~$ kubectl exec -it -n free5gc free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfmr -- 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   STATUS
free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb    1/1     Running
free5gc-v1-free5gc-ausf-ausf-6fd5b5f6d-fp9c7    1/1     Running
free5gc-v1-free5gc-nrf-nrf-5664d64868-rp8tn     1/1     Running
free5gc-v1-free5gc-nssf-nssf-6c5658c97f-w8c48   1/1     Running
free5gc-v1-free5gc-pcf-pcf-7c4bb7d9b-n2wxc     1/1     Running
free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfnr    1/1     Running
free5gc-v1-free5gc-udm-udm-7c9b4dbd5f-wsfz7    1/1     Running
free5gc-v1-free5gc-udr-udr-fcdfdfb7d-625tz     1/1     Running
free5gc-v1-free5gc-upf-upf-57c686dd86-tf6jj    0/1     Container
free5gc-v1-free5gc-webui-webui-76db6dbdc7-vfokq 1/1     Running
mongodb-0                                       1/1     Running
ueransim-v1-gnb-6cdbcff47b-rq7nq             1/1     Running
ueransim-v1-ue-d6b68575-mpzk7                1/1     Running
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 chart to deploy Free5GC
towards5gs/free5gc-ausf 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-n3iwf 0.2.1          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-nrf 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-nssf 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-pcf 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-smf 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-udm 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-udr 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-upf 0.2.1          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-webui 0.1.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gcControlPlane 0.1.2          v3.0.5      DEPRECATED
towards5gs/free5gcN3iwf 0.1.2          v3.0.5      DEPRECATED
towards5gs/free5gcUserPlane 0.1.2          v3.0.5      DEPRECATED
towards5gs/networks5g 0.1.2          0.1.2        DEPRECATED
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'

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

```
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:
`
kubect! 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:
`
kubect! 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"
```



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-uersanim-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              uersanim-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

```
jslab@5g:~$ sudo su - root
[sudo] password for jslab:
root@5g:~# helm show values openverso/open5gs
# Default values for open5gs
# This is a YAML-formatted file.
# Declare variables to be passed into your templates

# image - The base opensdb image
# for default see https://github.com/5GS-Open/open5gs

registry: docker.io
repository: openverso/
tag: 2.4.4

# Specify a imagePullPolicy
## Defaults to 'Always' if not present, and 'IfNotPresent' if set to false
pullPolicy: IfNotPresent

# Optionally specify a secret to use as pullSecrets:
# Secrets must be manually created in the namespace
pullSecrets: []

# imageCredentials:
# registry:
# username:
# password:
# email:

# Ingress annotations
## For a full list of ingress annotations see https://kubernetes.io/docs/concepts/services-networking/ingress/#annotations
## ref: https://kubernetes.io/docs/concepts/services-networking/ingress/#annotations
ref: http://kubernetes.io/docs/concepts/services-networking/ingress/#annotations

# If certManager is enabled, this will automatically generate the ingress.yaml file for you
## You can use this to generate the ingress.yaml file for you
certManager: true

# db_uri -- default is mongodb://mongodb:27017
# mongodb -- password for mongodb
mongodb:
  enabled: true
  auth:
    enabled: false

securityPolicy:
  enabled: false

# Set to true to enable the ingress controller
ingress:
  enabled: true

# Set this to true in order to use the certManager
certManager: false

# Ingress Path type
pathType: ImplementationSpecific

## When the ingress is enabled, a route pointing to this will be created
## If empty, defaults to .Release.Name-.Release.Namespace.ingress.lab5g.gradiant.org
hostname: ""

## The Path to open5gs webui. You may need to set this to '/' in order to use this
## with ALB ingress controllers.
path: /

webui:
  image:
    registry: docker.io
    repository: openverso/
    tag: 2.3.3
    ## Specify a imagePullPolicy
    ## Defaults to 'Always' if not present, and 'IfNotPresent' if set to false
    pullPolicy: IfNotPresent
  ## Optionally specify a secret to use as pullSecrets:
  ## Secrets must be manually created in the namespace
  pullSecrets: []
  ingress:
    ## Set to true to enable the ingress controller
    enabled: true
    ## Set this to true in order to use the certManager
    certManager: false
    ## Ingress Path type
    pathType: ImplementationSpecific
  ## When the ingress is enabled, a route pointing to this will be created
  ## If empty, defaults to .Release.Name-.Release.Namespace.ingress.lab5g.gradiant.org
  hostname: ""
  ## The Path to open5gs webui. You may need to set this to '/' in order to use this
  ## with ALB ingress controllers.
  path: /

amf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
    sst: 1
    sd: "ffffff"
    configYaml: {}
  externalService:
    enabled: false
    advertiseDomain: "ext.lab5g.gradiant.org"
    type: LoadBalancer
    ## @param service.loadBalancerSourceRanges
    ## e.g.:
    ## - 0.0.0.0/0
    loadBalancerSourceRanges:
    ## @param service.loadBalancerIP
    ## ref: https://kubernetes.io/docs/concepts/services-networking/service/#load-balancer-ip
    loadBalancerIP:
    # external advertise name or IP
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

ausf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
    sst: 1
    sd: "ffffff"
    configYaml: {}
  externalService:
    enabled: false
    type: LoadBalancer
    ## @param service.loadBalancerSourceRanges
    ## e.g.:
    ## - 0.0.0.0/0
    loadBalancerSourceRanges:
    ## @param service.loadBalancerIP
    ## ref: https://kubernetes.io/docs/concepts/services-networking/service/#load-balancer-ip
    loadBalancerIP:
    # external advertise name or IP
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

hss:
  enabled: true
  configType: config
  config:
    logLevel: info
    configYaml: {}
    resources: {}

mme:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
    configYaml: {}
  externalService:
    enabled: false
    type: LoadBalancer
    ## @param service.loadBalancerSourceRanges
    ## e.g.:
    ## - 0.0.0.0/0
    loadBalancerSourceRanges:
    ## @param service.loadBalancerIP
    ## ref: https://kubernetes.io/docs/concepts/services-networking/service/#load-balancer-ip
    loadBalancerIP:
    # external advertise name or IP
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

nrf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
    configYaml: {}
  externalService:
    enabled: false
    type: LoadBalancer
    ## @param service.loadBalancerSourceRanges
    ## e.g.:
    ## - 0.0.0.0/0
    loadBalancerSourceRanges:
    ## @param service.loadBalancerIP
    ## ref: https://kubernetes.io/docs/concepts/services-networking/service/#load-balancer-ip
    loadBalancerIP:
    # external advertise name or IP
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

nsmf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
    sd: "ffffff"
    configYaml: {}
  externalService:
    enabled: false
    type: LoadBalancer
    ## @param service.loadBalancerSourceRanges
    ## e.g.:
    ## - 0.0.0.0/0
    loadBalancerSourceRanges:
    ## @param service.loadBalancerIP
    ## ref: https://kubernetes.io/docs/concepts/services-networking/service/#load-balancer-ip
    loadBalancerIP:
    # external advertise name or IP
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

nssf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    mnc: 999
    mnc: 70
    tac: 1
    sd: "ffffff"
    configYaml: {}
  externalService:
    enabled: false
    type: LoadBalancer
    ## @param service.loadBalancerSourceRanges
    ## e.g.:
    ## - 0.0.0.0/0
    loadBalancerSourceRanges:
    ## @param service.loadBalancerIP
    ## ref: https://kubernetes.io/docs/concepts/services-networking/service/#load-balancer-ip
    loadBalancerIP:
    # external advertise name or IP
    # Due to the implementation of LoadBalancer, this
    # is not the original source IP of the client
    # To enable preservation of the client IP set
    externalTrafficPolicy: Local

pcf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    configYaml: {}
    resources: {}

pcrf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    configYaml: {}
    resources: {}

sgw:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    pdn:
      addr: 10.45.0.1/16
    configYaml: {}
    resources: {}

sgwu:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    pdn:
      addr: 10.45.0.1/16
    configYaml: {}
    resources: {}

smf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    pdn:
      addr: 10.45.0.1/16
    configYaml: {}
    resources: {}

udm:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    pdn:
      addr: 10.45.0.1/16
    configYaml: {}
    resources: {}

udr:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    pdn:
      addr: 10.45.0.1/16
    configYaml: {}
    resources: {}

upf:
  enabled: true
  resources: {}
  configType: config
  config:
    logLevel: info
    pdn:
      addr: 10.45.0.1/16
    configYaml: {}
    resources: {}
    tunSubnet: 10.45.0.1/16
  externalService:
    enabled: false

# set domain or ip accessible from enodeb.
# If not set, it is automatically set to SVC_NAME-ext.NAMESPACE.advertiseDomain
# advertise: "upf.lab5g.gradiant.org"
# advertiseDomain: "ext.lab5g.gradiant.org"
type: LoadBalancer
## @param service.loadBalancerSourceRanges
# Restricts access for LoadBalancer (only with service.type: LoadBalancer)
## e.g.:
## - 0.0.0.0/0
loadBalancerSourceRanges: []
## @param service.loadBalancerIP
loadBalancerIP for the SGWU Service (optional, cloud specific)
## ref: https://kubernetes.io/docs/user-guide/services/#type-loadbalancer
loadBalancerIP:
# external advertise name or IP
# Due to the implementation of LoadBalancer, this
# source IP seen in the target container
# is not the original source IP of the client
# To enable preservation of the client IP set
# with default "Cluster" policy,
# this to "Local".
externalTrafficPolicy: Local
with default Cluster policy,
this to "Local".
```



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 secrets
## @param global.storageClass Global StorageClass for PersistentVolumes
##
global:
  imageRegistry:
    ## E.g.
    ## imagePullSecrets:
    ##   - myRegistryKeySecretName
    ##
    imagePullSecrets: []
  storageClass:

## @section Common parameters

## @param kubeVersion Override Kubernetes version
##
kubeVersion:
## @param nameOverride String to partially override common.namespaces
##
nameOverride:
## @param fullnameOverride String to fully override common.namespaces
##
fullnameOverride:
## @param commonLabels Labels to add to all deployed objects
##
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: "0xfffff"
tac: '0001'

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

ues:
  enabled: false
  count: 1
  initialMSISDN: '0000000001'
  key: 465B5CE8B199B49FAA5FOA2EE238A6BC
  op: E8ED289DEBA952E4283B54E88E6183CA
  opType: OPC
  apn: internet
  resources:
    limits: {}
    requests: {}
  podSecurityContext:
    enabled: false
  containerSecurityContext:
    enabled: false
  podLabels: {}
  podAnnotations: {}
  affinity: {}
  nodeSelector: {}
  tolerations: []

50.238
```

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



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 under the terms of the Apache License 2.0
# the text of which is available at https://www.apache.org/licenses/LICENSE-2.0
# or see the "LICENSE" file for more details.
#
# Author: Abderaouf KHICHANE, Ilhem KHICHANE
# Software description: An open-source 5G RAN/UE simulator
#
# Default values for ueransim-chart:
# This is a YAML-formatted file.
# Declare variables to be passed into your templates.

global:
  multiCluster: false
  #Global network parameters
  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:
      name: 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: |-
  mnc: '208' # Mobile Country Code value
  nci: '0x000000010' # NR Cell Identity (36-bit)
  idLength: 32 # NR gNB ID length in bits
  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
  # 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-20893000000003" # IMSI number
  mnc: '208' # Mobile Country Code value
  mnc: '93' # Mobile Network Code value (2 or 3 digits)
  key: "8baf473f2f8fd09487ccbd7097c6862" # 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 the UE
  imeiSv: '4370816125816151' # 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-
      volume:
        name: connectivity-test-volume
        mount: /scripts
        ttlseconds: 50
  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
```

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



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
#
# 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) 2020 OpenVerse  
# SPDX-License-Identifier: Apache-2.0  
#  
# This software is distributed under the terms of the Apache License, Version 2.0  
# the text of which is available at https://www.apache.org/licenses/LICENSE-2.0  
# or see the "LICENSE" file for more details  
#  
# Author: Abderaouf KHICHANE, Ilhem FAJJAJ  
# Software description: An open-source project for 5G RAN/UE deployment  
#  
# Default values for ueransim-chart.  
# This is a YAML-formatted file.  
# Declare variables to be passed into your templates
```

```
global:  
  multiCluster: false  
  #Global network parameters  
  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"] # This  
  # command that will be launched in the UE container  
  # A script that will be run after the UE creation. It  
  # is 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  
  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  
  either 'OP' or 'OPC'  
  amf: '8000' # Authentication Management Field (AMF) value  
  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
```





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**

- 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/>

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.



BACKUP

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

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`

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



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://kubernetes.io/docs/v3.3/faq/observability/byop/>

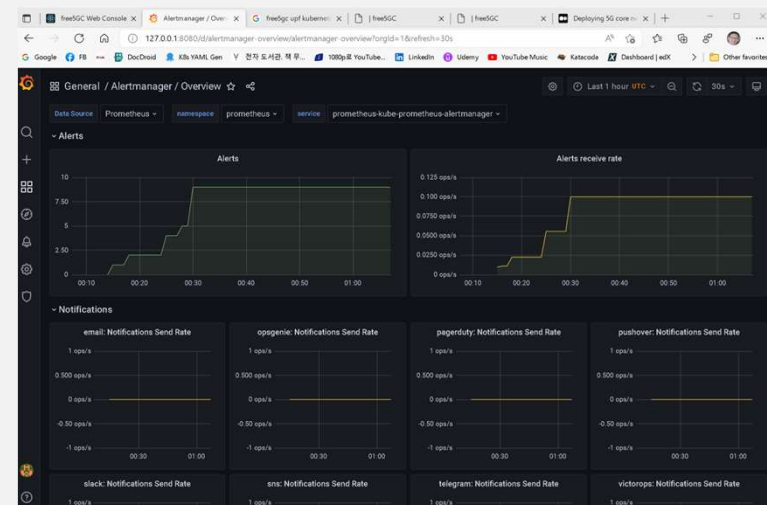
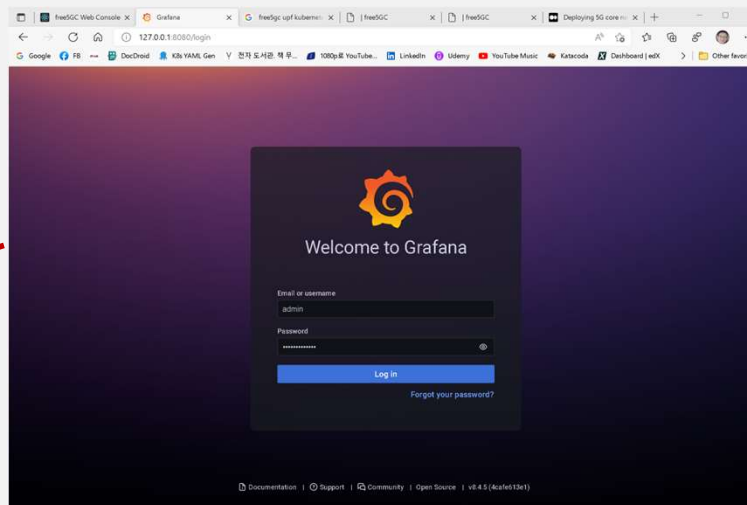
Source: <https://medium.com/rahasak/deploying-5g-core-network-with-free5gc-kubernetes-and-helm-charts-29741cea3922>



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`



Source: <https://medium.com/rahasak/deploying-5g-core-network-with-free5gc-kubernetes-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

Filter labels key=val, ip=0.0.0.0, dns=google.com

Source Pod Name	Source Service	Destination Pod Name	Destination Service	Destination IP	Destination Port	Destination L7 Info	Status	Last Seen
open5gs-pcf-0	app.kubernetes.io/name=...	open5gs-mongodb-kd7fd7...	app.kubernetes.io/name=m...	10.233.64.254	TCP:27017		forwarded	a few seconds ago
open5gs-pcrf-0	app.kubernetes.io/name=...		10.233.36.49 reservedworld	10.233.36.49	TCP:3868		forwarded	a few seconds ago
open5gs-smf-0	app.kubernetes.io/name=...		10.233.45.169 reservedworld	10.233.45.169	TCP:3868		forwarded	a few seconds ago
open5gs-smf-0	app.kubernetes.io/name=...		10.233.45.169 reservedworld	10.233.45.169			dropped	
open5gs-hss-0	app.kubernetes.io/name=...		10.233.19.242 reservedworld	10.233.19.242	TCP:3868		forwarded	a few seconds ago
open5gs-hss-0	app.kubernetes.io/name=...		10.233.19.242 reservedworld	10.233.19.242			dropped	a few seconds ago



BACKUP

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



IV. TESTBED 3 (CLOUD NATIVE)

❖ 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 parameters
  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 under the terms of the license
# the text of which is available at https://www.apache.org/licenses/LICENSE-2.0
# or see the "LICENSE" file for more details.
#
# Author: Abderaouf KHICHANE. Ithel
# Software description: An open-source 5G RAN/UE simulator
#
# Default values for ueransim-chart:
# This is a YAML-formatted file.
# Declare variables to be passed into your templates.

global:
  multiCluster: false
#Global network parameters
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: {}
  requests:
    cpu: 250m
    memory: 256Mi
  nodeSelector: {}
  tolerations: []
  affinity: {}

configuration: |-
  mnc: '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
  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
  # 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: {}
  requests:
    cpu: 120m
    memory: 128Mi
  nodeSelector: {}
  tolerations: []
  affinity: {}

configuration: |-
  supi: "imsi-20893000000003" # IMSI number
  mnc: '208' # Mobile Country Code value
  mnc: '93' # Mobile Network Code value (2 or 3 digits)
  key: "8baf473f2f8fd09487ccbd7097c6862" # 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 the UE
  imeiSv: '4370816125816151' # 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-
      volume:
        name: connectivity-test-volume
        mount: /scripts
        ttlseconds: 50
  uacAcc:
    mps: false
    mcs: false
  # UAC Access Control Class
  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
  configuredNssai:
    - sst: 0x01
      sd: 0x010203
  # Default Configured NSSAI for this UE
  defaultNssai:
    - sst: 1
      sd: 1

```



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-5c548c9dccc-q9mzg         1/1     Running   0           30m
jslab5gc           jslab5gc-v1-free5gc-ausf-ausf-5774d545f9-xf1mm        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-9smw          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-r-j29r                                  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       node-local-dns-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-6dbc94855-fljck                          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-gpwrp                                    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   STATUS
free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb    1/1     Running
free5gc-v1-free5gc-ausf-ausf-6fd5b5f6d-fp9c7    1/1     Running
free5gc-v1-free5gc-nrf-nrf-5664d64868-rp8tn     1/1     Running
free5gc-v1-free5gc-nssf-nssf-6c5658c97f-w8c48  1/1     Running
free5gc-v1-free5gc-pcf-pcf-7c4bb7d9b-n2wxc     1/1     Running
free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfnr    1/1     Running
free5gc-v1-free5gc-udm-udm-7c9b4dbd5f-wsfz7    1/1     Running
free5gc-v1-free5gc-udr-udr-fcdfd7d-625tz      1/1     Running
free5gc-v1-free5gc-upf-upf-57c686dd86-tf6jj    0/1     Container
free5gc-v1-free5gc-webui-webui-76db6dbdc7-vfokq 1/1     Running
mongodb-0                                       1/1     Running
ueransim-v1-gnb-6cdbcff47b-rq7nq             1/1     Running
ueransim-v1-ue-d6b68575-mpzk7                1/1     Running
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-zzfmr -- ip a`

```
jslab@jslab:~$ kubectl get pods -n free5gc
NAME                                READY   STATUS
free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb    1/1     Running
free5gc-v1-free5gc-ausf-ausf-6fd5b5f6d-fp9c7    1/1     Running
free5gc-v1-free5gc-nrf-nrf-5664d64868-rp8tn     1/1     Running
free5gc-v1-free5gc-nssf-nssf-6c5658c97f-w8c48  1/1     Running
free5gc-v1-free5gc-pcf-pcf-7c4bb7d9b-n2wxc     1/1     Running
free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfmr    1/1     Running
free5gc-v1-free5gc-udm-udm-7c9b4dbd5f-wsfz7    1/1     Running
free5gc-v1-free5gc-udr-udr-fcdfd7d-625tz      1/1     Running
free5gc-v1-free5gc-upf-upf-57c686dd86-tf6jj    0/1     Container
free5gc-v1-free5gc-webui-webui-76db6dbdc7-vfokq 1/1     Running
mongodb-0                                      1/1     Running
ueransim-v1-gnb-6cdbcff47b-rq7nq             1/1     Running
ueransim-v1-ue-d6b68575-mpzk7                1/1     Running
jslab@jslab:~$
```

```
jslab@jslab:~$ kubectl exec -it -n free5gc free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfmr -- 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   STATUS
free5gc-v1-free5gc-amf-amf-76778dccb4-f5mdb    1/1     Running
free5gc-v1-free5gc-ausf-ausf-6fd5b5f6d-fp9c7    1/1     Running
free5gc-v1-free5gc-nrf-nrf-5664d64868-rp8tn     1/1     Running
free5gc-v1-free5gc-nssf-nssf-6c5658c97f-w8c48   1/1     Running
free5gc-v1-free5gc-pcf-pcf-7c4bb7d9b-n2wxc     1/1     Running
free5gc-v1-free5gc-smf-smf-5f4d665c66-zzfnr    1/1     Running
free5gc-v1-free5gc-udm-udm-7c9b4dbd5f-wsfz7    1/1     Running
free5gc-v1-free5gc-udr-udr-fcdfdfb7d-625tz     1/1     Running
free5gc-v1-free5gc-upf-upf-57c686dd86-tf6jj    0/1     Container
free5gc-v1-free5gc-webui-webui-76db6dbdc7-vfokq  1/1     Running
mongodb-0                                       1/1     Running
ueransim-v1-gnb-6cdbcff47b-rq7nq             1/1     Running
ueransim-v1-ue-d6b68575-mpzk7                1/1     Running
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      SRS LTE 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 chart to deploy Free5GC
towards5gs/free5gc-ausf 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-n3iwf 0.2.1          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-nrf 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-nssf 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-pcf 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-smf 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-udm 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-udr 0.2.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-upf 0.2.1          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gc-webui 0.1.2          v3.1.1      A Helm chart to deploy Free5GC
towards5gs/free5gcControlPlane 0.1.2          v3.0.5      DEPRECATED Helm chart to deploy Free5GC
towards5gs/free5gcN3iwf 0.1.2          v3.0.5      DEPRECATED Helm chart to deploy Free5GC
towards5gs/free5gcUserPlane 0.1.2          v3.0.5      DEPRECATED Helm chart to deploy Free5GC
towards5gs/networks5g 0.1.2          0.1.2        DEPRECATED Helm chart to deploy networks5g
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      SRS LTE 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'

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

```

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:
`
kubect! 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:
`
kubect! 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"

```



BACKUP

❖ 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-uersanim-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              uersanim-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
```



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 secrets
## @param global.storageClass Global StorageClass for PersistentVolumes
##
global:
  imageRegistry:
    ## E.g.
    ## imagePullSecrets:
    ##   - myRegistryKeySecretName
  imagePullSecrets: []
  storageClass:

## @section Common parameters

## @param kubeVersion Override Kubernetes version
##
kubeVersion:
## @param nameOverride String to partially override common.namespaces
##
nameOverride:
## @param fullnameOverride String to fully override common.namespaces
##
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: "0xfffff"
tac: '0001'

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

ues:
  enabled: false
  count: 1
  initialMSISDN: '0000000001'
  key: 465B5CE8B199B49FAA5FOA2EE238A6BC
  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 under the terms of the Apache License 2.0
# the text of which is available at https://www.apache.org/licenses/LICENSE-2.0
# or see the "LICENSE" file for more details.
#
# Author: Abderaouf KHICHANE, Ilhem KHICHANE
# Software description: An open-source 5G RAN/UE simulator
#
# Default values for ueransim-chart:
# This is a YAML-formatted file.
# Declare variables to be passed into your templates

global:
  multiCluster: false
  #Global network parameters
  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: |-
  mnc: '208' # Mobile Country Code value
  nci: '0x000000010' # NR Cell Identity (36-bit)
  idLength: 32 # NR gNB ID length in bits
  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
    # 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-20893000000003" # IMSI number
  mnc: '208' # Mobile Country Code value
  mnc: '93' # Mobile Network Code value (2 or 3 digits)
  key: "8baf473f2f8fd09487ccbd7097c6862" # 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 the UE
  imeiSv: '4370816125816151' # 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-
      volume:
        name: connectivity-test-volume
        mount: /scripts
        ttlseconds: 50
  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

```

```
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: |-
  mnc: '208' # Mobile Country Code value
  nci: '0x000000010' # NR Cell Identity (36-bit)
  idLength: 32 # NR gNB ID length in bits
  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
    # 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-20893000000003" # IMSI number
  mnc: '208' # Mobile Country Code value
  mnc: '93' # Mobile Network Code value (2 or 3 digits)
  key: "8baf473f2f8fd09487ccbd7097c6862" # 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 the UE
  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-
    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
#
# 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) 2021 OpenVerse
# SPDX-License-Identifier: Apache-2.0
#
# This software is distributed under the terms of the
# the text of which is available at https://www.apache.org/licenses/LICENSE-2.0
# or see the "LICENSE" file for more details
#
# Author: Abderaouf KHICHANE, Ilhem FAJJAJ
# Software description: An open-source project for 5G RAN/UE deployment
#
# Default values for ueransim-chart.
# This is a YAML-formatted file.
# Declare variables to be passed into your templates
```

```
global:
  multiCluster: false
  #Global network parameters
  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" # This
  # A script that will be run after the UE creation. It
  # is 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
  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
  either 'OP' or 'OPC'
  amf: '8000' # Authentication Management Field (AMF) value
  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
```

