

Intel® FlexRAN™ Reference Solution Setup for SUSE

FlexRAN™ Deployment Guide for Rancher Kubernetes Cluster



Suse Linux Enterprise Server 15.3 Real Time
Suse Linux Enterprise Micro 5.2 Real Time
Rancher 2.6 by Suse

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Summary

This document provides detailed steps on how to configure Intel® FlexRAN™ 22.07 on SUSE Linux Enterprise 15 SP3 Real-Time (SLES 15 SP3 RT) and deploy FlexRAN™ containers on Rancher Kubernetes Engine v2 (RKE2) cluster running on SUSE Linux Enterprise Micro 5.2 (SLE Micro) as SUSE/Intel Solution for Telco.

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Contents

- 1 Introduction 4
- 2 Prerequisites 4
- 3 Intel® FlexRAN™ Installation 17
- 4 Baremetal Host Testing 23
- 5 Deploy FlexRAN™ on Container through Kubernetes 28
- 6 Summary 38
- 7 Reference 38
- 8 Legal notice 40
- 9 GNU Free Documentation License 41

1 Introduction

This document is providing detailed steps to setup a cloud-native stack for Intel® FlexRAN™ on SUSE Rancher kubernetes cluster. This demonstration shows required steps to install and configure Intel's FlexRAN PHY Reference Design using SUSE Linux Enterprise Server Real Time as the base Operating System and SUSE Linux Enterprise Micro Real Time as target hosts for Rancher RKE2 or K3s kubernetes cluster with SUSE Rancher Server to manage this deployment.

The Intel® FlexRAN™ 22.07™ is a 4G and 5G baseband PHY Reference design utilizing Xeon series processors and consists of a L1 library for SkyLake/CascadeLake platforms to demonstrate the capabilities of the software running 5GNR L1 features. See <https://www.intel.com/content/www/us/en/developer/topic-technology/edge-5g/tools/flexran.html> [FlexRAN™ Reference Architecture] for more information.

The goal is to empower Telco developers and/or engineers to put together an Intel® FlexRAN™ test and/or proof-of-concept (PoC) environment leveraging the benefits of the complete SUSE stack from the real-time OS to Kubernetes orchestration and management.

This guide will help you to configure and deploy a test kubernetes cluster using SUSE Products such as Rancher Server, SUSE Linux Enterprise Server Real Time and Suse Linux Enterprise Micro Real Time to create and manage RKE2 cluster with Intel® FlexRAN™ containers.

2 Prerequisites

2.1 Hardware configuration

The following hardware components were used during the development of this guide:

Component	Specification
Processor	Intel® Xeon® Silver 4316 @ 2.30Ghz
Memory	128 GB RAM
Network	Intel® vRAN ACC100-based accelerator Intel® E810 100Gb Ethernet controller

Component	Specification
Storage	480GB SSD SATA Read Intensive 6Gbps 960GB Data Center NVMe

```
XR12-B:~ # lspci | grep -i --color eth
1b:00.0 Ethernet controller: Broadcom Inc. and subsidiaries BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet (rev 11)
1b:00.1 Ethernet controller: Broadcom Inc. and subsidiaries BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet (rev 11)
1b:00.2 Ethernet controller: Broadcom Inc. and subsidiaries BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet (rev 11)
1b:00.3 Ethernet controller: Broadcom Inc. and subsidiaries BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet (rev 11)
51:00.0 Ethernet controller: Intel Corporation Ethernet Controller E810-C for QSFP (rev 02)
51:00.1 Ethernet controller: Intel Corporation Ethernet Controller E810-C for QSFP (rev 02)
8a:00.0 Ethernet controller: Intel Corporation Ethernet Controller X710 for 10GbE-T (rev 02)
8a:00.1 Ethernet controller: Intel Corporation Ethernet Controller X710 for 10GbE-T (rev 02)
```



Note

For more details on required components check Intel FlexRAN reference documentation: Installation Guide Software Release v22.07 (Doc. No.: 575834-15.0) and FlexRAN™ 5GNR Reference Solution 22.07 - PHY Software Documentation (Doc. No.: 603577)

```
XR12-B:~ # lscpu
Architecture: x86_64
CPU op-mode(s): 32-bit, 64-bit
Byte Order: Little Endian
Address sizes: 46 bits physical, 57 bits virtual
CPU(s): 40
On-line CPU(s) list: 0-39
Thread(s) per core: 2
Core(s) per socket: 20
Socket(s): 1
NUMA node(s): 1
Vendor ID: GenuineIntel
CPU family: 6
Model: 106
Model name: Intel(R) Xeon(R) Silver 4316 CPU @ 2.30GHz
Stepping: 6
CPU MHz: 1600.000
CPU max MHz: 3400.0000
CPU min MHz: 800.0000
BogoMIPS: 3200.00
Virtualization: VT-x
L1d cache: 960 KiB
L1i cache: 640 KiB
L2 cache: 25 MiB
L3 cache: 30 MiB
NUMA node0 CPU(s): 0-39
```

- BIOS Setup

BIOS configuration may be different for each server, but most modern servers should have similar settings.

Among the most important are CPU C state and P state.

For example: image::bios1.png[bios1,scaledwidth = "75%", align = "center"]

For CPU power management in the bios settings use OS DBPM (or similar) setting to control setting from OS to manipulate processor frequencies. image::bios2.png[bios2,scaledwidth = "75%", align = "center"]

Processor Settings		
Logical Processor	<input checked="" type="radio"/> Enabled	<input type="radio"/> Disabled
Virtualization Technology	<input checked="" type="radio"/> Enabled	<input type="radio"/> Disabled
Kernel DMA Protection	<input type="radio"/> Enabled	<input checked="" type="radio"/> Disabled
Directory Mode	<input checked="" type="radio"/> Enabled	<input type="radio"/> Disabled
Adjacent Cache Line Prefetch	<input checked="" type="radio"/> Enabled	<input type="radio"/> Disabled
Hardware Prefetcher	<input checked="" type="radio"/> Enabled	<input type="radio"/> Disabled
DCU Streamer Prefetcher	<input checked="" type="radio"/> Enabled	<input type="radio"/> Disabled
DCU IP Prefetcher	<input checked="" type="radio"/> Enabled	<input type="radio"/> Disabled
Sub NUMA Cluster	<input type="radio"/> 2-Way Clustering	<input checked="" type="radio"/> Disabled
MADT Core Enumeration	<input checked="" type="radio"/> Round Robin	<input type="radio"/> Linear
UPI Prefetch	<input type="radio"/> Enabled	<input checked="" type="radio"/> Disabled
XPT Prefetch	<input checked="" type="radio"/> Enabled	<input type="radio"/> Disabled
LLC Prefetch	<input checked="" type="radio"/> Enabled	<input type="radio"/> Disabled
Dead Line LLC Alloc	<input checked="" type="radio"/> Enabled	<input type="radio"/> Disabled
Directory AtoS	<input type="radio"/> Enabled	<input checked="" type="radio"/> Disabled
Logical Processor Idling	<input type="radio"/> Enabled	<input checked="" type="radio"/> Disabled
AVX P1	<input type="radio"/> Normal	<input type="radio"/> Level 1 <input checked="" type="radio"/> Level 2
Intel SST-CP	<input type="radio"/> Enabled	<input checked="" type="radio"/> Disabled
x2APIC Mode	<input checked="" type="radio"/> Enabled	<input type="radio"/> Disabled
AVX ICCP Pre-Grant License	<input checked="" type="radio"/> Enabled	<input type="radio"/> Disabled
AVX ICCP Pre-Grant Level	512 Heavy	
 <u>Dell Controlled Turbo</u>		
Number of Cores per Processor	All	

For more details, please review section 2.4.2 of FlexRAN Software Reference Solution Cloud-Native Setup. (Intel® Doc. No. 575834-15.0) and BIOS Settings for FlexRAN Platforms Based on Intel® Xeon® Processors. (Doc. No.: 675g685, Rev.: 1.3)

2.2 OS prerequisites

Intel® FlexRAN™ stipulates a real-time kernel, as listed in Intel FlexRAN Installation Guide (Doc. No.: 575834-15.0)

For this particular test we used a baremetal node as a development host running SUSE Linux Enterprise 15 SP3 Real-Time to preconfigure and test FlexRAN functionality and build container image before exporting it to a Rancher kubernetes cluster.

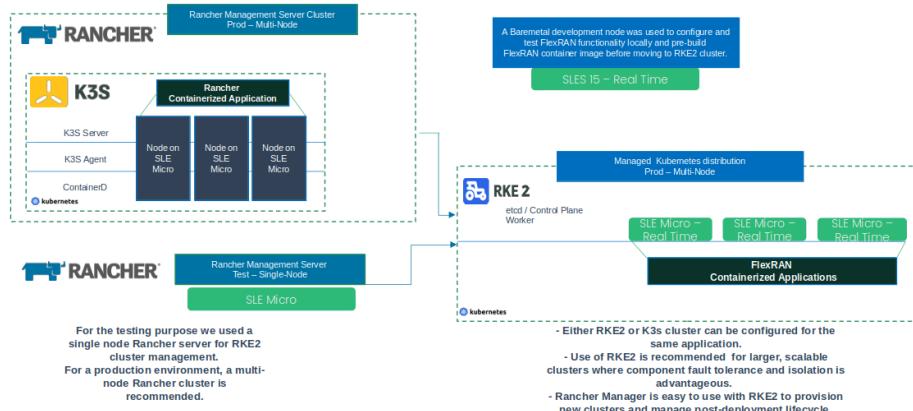


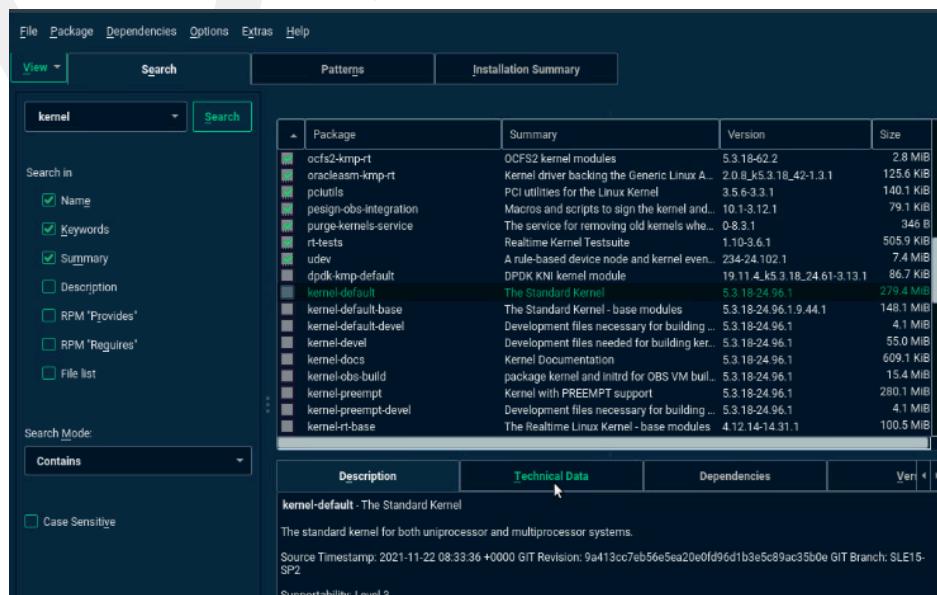
FIGURE 1: TEST SETUP DIAGRAM

SUSE Linux Enterprise Real Time is a real time operating system designed to reduce latency and increase the predictability and reliability of time-sensitive, business-critical applications.

For more details about SLES RT please review <https://www.suse.com/products/realtime/>

- Install SUSE Linux Enterprise Server 15 Real Time.

Please refer to <https://documentation.suse.com/sle-rt/15-SP3/> When installing SLE 15 RT, during the installation make sure to unmark kernel-default.



Verify that kernel-rt is selected

Package	Summary	Version	Size
dlm-kmp-rt	DLM kernel modules	5.3.18-62.2	409.4 KIB
gfs2-kmp-rt	GFS2 kernel modules	5.3.18-62.2	1021.7 KIB
kernel-devel-rt	Development files needed for building ker...	5.3.18-62.3	55.1 MIB
kernel-firmware	Linux kernel firmware files	20200107-3.23.1	490.5 MIB
kernel-macros	RPM macros for building Kernel Module ...	5.3.18-24.9.6.1	25.3 KIB
kernel-rt	The Linux Kernel	5.3.18-62.2	279.3 MIB
kernel-rt-devel	Development files necessary for building ...	5.3.18-62.2	4.1 MIB
kernel-source-rt	The Linux Kernel Sources	5.3.18-62.3	774.6 MIB



Note

During the installation, add a sufficient space to the /opt or /var directory which will be used for most Intel components and containers. We would recommend 200 Gb of storage for these directories. Don't install FlexRAN under root directory.

- Real Time configuration

- Isolate cores Verify that tuned installed.

```
zypper in tuned*
```

```
XR12-B:~ # lscpu|grep NUMA
NUMA node(s):               1
NUMA node0 (CPU(s)):        0-39
```

In our case we have 1 socket and 40 cores.

Add isolated cores to the configuration.

```
vi /etc/tuned/cpu-partitioning-variables.conf
```

```
# Examples:
# isolated_cores=2,4-7
# isolated_cores=2-23
isolated_cores=2-39
# To disable the kernel load balancing in certain isolated CPUs:
# no_balance_cores=5-10
```

- Activate RT profile

```
tuned-adm profile cpu-partitioning
```

```
For UEFI modify /boot/efi/EFI/sle_rt/grub.cfg
```

```
as following:
```

```
//
```

```
set tuned_params="skew_tick=1 nohz=on nohz_full=2-39 rcu_nocbs=2-39 nosoftlockup isolcpus=2-39"
```

```
linuxefi /boot/vmlinuz-5.3.18-150300.96-rt root=UUID=d487d26d-5a91-4c49-a086-4240636a30b8 crashkernel=auto processor.max_cstate=1 intel_pstate=passive nohz=on audit=0 mce=off intel_iommu=on iommu=pt intel_idle.max_cstate=0 idle=poll usbcore.autosuspend=-1 selinux=0 enforcing=0 nmi_watchdog=0 nosoftlockup hugepagesz=1G hugepages=40 hugepagesz=2M hugepages=0 default_hugepagesz=1G kthread_cpus=0,1 irqaffinity=0,1 ${extra_cmdline} $tuned_params
```



Note

Settings depends on the number of CPU and isolated cores.

Please review section 2.4.3 of Intel's document 575834-15.0

- Save changes

```
grub2-mkconfig -o /boot/grub2/grub.cfg
```

or for UEFI

```
grub2-mkconfig -o /boot/efi/EFI/sle_rt/grub.cfg
```

- Reboot server and verify parameters:

```
grep tuned_params= /boot/grub2/grub.cfg
```

```
XR12-B:~ # grep tuned_params= /boot/grub2/grub.cfg
set tuned_params="skew_tick=1 nohz=on nohz_full=2-39 rcu_nocbs=2-39 nosoftlockup isolcpus=2-39"
```

```
cat /proc/cmdline
```

```
XR12-B:~ # cat /proc/cmdline
processor.max_cstate=1 intel_idle.max_cstate=1 skew_tick=1 hpc_cpusets BOOT_IMAGE=/boot/vmlinuz-5.3.18-150300.96-rt root=UUID=d487d26d-5a91-4c49-a086-4240636a30b8 crashkernel=auto processor.max_cstate=1 intel_pstate=passive nohz=on audit=0 mce=off intel_iommu=on iommu=pt intel_idle.max_cstate=0 idle=poll usbcore.autosuspend=-1 selinux=0 enforcing=0 nmi_watchdog=0 nosoftlockup hugepagesz=1G hugepages=40 hugepagesz=2M hugepages=0 default_hugepagesz=1G kthread_cpus=0,1 irqaffinity=0,1 skew_tick=1 nohz=on nohz_full=2-39 rcu_nocbs=2-39 nosoftlockup isolcpus=2-39
```

2.3 Set CPU Frequency

AVX512 CPU frequency of your specific CPU should be adjusted according to Figure 4 of Intel's doc Reference Number: 637779, Revision: 1.2 3rd Gen Intel® Xeon® Scalable Processors, Codename Ice Lake NDA Specification Update June 2021 or #613537 for Skylake processor family

					# of active cores / maximum core frequency in turbo mode (GHz)																									
SKU	Cores	LCC (MB)	TDP (W)	Base AVX 512 Core Freq (GHz)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
					3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3		
5320	26	39	185	1.6	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.1	3.1	2.9	2.9	2.7	2.7	2.7	2.6	2.6	2.6
6342	24	36	230	2.1	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.2	3.2	3.2
6338T	24	36	165	1.5	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.1	3.1	2.9	2.9	2.6	2.6	2.6	2.5	2.5	2.5
6336Y	24	36	185	1.7	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.2	3.2	3.2	3.2	3.1	3.1	2.8	2.8	2.8	2.8	
6312U	24	36	185	1.8	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.3	3.3	3.2	3.2	3.0	3.0	3.0	2.8	2.8	2.8	
5318Y	24	36	165	1.5	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.1	3.1	2.9	2.9	2.6	2.6	2.6	2.5	2.5	2.5	
5318S	24	36	165	1.5	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.1	3.1	2.9	2.9	2.6	2.6	2.6	2.5	2.5	2.5	
5318N	24	36	150	1.5	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.0	3.0	2.7	2.7	2.7	2.6	2.6	2.5	2.5	2.5	2.5	
5320T	20	30	150	1.6	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.2	3.2	3.0	3.0	2.9	2.9	2.8	2.8	2.7	2.7			
4316	20	30	150	1.6	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.1	2.9	2.9	2.8	2.8	2.7	2.7	2.6	2.6	2.6	2.6	
6326	16	24	185	2.1	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.2	3.2	3.2	3.2	3.2	3.1	3.1					
4314	16	24	135	1.7	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.1	3.1	3.0	3.0	2.8	2.8	2.7	2.7								
5317	12	18	150	2.2	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	

In this test Xeon 4316 was used with 2.6 GHz.

- There are two options to setup your CPU frequency.
 - Use cpupower tool

For example, by running

```
cpupower frequency-info
```

you can check available frequencies for your CPU and drivers.

```
Setting up cpufreq
XR12-B:/etc/default # cpupower frequency-info
analyzing CPU 0:
  driver: intel_cpufreq
  CPUs which run at the same hardware frequency: 0
  CPUs which need to have their frequency coordinated by software: 0
  maximum transition latency: 20.0 us
  hardware limits: 800 MHz - 3.40 GHz
  available cpufreq governors: userspace ondemand performance schedutil
  current policy: frequency should be within 800 MHz and 3.40 GHz.
    The governor "userspace" may decide which speed to use
    within this range.
  current CPU frequency: Unable to call hardware
  current CPU frequency: 2.60 GHz (asserted by call to kernel)
  boost state support:
    Supported: yes
    Active: yes
```

In this example intel_cpufreq was used. The userspace governor is available with the older acpi-cpufreq driver (which will be automatically used if you disable intel_pstate at boot time; you then set the governor/frequency with cpupower)

Set intel_pstate driver to passive in grub (intel_pstate=passive).

```
echo passive | sudo tee /sys/devices/system/cpu/intel_pstate/status
```

or add intel_pstate=passive to the grub

```
modprobe cpufreq_userspace
```

Set cpu governor to userspace

```
cpupower frequency-set --governor userspace
```

Set frequency according to the AVX-512 table (2600MHz in this case)

```
cpupower --cpu all frequency-set --freq 2600MHz
```



Note

It's important to set C-state and P-state on the Bios settings as well as on the kernel side. If you don't do this, you won't be able to change governors from the cpupower command and set the cpu frequency. Also, make sure that the BIOS can be changed from the OS by proper setting.

Verify that settings applied by running:

```
turbostat -i 1
```

Core	CPU	Avg_MHz	Busy%	Bzy_MHz	TSC_MHz	IRQ	SMI	CPU%c1	CPU%c6	CoreTmp	PkgTmp	Pkg%pc2	Pkg%pc6	PkgWatt	RAMWatt	PKG %	RAM %
-	-	2594	100.00	2600	1596	6661	0	0.00	0.00	45	45	0.00	0.00	107.91	16.64	0.00	0.00
0	0	2594	100.00	2600	1596	166	0	0.00	0.00	44	45	0.00	0.00	107.91	16.64	0.00	0.00
0	20	2594	100.00	2600	1596	176	0	0.00									
1	2	2594	100.00	2600	1596	166	0	0.00	0.00	44							
1	22	2594	100.00	2600	1596	165	0	0.00									
2	4	2594	100.00	2600	1596	166	0	0.00	0.00	44							
2	24	2594	100.00	2600	1596	165	0	0.00									
3	6	2594	100.00	2600	1596	166	0	0.00	0.00	43							
3	26	2594	100.00	2600	1596	166	0	0.00									
4	8	2594	100.00	2600	1596	166	0	0.00	0.00	43							
4	28	2594	100.00	2600	1596	166	0	0.00									
5	10	2594	100.00	2600	1596	166	0	0.00	0.00	43							
5	30	2594	100.00	2600	1596	166	0	0.00									
6	12	2594	100.00	2600	1596	166	0	0.00	0.00	42							
6	32	2594	100.00	2600	1596	166	0	0.00									

You can also check with other available tools

Mperf			
CPU	C0	Cx	Freq
0	99.94	0.06	2593
20	99.94	0.06	2593
2	99.94	0.06	2593
22	99.94	0.06	2593
4	99.94	0.06	2593
24	99.94	0.06	2593
6	99.94	0.06	2593
26	99.94	0.06	2593
8	99.94	0.06	2593
28	99.94	0.06	2593
10	99.94	0.06	2593
30	99.94	0.06	2593
12	99.94	0.06	2593
32	99.94	0.06	2593
14	99.94	0.06	2593
34	99.94	0.06	2593
16	99.94	0.06	2593
36	99.94	0.06	2593
18	99.94	0.06	2593
38	99.94	0.06	2593
1	99.94	0.06	2593

```
XR12-B:~ # grep MHz /proc/cpuinfo
cpu MHz : 2600.000
cpu MHz : 2600.001
cpu MHz : 2600.000
```

- The 2nd method to change AVX512 frequency is to install Intel msr-tools with the following commands:

```
git clone https://github.com/intel/msr-tools/
cd msr-tools/
git checkout msr-tools-1.3
make
modprobe msr
```

Create bash script setFreq.sh with the following context:

```
#!/bin/bash

cpupower frequency-set -g performance

for i in {0..39}

do

/home/Intel/msr-tools/msr-tools/wrmsr -p $i 0x199 0x1A00

done

#Set Uncore max frequency

/home/Intel/msr-tools/msr-tools/wrmsr -p 0 0x606A6 0x1A00

/home/Intel/msr-tools/msr-tools/wrmsr -p 39 0x606A6 0x1A00
```



Note

Values in the script are taking from Intel document #637779 (for ice lake family) specific to your CPU avx512 numbers. (2.6 GHz in the above example)

Table 2. 3rd Gen Intel® Xeon® Scalable Processors Identification

Processor Number	QDF/S-Spec Number	Die	Stepping	CPUID	Speed (GHz)	DDR4 (MHz)	TDP (W)	# of Cores	LLC Cache Size (MB)	Max. Supported Sockets/Intel UPI Links
4309Y	SRKXS	HCC	M1	0x606A6	2.8	2667	105	8	12	2/2
6342	QXRU	HCC	M1	0x606A6	2.8	3200	230	24	36	2/3
6338T	QXS3	HCC	M1	0x606A6	2.1	3200	165	24	36	2/3
6336Y	QXRV	HCC	M1	0x606A6	2.4	3200	185	24	36	2/3
6334	QXRQ	HCC	M1	0x606A6	3.6	3200	165	8	12	2/3
6326	QXS7	HCC	M1	0x606A6	2.9	3200	185	16	24	2/3
6312U	QXRW	HCC	M1	0x606A6	2.4	3200	185	24	36	1/0
5320T	QXS6	HCC	M1	0x606A6	2.3	2933	150	20	30	2/3
5320	QXRT	HCC	M1	0x606A6	2.2	2933	185	26	39	2/3
5318Y	QXS2	HCC	M1	0x606A6	2.1	2933	165	24	36	2/3
5318S	QRXR	HCC	M1	0x606A6	2.1	2933	165	24	36	2/3
5318N	QXS4	HCC	M1	0x606A6	2.1	2667	150	24	36	2/2
5317	QXRM	HCC	M1	0x606A6	3.0	2933	150	12	18	2/3
5315Y	QXRR	HCC	M1	0x606A6	3.2	2933	140	8	12	2/3
4316	QXS5	HCC	M1	0x606A6	2.3	2667	150	20	30	2/2
4314	QXS8	HCC	M1	0x606A6	2.4	2667	135	16	24	2/2
4310T	QXRP	HCC	M1	0x606A6	2.3	2667	105	10	15	2/2
4310	QXRN	HCC	M1	0x606A6	2.1	2667	120	12	18	2/2
4309Y	QXRS	HCC	M1	0x606A6	2.8	2667	105	8	12	2/2

Run the above bash script with your specific numbers which should be changed to the required frequency and verify that required frequency was applied.

Review performance with a Cyclictest.

```
KR12-B:~ # taskset -c 0-19 cyclictest -m -p95 -h 15 -a 1-19 -t 19 --mainaffinity=0
# /dev/cpu_dma_latency set to 0us
policy: fifo: loadavg: 2.76 3.02 2.86 2/1182 14957

T: 0 ( 8667) P:95 I:1000 C:1726624 Min:      1 Act:    2 Avg:    2 Max:      17
T: 1 ( 8668) P:95 I:1000 C:1726630 Min:      2 Act:    2 Avg:    2 Max:      15
T: 2 ( 8669) P:95 I:1000 C:1726629 Min:      2 Act:    3 Avg:    2 Max:      12
T: 3 ( 8670) P:95 I:1000 C:1726629 Min:      2 Act:    2 Avg:    2 Max:      15
T: 4 ( 8671) P:95 I:1000 C:1726629 Min:      2 Act:    2 Avg:    2 Max:      13
T: 5 ( 8672) P:95 I:1000 C:1726628 Min:      2 Act:    2 Avg:    2 Max:      13
T: 6 ( 8673) P:95 I:1000 C:1726628 Min:      2 Act:    2 Avg:    2 Max:      11
T: 7 ( 8674) P:95 I:1000 C:1726628 Min:      2 Act:    2 Avg:    2 Max:      11
T: 8 ( 8675) P:95 I:1000 C:1726627 Min:      2 Act:    2 Avg:    2 Max:      11
T: 9 ( 8676) P:95 I:1000 C:1726627 Min:      2 Act:    2 Avg:    2 Max:      10
T:10 ( 8677) P:95 I:1000 C:1726627 Min:      2 Act:    2 Avg:    2 Max:      13
T:11 ( 8678) P:95 I:1000 C:1726627 Min:      2 Act:    2 Avg:    2 Max:      15
T:12 ( 8679) P:95 I:1000 C:1726626 Min:      2 Act:    2 Avg:    2 Max:      13
T:13 ( 8680) P:95 I:1000 C:1726626 Min:      2 Act:    2 Avg:    2 Max:      11
T:14 ( 8681) P:95 I:1000 C:1726625 Min:      2 Act:    2 Avg:    2 Max:      10
T:15 ( 8682) P:95 I:1000 C:1726625 Min:      2 Act:    2 Avg:    2 Max:      8
T:16 ( 8683) P:95 I:1000 C:1726625 Min:      2 Act:    2 Avg:    2 Max:      12
T:17 ( 8684) P:95 I:1000 C:1726625 Min:      2 Act:    3 Avg:    2 Max:      10
T:18 ( 8685) P:95 I:1000 C:1726624 Min:      2 Act:    3 Avg:    2 Max:      11
```

For more details review [SLE RT Hardware Testing] https://documentation.suse.com/sle-rt/15-SP3/pdf/article-hardware-testing_color_en.pdf

- Install Intel GPU drivers

Review <https://dgpu-docs.intel.com/installation-guides/suse/suse-15sp3.html> for more details.

```
zypper addrepo -r https://repositories.intel.com/graphics/sles/15sp3/intel-graphics.repo  
zypper install intel-opencl intel-media-driver libmfx1 intel-level-zero-gpu level-zero
```

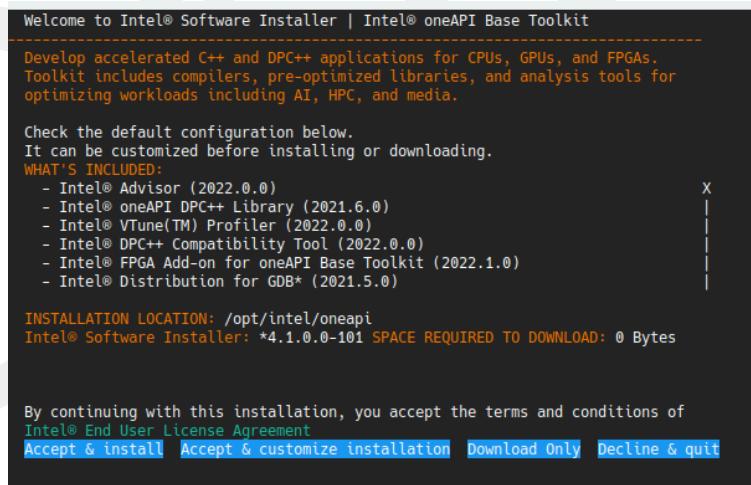
2.4 Install Intel® oneAPI

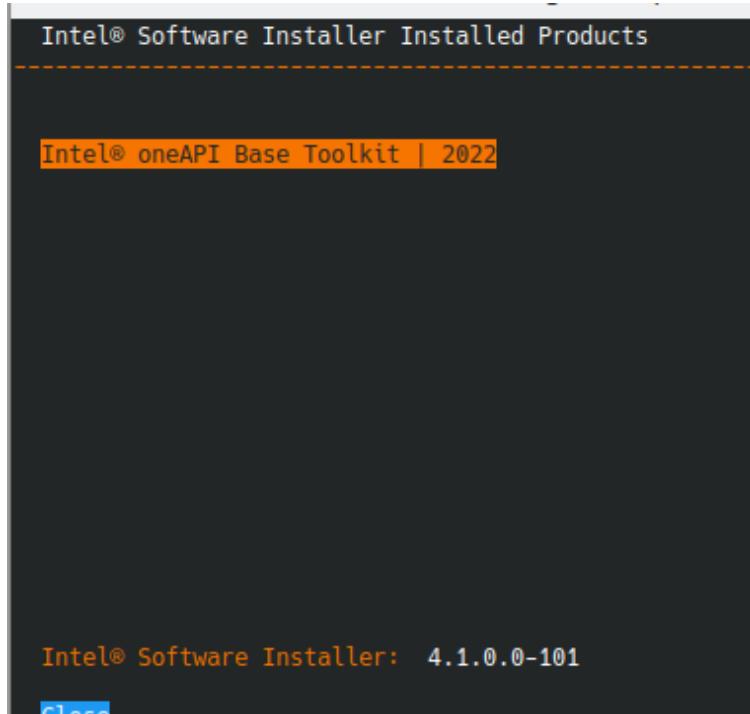
```
wget https://registrationcenter-download.intel.com/akdlm/irc_nas/18236/  
l_BaseKit_p_2021.4.0.3422_offline.sh  
  
bash l_BaseKit_p_2021.4.0.3422_offline.sh
```



Note

Make sure that the installation directory has enough space. Intel oneAPI is using about 40Gb of space.





Source the env and verify installed version.

```
XR12-B:/opt/intel/oneapi # source /opt/intel/oneapi/setvars.sh
:: initializing oneAPI environment ...
-bash: BASH_VERSION = 4.4.23(1)-release
args: Using "$@" for setvars.sh arguments:
:: advisor -- latest
:: ccl -- latest
:: compiler -- latest
:: dal -- latest
:: debugger -- latest
:: dev-utilities -- latest
:: dmnl -- latest
:: dpcpp-ct -- latest
:: dpl -- latest
:: intelpython -- latest
:: ipp -- latest
:: ippcp -- latest
:: mkl -- latest
:: mpi -- latest
:: tbb -- latest
:: vpl -- latest
:: vtune -- latest
:: oneAPI environment initialized ::

XR12-B:/opt/intel/oneapi # icx -v
Intel(R) oneAPI DPC++/C++ Compiler 2022.0.0 (2022.0.0.20211123)
Target: x86_64-unknown-linux-gnu
Thread model: posix
InstalledDir: /opt/intel/oneapi/compiler/2022.0.2/linux/bin-llvm
Found candidate GCC installation: /usr/lib64/gcc/x86_64-suse-linux/7
Selected GCC installation: /usr/lib64/gcc/x86_64-suse-linux/7
Candidate multilib: .;@m64
Selected multilib: .;@m64
```

Make sure that GCC is installed to work with ICX compiler.

```
XR12-B:/etc/default # gcc --version
gcc (SUSE Linux) 7.5.0
Copyright (C) 2017 Free Software Foundation, Inc.
This is free software; see the source for copying conditions. There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.
```

3 Intel® FlexRAN™ Installation

Review Compilation tools section of FlexRAN 5GNR Reference Solution 22.07 PHY Software Documentation - Document #603577

Make sure that your instance has installed cmake, meson and ninja.

In order to build the L1 application and L1 standalone Test Application, the following steps are required (in order):

3.1 Install pkgconf tool

```
zypper in automake
zypper in libtool
git clone https://github.com/pkgconf/pkgconf.git
cd pkgconf/
./configure
make
make install
export LD_LIBRARY_PATH=$LD_LIBRARY_PATH:/usr/local/lib
```

```
XR12-B:/var/pkgconf-1.9.3/libpkgconf # pkgconf --version
1.9.3
XR12-B:/var/pkgconf-1.9.3/libpkgconf # □
```

3.2 Install DPDK



Note

Don't use /root directory for the installation.
You need to get the dpdk patch from Intel which is required.

```
wget http://static.dpdk.org/rel/dpdk-21.11.tar.xz
```

```
tar xf dpdk-21.11.tar.xz  
export RTE_SDK=/var/dpdk/dpdk-21.11
```

Copy patch to RTE_SDK directory and apply dpdk patch

```
patch -p1 < dpdk_patch_21.11.patch
```

3.3 Download and install FlexRAN

Download FlexRAN release as per Intel document 645964. Extract file and source the environment.

```
tar -zxvf FlexRan-22.07.tar.gz  
.extract.sh  
export RTE_SDK=/var/dpdk/dpdk-21.11  
source ./set_env_var.sh
```

```
XR12-B:/var/FlexRan22.07 # source set_env_var.sh  
Compiler not set, defaulting to icx  
=====  
Environment Variables:  
=====  
RTE_SDK=/var/dpdk/dpdk-21.11  
WIRELESS_SDK_TARGET_ISA=avx512  
CPA_DIR=/var/FlexRan22.07/libc/cpa  
XRAN_DIR=/var/FlexRan22.07/xran  
DIR_WIRELESS_SDK_ROOT=/var/FlexRan22.07/sdk  
SDK_BUILD=build-avx512-icx  
DIR_WIRELESS_SDK=/var/FlexRan22.07/sdk/build-avx512-icx  
FLEXRAN_SDK=/var/FlexRan22.07/sdk/build-avx512-icx/install  
DIR_WIRELESS_FW=/var/FlexRan22.07/framework  
DIR_WIRELESS_TEST_4G=/var/FlexRan22.07/tests/lte  
DIR_WIRELESS_TEST_5G=/var/FlexRan22.07/tests/nr5g  
DIR_WIRELESS_TABLE_5G=/var/FlexRan22.07/bin/nr5g/gnb/l1/table  
=====  
XR12-B:/var/FlexRan22.07 #
```

3.4 Compile SDK

Get gcc11-c++

```
zypper in gcc11-c++
```

Export PKG_CONFIG_PATH

```
export PKG_CONFIG_PATH=$DIR_WIRELESS_SDK/pkgcfg:$PKG_CONFIG_PATH
```

Source Intel oneAPI

```
source /opt/intel/oneapi/setvars.sh --force  
export PATH=/opt/intel/oneapi/compiler/2022.0.2/linux/bin-llvm/:$PATH
```

Review possible compilation options from ./flexran_build.sh -h command

```
XR12-B:/var/FlexRan22.07 # ./flexran_build.sh -h  
./flexran_build.sh [options]  
Options:  
-c, --clean      bypasses clean during build process. By default clean is always enabled  
-e, --set-env    set environment for the build if not already set elsewhere  
-v, --verbose    display all build messages to terminal  
-r, --rat        Radio access technology, mandatory option: lte or 5gnr or multi_rat  
-i, --isa        specify target isa: avx2 or avx512 or snc or spr (default if not set)  
For 5gnr the isa only applies to the SDK component  
-x, --compiler   specify target compiler: icc or icx (default if not set)  
-o, --old-scheduler enable old framework scheduler option for liapp  
-l, --lib-mode    build liapp as a lib, only support 5gnr liapp  
-p, --poll-offload enable polling event offloading option, only support 5gnr liapp  
-m, --mode       mode of operation / build option. Option can be set multiple times  
  sdk - SDK Library  
  bbu - Framework Library  
  wls - Wireless Shared Memory Library  
  mlog - MLog library  
  cpa - CPA 5GNR library  
  xran - xran library  
  liapp - Build L1 Application for radio mode chosen with -r option  
  testmac - Build Testmac Application for radio mode chosen with -r option  
  testapp - Build Testapp Application for radio mode chosen with -r option  
  all - Build all of the above for the specified RAT(s) (default if not set)  
-h, --help        show help info and exit
```

Compile SDK

```
./flexran_build.sh -x icx -e -r 5gnr -i avx512 -m sdk
```



Note

The FlexRAN SDK libraries must be built first to the provided path before starting the DPDK build process so that software FEC libraries are present.

3.5 Patch and Compile DPDK

```
zypper in python3-pyelftools.rpm
```

Create dpdk script

```
vi dpdk-dep.sh  
  
#!/bin/bash
```

```
work_path=$PWD
sdk_path= /var/FlexRan22.07/sdk
echo "-----build base dpdk -----"
cd $RTE_SDK; meson build; cd build; meson configure -Dflexran_sdk=$sdk_path/build-avx512-icx/install; ninja
```

Run dpdk script

```
./dpdk-dep.sh
```

Create dpdk-kmods

```
git clone http://dpdk.org/git/dpdk-kmods
cd dpdk-kmods/linux/igb_uio/
make
modprobe uio
insmod $RTE_SDK_KMOD/linux/igb_uio/igb_uio.ko
export RTE_SDK_KMOD=/var/dpdk/dpdk-kmods
```

3.6 Build the L1 Application, L1 Standalone Test Application, and Test MAC in Linux:

Verify that you have numa*, libhuge* and libnuma-dev* installed

Mount hugepages

```
mount -t hugetlbfs nodev /mnt/huge
```

Compile 5gnr

```
./flexran_build.sh -x icx -e -r 5gnr
```

Compile lte

```
./flexran_build.sh -x icx -e -r lte -i avx512
```

After following above steps, upon a successful build, a new L1 application file <install_dir>/bin/nr5g/gnb/l1 will be created. L1 standalone Test Application will be created in <install_dir>/tests/nr5g/nr5g_testapp

- For ACC100 acceleration

Verify acc card.

```
lspci | grep acc  
51:00.0 Processing accelerators: Intel Corporation Device 0d5c
```

```
XR12-B:/var/pf-bb-config # /var/dpdk/dpdk-21.11/usertools/dpdk-devbind.py -s  
Network devices using kernel driver  
=====  
0000:18:00.0 'BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet 1751' if=em1 drv=bnxt_en unused=igb_uio  
0000:18:00.1 'BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet 1751' if=em2 drv=bnxt_en unused=igb_uio  
0000:18:00.2 'BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet 1751' if=em3 drv=bnxt_en unused=igb_uio  
0000:18:00.3 'BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet 1751' if=em4 drv=bnxt_en unused=igb_uio  
0000:8a:00.0 'Ethernet Controller X710 for 10GBASE-T 15ff' if=p4p1 drv=i40e unused=igb_uio *Active*  
0000:8a:00.1 'Ethernet Controller X710 for 10GBASE-T 15ff' if=p4p2 drv=i40e unused=igb_uio  
Other Baseband devices  
=====  
0000:51:00.0 'Device 0d5c' unused=igb_uio
```

When using Mount Bryce (ACC100) acceleration follow <https://github.com/intel/pf-bb-config>

```
git clone https://github.com/intel/pf-bb-config  
cd pf-bb-config/  
make
```

- For PF option: Bind the PF with the igb_uio module (or alternatively with pci-pf-stub):

```
/var/dpdk/dpdk-21.11/usertools/dpdk-devbind.py --bind=igb_uio 51:00.0
```

Configure the devices using the pf_bb_config application

```
/var/dpdk/dpdk-21.11/usertools/dpdk-devbind.py --bind=igb_uio 52:00.0 52:00.1
```

```
XR12-B:/var/pf-bb-config # ./pf_bb_config ACC100 -c acc100/acc100_config_2vf_4g5g.cfg  
== pf_bb_config Version #VERSION_STRING# ==  
Queue Groups: 2 5GUL, 2 5GDL, 2 4GUL, 2 4GDL  
Number of 5GUL engines 8  
Configuration in VF mode  
ROM version MM 99AD92  
DDR Training completed in 1369 msPF ACC100 configuration complete  
ACC100 PF [0000:51:00.0] configuration complete!
```

- For VF option:

Create 2 VFs from the PF

```
XR12-B:/var/pf-bb-config/acc100 # echo 2 | sudo tee /sys/bus/pci/devices/0000:51:00.0/max_vfs  
2  
wrote 2 bytes to '/sys/bus/pci/devices/0000:51:00.0/max_vfs'
```

Check available interfaces:

```
/opt/dpdk/dpdk-stable-20.11.3/usertools/dpdk-devbind.py -s
```

```
KR12-B:/var/pf-bb-config/acc100 # /var/dpdk/dpdk-21.11/usertools/dpdk-devbind.py -s
Network devices using kernel driver
0000:18:00.0 BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet 1751' if=em1 drv=bnx2_en unused=igb_uio
0000:18:00.1 BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet 1751' if=em2 drv=bnx2_en unused=igb_uio
0000:18:00.2 BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet 1751' if=em3 drv=bnx2_en unused=igb_uio
0000:18:00.3 BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet 1751' if=em4 drv=bnx2_en unused=igb_uio
0000:8a:00.0 'Ethernet Controller X710 for 10GBASE-T 15ff' if=p4p1 drv=l40e unused=igb_uio *Active*
0000:8a:00.1 'Ethernet Controller X710 for 10GBASE-T 15ff' if=p4p2 drv=l40e unused=igb_uio

Baseband devices using DPDK-compatible driver
=====
0000:51:00.0 'Device 0d5c' drv=igb_uio unused=

Other Baseband devices
=====
0000:52:00.0 'Device 0d5d' unused=igb_uio
0000:52:00.1 'Device 0d5d' unused=igb_uio
```

In the above example there are 2 VFs created:

Bind with VF

```
/var/dpdk/dpdk-21.11/usertools/dpdk-devbind.py --bind=igb_uio 52:00.0 52:00.1
```

Configure the devices using the pf_bb_config application for VF usage with both 5G and 4G enabled:

Select the proper config file for your test for VF.

```
./pf_bb_config ACC100 -c acc100/acc100_config_2vf_4g5g.cfg
```

Check available interfaces and verify number of acc

```
KR12-B:/var/pf-bb-config # lspci | grep acc
51:00.0 Processing accelerators: Intel Corporation Device 0d5c
52:00.0 Processing accelerators: Intel Corporation Device 0d5d
52:00.1 Processing accelerators: Intel Corporation Device 0d5d
```

Test that the VF is functional on the device using bbdev-test:

```
/var/dpdk/dpdk-21.11/app/test-bbdev # /var/dpdk/dpdk-21.11/build/app/dpdk-test-bbdev -c F0 -a 52:00.0 -- -c validation -v ./ldpc_dec_default.data
```

```
KR12-B:/var/dpdk/dpdk-21.11/app/test-bbdev # /var/dpdk/dpdk-21.11/build/app/dpdk-test-bbdev -c F0 -a 52:00.0 -- -c validation -v ./ldpc_dec_default.data
default.data
FlexRAN SDK bplib_lte_ldpc_decoder version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
FlexRAN SDK bplib_lte_ldpc_encoder version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
FlexRAN SDK bplib_lte_rate_matching version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
FlexRAN SDK bplib_lte_rate_matching_5gnr version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
FlexRAN SDK bplib_lte_turbo version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
FlexRAN SDK bplib_lte_crc version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
FlexRAN SDK bplib_lte_rate.matching version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
FlexRAN SDK bplib_common version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
FlexRAN SDK bplib_srs_fft_estimate_5gnr version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
EAL: Detected CPU Core(s): 40
EAL: Detected NUMA Node(s): 1
EAL: Detected static linkage of DPDK
EAL: Multi-process socket /var/run/dpdk/rte/mp_socket
EAL: Selected IOMMU mode 'PA'
EAL: Probe PCI driver: intel_acc100_vf (8086:0d5d) device: 0000:52:00.0 (socket 0)
TELEMETRY: No legacy callbacks, legacy socket not created
WARNING: Num of operations was not provided or was set 0. Set to default (64)
WARNING: Burst size was not provided or was set 0. Set to default (32)
WARNING: Num of lcores was not provided or was set 0. Set to value from RTE config (4)

=====
Starting Test Suite : BBdev Validation Tests
Test vector file = ./ldpc_dec_default.data
+ ----- + 
+ Test: validation
dev:52:00.0, burst size: 32, num ops: 64, op type: RTE_BBDEV_OP_LDPC_DEC
Operation latency:
    avg: 40375 cycles, 25.2344 us
    min: 38339 cycles, 23.9575 us
    max: 42416 cycles, 26.5113 us
Testcase [ 0 ] : validation_tc passed
+ ----- + 
+ Test Suite Summary : BBdev Validation Tests
+ Tests Total : 1
+ Tests Skipped : 0
+ Tests Passed : 1
+ Tests Failed : 0
+ Tests Lasted : 105.743 ms
+ ----- + 
```

4 Baremetal Host Testing

4.1 FlexRAN L1 and Testmac test

Follow steps from the TestMac section of FlexRAN 5GNR Reference Solution 22.07 PHY Software Documentation - Document #603577

- Testmac can be built only in the Linux environment using the ICC version recommended in the compilation tools section.
- The source code for the tool is under `source/test/testmac`.
- The make files and projects are under `build/testmac`.
- After building process is completed, the application binary is placed under `bin`.
- To run the application, start the `bin/nr5g/gnb/testmac/l2.sh` script file. This needs to be run after starting the l1app application in timer mode by running `bin/nr5g/gnb/l1/l1.sh -e`.
- Once the application comes up, you will see a `TESTMAC>` prompt. The same Unit tests can be run using the command:
 - `run rat_type test_type Numerology Bandwidth testnum` where
 - `rat_type` is 0 (LTE), 1 (5G NR)
 - `test_type` is 0 (OL), 1 (UL) or 2 (FD)
 - `Numerology`[0 -> 4], 0=15khz, 1=30khz, 2=60khz, 3=120khz, 4=240khz (for 5G NR only, value is ignored for LTE)
 - `Bandwidth`5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 400 (in MHz) (for 5G NR only, value is ignored for LTE)
 - `testnum` is the Bit Exact TestNum, [1]001 -> above! If this is left blank, then all tests under type testtype are run
 - `testnum` is always a 4 digit number. First digit represents the number of carriers to run.
 - For example, to run 5G NR Test Case 5 for Uplink Rx mu=3, 100MHz for 1 carrier, the command would be:
 - `run 1 1 3 100 1005`
 - For example, to run LTE Test Case 5 for Uplink Rx, the command would be:
 - `run 0 1 0 20 1005`



Note

Always source FlexRAN env and the oneAPI in each tab and make sure that all paths are exported. For simplicity create a script to source all paths every time when running tests in each terminal.

Change dpdkBasebandDevice values from phycfg_timer.xml to either physical or virtual acc.

```
/opt/FlexRan/bin/nr5g/gnb/l1 # vi phycfg_timer.xml
```

For example

```
<dpdkBasebandFecMode>1</dpdkBasebandFecMode>
<!-- DPDK BBDev name added to the passlist. The argument format is <[domain:]bus:devid.func> -->
<dpdkBasebandDevice>0000:52:00.0</dpdkBasebandDevice>
<!-- VFIO token for DPDK EAL commandline, required when PF is bound to vfio-pci -->
<!--dpdkVfioVfToken>00112233-4455-6677-8899-aabbccddeeff</dpdkVfioVfToken>-->
</DPDK>
```

Where FecMode is set to 1 (HW accelerotor) and 0000:52:00.0 is the VF value from acc. Set dpdkBasebandFecMode to VF value according to your specific card.

From terminal 1 run:

```
./FlexRAN-<version>/bin/nr5g/gnb/l1/l1.sh -e
```

You should be able to see the following console

```
-----  
Non BBU threads in application  
-----  
phy_print_thread: [PID: 29297] binding on [CPU 0] [PRIO: 0] [POLICY: 1]  
wls_rx_handler (non-rt): [PID: 29301] binding on [CPU 0]  
-----  
  
PHY>welcome to application console
```

From the 2nd terminal run:

```
/var/FlexRan22.07/bin/nr5g/gnb/testmac # ./l2.sh
```

run 1 1 3 100 1005

4065 4066 4071 4072 4073 4074
TESTMAC>welcome to application console

TESTMAC>run 1 1 3 100 1005

See examples from Document #603577 TestMac section

- To run the application, start the `bin/nr5g/gnb/testmacV2.sh` script file. This needs to be run after starting the l1app application in timer mode by running `bin/nr5g/gnb/11/11.sh -e`.
 - Once the application comes up, you will see a `TESTMAC>` prompt. The same Unit tests can be run using the command:
 - `run rat_type test_type Numerology Bandwidth testnum` where
 - `rat_type` is 0 (LTE), 1 (5GNR)
 - `test_type` is 0 (DL), 1 (UL) or 2 (FD)
 - `Numerology[0 > 4], 1=0.15kHz, 1=30kHz, 2=60kHz, 3=120kHz, 4=240kHz` (for 5GNR only, value is ignored for LTE)
 - `Bandwidth[5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 400` (in MHz) (for 5GNR only, value is ignored for LTE)
 - `testnum` is the Bit Exact TestNum. [100] > above! If this is left blank, then all tests under type testtype are run
 - `testnum` is always a 4 digit number. First digit represents the number of carriers to run.
 - For example, to run 5GNR Test Case 5 for Uplink Rx mu=3, 100Mhz for 1 carrier, the command would be:
 - `run 1 1 3 100 1005`
 - For example, to run LTE Test Case 5 for Uplink Rx, the command would be:
 - `run 0 1 20 2005`

The connection should be established in the 1st terminal once you'll run 12.sh from the 2nd terminal

```

timer_rec_proc_symbol: nSymbol: 6, pProc: 0x8d2570, lpData: (nil)
timer_rec_proc_symbol: nSymbol: 10, pProc: 0x8d25a0, lpData: (nil)
timer_rec_proc_symbol: nSymbol: 1, pProc: 0x8d25d0, lpData: (nil)
timer_rec_proc_symbol: nSymbol: 3, pProc: 0x8d2600, lpData: (nil)
nrsg_gnb_urllc_register_call_backs: nTimerMode[1] nUrllcMinSlotMask[0]
timer_main_thread: [PID: 29386] binding on [CPU 2] [PRIO: 96] [POLICY: 1]
Numerology: [ 3 ], numSlotsPerSubframe: [ 8 ], ttiPeriod: [ 125 usecs ]
Period (usecs): 357 /14 1071 1428 1785 2142 2500 2857 3214 3571 3928
4285 4642 5000
Fn Callbacks (Sym): 0 1 2 3 4 5 6 7 8 9 10
11 12 13 Instance 0 : YES YES NO YES NO NO YES NO NO NO YES
NO NO NO Instance 1 : NO NO
NO NO NO Instance 2 : NO NO
NO NO NO

ebbb_pool_update_frame_slot_sym_num: PhyId[0] nSlotIdx[7997] frame.slot[1023,78] gNumSlotsPerSfn[80]
ebbb_pool_update_multi_cell_status: Call Stop: [PhyStartCurrCount 17 PhyStartCount 17]
phydi_stop[from 2]: phyInstance: -1, sendstop: 1, phyIdStart: 0, phyIdStop: 1
    PHY_STOP PhyInstance[0] PhyState[1] PhyStartMode[1] PhyStateCount[1]

```

In the 2nd terminal you should be able to see test result

```
wls_mac_print_stats:
    nTotalBlocks[4009] nAllocBlocks[2399] nFreeBlocks[1610] nWaterMarkAllocBlocks[2418]
    nTotalAllocCnt[2509] nTotalFreeCnt[110] Diff[2399]
    nDLBufAllocCnt[57] nDLBufFreeCnt[57] Diff[0]
    nULBufAllocCnt[2452] nULBufFreeCnt[53] Diff[2399]

All Tests Completed, Total run 1 Tests, PASS 1 Tests, and FAIL 0 Tests
-----
mem_mgr_display_size:
    Num Memory Alloc:           11
    Total Memory Size:        264,018
```

Another example is to use a preconfigured test file.

For example from the 2nd terminal run:

```
/var/FlexRan22.07/bin/nr5g/gnb/testmac # ./l2.sh --testfile=/var/FlexRan22.07/bin/nr5g/
gnb/testmac/icelake-sp/icxsp_mu1_100mhz_4x4_hton.cfg
```

```
-----| MAC | MAC-to-PHY Tput | PHY-to-MAC Tput | UL FEC CB Iteration
s |   Cell | Inst | kbps     Num CB |          kbps      UL BLER   Num CB | Min Avg Max
|   SRS SNR
-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0 (MU 1) | 0 | 863,091 567,928 | 72,960 / 72,960 0.00% 63,968 | 1 1.00 1
| 0 Db
-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
Core Utilization [2 BBU core(s)]:
Core Id : 4 36 Avg
Numa Node : 0 0
Util % : 34.04 34.06 34.05
Intr % : 0.68 0.69 0.69
Spare % : 0.62 0.62 0.62
Sleep % : 64.64 64.62 64.63
TTI Cn : 8280 8280
TTI Min : 1 0
TTI Avg : 33 33
TTI Max : 96 96
```

```
==== llapp [Time: 0Hr 0Min 20Sec ] NumCarrier: 2 NumBbuCores: 3. Tti2Tti Time: [500.00..504.15..510.00] usces
-----| LateRcy | usecs | % of TTI
-----|-----|-----|-----|
| DL_LINK MU1 | 125.00 202.21 385.00 | 25% 40% 77%
| UL_LINK MU1 | 860.00 875.67 890.00 | 172% 175% 178%
| SRS_LINK MU1 | 0.00 0.00 0.00 | 0% 0% 0%
-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
-----| MAC | MAC-to-PHY Tput | PHY-to-MAC Tput | UL FEC CB Iterations
|   Cell | Inst | kbps     Num CB |          kbps      UL BLER   Num CB | Min Avg Max
|   SRS SNR
-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0 (MU 1) | 0 | 300,851 255,968 | 28,672 / 28,672 0.00% 31,984 | 1 1.00 1
| 1 (MU 1) | 0 | 300,851 255,968 | 28,672 / 28,672 0.00% 31,984 | 1 1.00 1
| 0 Db
-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
```

```
mem_mgr_display_size:
    Num Memory Alloc:           12
    Total Memory Size:        268,818
-----
Test[FD_mu1_100mhz_4308] Completed
wls_mac_print_stats:
    nTotalBlocks[4009] nAllocBlocks[2399] nFreeBlocks[1610] nWaterMarkAllocBlocks[2874]
    nTotalAllocCnt[82221232] nTotalFreeCnt[82218833] Diff[2399]
    nDLBufAllocCnt[64873831] nDLBufFreeCnt[64873831] Diff[0]
    nULBufAllocCnt[17347401] nULBufFreeCnt[17345002] Diff[2399]

All Tests Completed, Total run 27 Tests, PASS 21 Tests, and FAIL 6 Tests
-----
mem_mgr_display_size:
    Num Memory Alloc:           11
    Total Memory Size:        264,018
```



Note

Number of failed tests listed above related to a different number of cores defined in the test file.

4.2 CPU set shielding

Another tool for more tuned cores isolation is cpu set shielding.

You can also review CPU manipulation commands from → https://documentation.suse.com/sle-rt/15-SP3/pdf/book-shielding_color_en.pdf

Some examples of using shielding on CPU with integrated tools like cset.

- Creating a cset called flexran_set

```
XR12-B:/var/FlexRan22.07/bin/nr5g/gnb/testmac/icelake-sp # cset set -c 7-11 -s flexran_set
cset: --> created cpuset "flexran_set"
XR12-B:/var/FlexRan22.07/bin/nr5g/gnb/testmac/icelake-sp # cset set -l
cset:
      Name      CPUs-X      MEMs-X Tasks Subs Path
-----+
      root      0-39   y      0 y    1329   3 /
     user      6-10   n      0 n     0     0 /user
  flexran_set  7-11   n      0 n     0     0 /flexran_set
    system     0-5   n      0 n     0     0 /system
```

Example of moving <top> command from root set to flexran_set

```
XR12-B:/var/FlexRan22.07/bin/nr5g/gnb/testmac/icelake-sp # cset proc -l -s root | grep 6135
root      6135  6103 Soth top
root      6885 35056 Soth grep --color=auto 6135
XR12-B:/var/FlexRan22.07/bin/nr5g/gnb/testmac/icelake-sp # cset proc -m -p 6135 -t flexran_set
cset: moving following pidspec: 6135
cset: moving 1 userspace tasks to /flexran_set
cset: done
XR12-B:/var/FlexRan22.07/bin/nr5g/gnb/testmac/icelake-sp # cset set -l -s flexran_set
cset:
      Name      CPUs-X      MEMs-X Tasks Subs Path
-----+
  flexran_set  7-11   n      0 n     1     0 /flexran_set
XR12-B:/var/FlexRan22.07/bin/nr5g/gnb/testmac/icelake-sp # cset proc -l -s flexran_set
cset: "flexran_set" cpuset of CPUSPEC(7-11) with 1 task running
USER      PID  PPID SPPR TASK NAME
-----+
root      6135  6103 Soth top
```

When starting a testmac you can move pid to a dedicated cset

```
XR12-B:~ # cset proc -m -p 9319,9444 -t flexran_set
cset: moving following pidspec: 9319,9444
cset: moving 2 userspace tasks to /flexran_set
cset: done
```

```

XR12-B:~ # cset proc -l -s flexran_set
cset: "flexran_set" cpuset of CPU SPEC(7-11) with 2 tasks running
USER      PID  PPID SPPR TASK NAME
-----
root     9319  9304 Soth ./liapp --cfgfile=phycfg_timer.xml
root     9444  9436 Soth ./testmac DIR_WIRELESS_TEST_4G=/var/FlexRan22.07/...

```

To move all siblings from pid use --threads

```
cset proc -m -p 16165 --threads -t two
```

For all features of cpu manipulations please review shielding tasks documents for cpu isolations:

- <https://www.suse.com/c/cpu-isolation-introduction-part-1/>
- https://documentation.suse.com/sle-rt/15-SP3/pdf/book-shielding_color_en.pdf
- https://documentation.suse.com/sle-rt/15-SP3/pdf/article-virtualization_color_en.pdf#%5B%7B%22num%22%3A30%2C%22gen%22%3A0%7D%2C%7B%22name%22%3A%22XYZ%22%7D%2C63.779%2C788.031%2Cnull%5D

To run Testmac with VF set, change setting to proper VF value and config

```

XR12-B:/var/pf-bb-config # ./pf_bb_config ACC100 -c acc100/acc100_config_vf_5g.cfg
== pf_bb_config Version #VERSION_STRING# ==
Queue Groups: 4 5GUL, 4 5GDL, 0 4GUL, 0 4GDL
Number of 5GUL engines 8
Configuration in VF mode
ROM version MM 99AD92
PF ACC100 configuration complete
ACC100 PF [0000:51:00.0] configuration complete!

```

```
./l1.sh -e
```

From the 2nd terminal run

```
run 1 1 3 100 1005
```

```

-----
1005 | Result: PASS | DL_IQ: - | PUSCH: P | RXBITS: - | PUCCH: - | MUXSCH: - | SNR: P | TA: P | RACH: - | SRS: - | RI: -
| NFLOOR: - | NDEMOM_CW: - | DL_BW: - | UL_BW: - |

vls_mac_print_stats:
nTotalBlocks[4009] nAllocBlocks[2399] nFreeBlocks[1610] nWaterMarkAllocBlocks[2417]
nTotalAllocCnt[2509] nTotalFreeCnt[110] Diff[2399]
nDLBufAllocCnt[57] nDLBufFreeCnt[57] Diff[0]
nULBufAllocCnt[2452] nULBufFreeCnt[53] Diff[2399]

All Tests Completed, Total run 1 Tests, PASS 1 Tests, and FAIL 0 Tests
-----
```

```

mem_mgr_display_size:
Num Memory Alloc:           11
Total Memory Size:          264,018
-----

XR12-B:~ # cset proc -m -p 13726,13849 --threads -t flexran_set
cset: moving following pidspec: 13726,13849,13727,13728,13729,13765,13766,13887,13888,13889,13890,13891
cset: moving 12 userspace tasks to /flexran_set
[=====]
cset: done
-----
```

```

XR12-B:~ # cset proc -l -s flexran_set
cset: "flexran_set" cpuset of CPUSPEC(7-11) with 12 tasks running
USER      PID  PPID SPPr TASK NAME
-----
root    13726 13711 Soth ./llapp --cfgfile=phycfg_timer.xml
root    13727 13711 Soth ./llapp --cfgfile=phycfg_timer.xml
root    13728 13711 Soth ./llapp --cfgfile=phycfg_timer.xml
root    13729 13711 Soth ./llapp --cfgfile=phycfg_timer.xml
root    13765 13711 Soth ./llapp --cfgfile=phycfg_timer.xml
root    13766 13711 Soth ./llapp --cfgfile=phycfg_timer.xml
root    13849 13841 Soth ./testmac DIR_WIRELESS_TEST_4G=/var/FlexRan22.07/...
root    13887 13841 Soth ./testmac DIR_WIRELESS_TEST_4G=/var/FlexRan22.07/...
root    13888 13841 Soth ./testmac DIR_WIRELESS_TEST_4G=/var/FlexRan22.07/...
root    13889 13841 Soth ./testmac DIR_WIRELESS_TEST_4G=/var/FlexRan22.07/...
root    13890 13841 Sf90 ./testmac DIR_WIRELESS_TEST_4G=/var/FlexRan22.07/...
root    13891 13841 Sf89 ./testmac DIR_WIRELESS_TEST_4G=/var/FlexRan22.07/...

```

If using a config file from the 2nd terminal run

```
./l2.sh --testfile=/var/FlexRan22.07/bin/nr5g/gnb/testmac/icelake-sp/
icxsp_mul_100mhz_mmimo_32x32_hton.cfg
```

If using a taskset

from terminal 1 run

```
~/gnb/l1 # taskset -c 12-19 ./l1.sh -e
```

from terminal 2 run

```
~/gnb/testmac # taskset -c 12-19 ./l2.sh
```

5 Deploy FlexRAN™ on Container through Kubernetes

5.1 Generae LTE/5G Docker Images with pre-build FlexRAN™

All prerequisite components and FlexRAN™ should be installed as descrtibe in the previous sections.

The main doc to follow → FlexRAN Reference Solution Cloud-Native Setup (Intel Document Number: 575834-15.0)

Use existing FlexRAN directory or create a FlexRAN pre-configured directory which will be used for the container image.

Source all env. variables

```
export RTE_SDK=/var/dpdk/dpdk-21.11
```

```
source /opt/intel/oneapi/setvars.sh
export PKG_CONFIG_PATH=$DIR_WIRELESS_SDK/pkgcfg:$PKG_CONFIG_PATH
source set_env_var.sh
```

- Create a Dockerfile

If you want to deploy a SUSE Linux Enterprise-based container to deploy to the cluster in the future, follow the steps below.

Modify `flexran_build_dockerfile.sh` from `flexran` directory

```
OS_TYPE_sle='ls /boot/efi/EFI/ | grep sle'
if [ -n "$OS_TYPE_sle" ]; then
    if [ -z $http_proxy ];then
        cat > flexran_build/Dockerfile << EOF
FROM registry.suse.com/suse/sle15:15.3
ENV no_proxy "localhost,127.0.0.1,192.168.0.100"
ADD http://192.168.150.160/repo/rmt-server.crt /etc/pki/trust/anchors/rmt.crt
ARG ADDITIONAL_MODULES
RUN update-ca-certificates
RUN zypper --gpg-auto-import-keys ref -s
RUN zypper ref && zypper --non-interactive in libhugetlbfs libhugetlbfs-devel gcc11-c++ numactl ethtool
ol gcc make kmod wget patch iproute2 pciutils python vim cmake unzip iutils libaio1 libaio-devel git
git-core net-tools gawk
ENV WIRELESS_SDK_TARGET_ISA=avx512 CPA_DIR=/opt/flexran/libs/cpa XRN_DIR=/opt/flexran/xran DIR_WIRELESS_SDK_ROOT=/opt/flexran/sdk SDK_BUILD=build-avx512-icx DIR_WIRELESS_SDK=/opt/flexran/sdk/build-avx512-icx FLEXRAN_SDK=/opt/flexran/sdk/build-avx512-icx/install DIR_WIRELESS_FW=/opt/flexran/framework DIR_WIRELESS_TEST_4G=/opt/flexran/tests/lte DIR_WIRELESS_TEST_5G=/opt/flexran/tests/nr5g DIR_WIRELESS_TABLE_E_5G=/opt/flexran/bin/nr5g/gnb/l1/table
WORKDIR /var/
COPY flexran ./flexran
COPY oneapi /opt/oneapi
COPY docker_entry.sh .
EOF
    else
        cat > $tmp_path/Dockerfile << EOF
FROM registry.suse.com/suse/sle15:15.3
# ENV http_proxy $http_proxy
# ENV https_proxy $https_proxy
RUN zypper ref && zypper --non-interactive in libhugetlbfs libhugetlbfs-devel numactl ethtool gcc make
kmod wget patch iproute2 pciutils python vim cmake unzip iutils libaio1 libaio-devel git git-core net-tools gawk
ENV WIRELESS_SDK_TARGET_ISA=avx512 CPA_DIR=/opt/flexran/libs/cpa XRN_DIR=/opt/flexran/xran DIR_WIRELESS_SDK_ROOT=/opt/flexran/sdk SDK_BUILD=build-avx512-icx DIR_WIRELESS_SDK=/opt/flexran/sdk/build-avx512-icx FLEXRAN_SDK=/opt/flexran/sdk/build-avx512-icx/install DIR_WIRELESS_FW=/opt/flexran/framework DIR_WIRELESS_TEST_4G=/opt/flexran/tests/lte DIR_WIRELESS_TEST_5G=/opt/flexran/tests/nr5g DIR_WIRELESS_TABLE_E_5G=/opt/flexran/bin/nr5g/gnb/l1/table
WORKDIR /var/

```



Note

Modify according to your local setup. If RMT server is used, you need to post `rmt-server.crt` file on your RMT server in the location which can be reachable from url.
So, on the local RMT server copy `/etc/rmt/ssl/rmt-server.crt` file to the `/usr/share/rmt/public/repo` directory, which creates symb link to `./var/lib/rmt/public/repo` which is a public repo of RMT server.
Setup a proper permission to `/usr/share/rmt/public/repo` directory.
Sync rmt server.

- Build a docker image

```
./flexran_build_dockerfile_suse.sh -v -e avx512 -r 5gnr -m all -x icx
```

```

Step 1/12 : FROM registry.suse.com/suse/sle15:15.3
--> 8f0c0b9d
Step 2/12 : ENV no_proxy "localhost,127.0.0.1,192.168.0.100"
--> Using cache
--> 930b2987992e
Step 3/12 : ADD http://192.168.158.168/repo/rmt-server.crt /etc/pki/trust/anchors/rmt.crt
Download complete: https://192.168.158.168/repo/rmt-server.crt [1/1] 2.676kB/2.676kB
Step 4/12 : RUN curl -s https://192.168.158.168/repo/rmt-server.crt > /etc/pki/trust/anchors/rmt.crt
--> Using cache
--> 63b3c403a9b0
Step 5/12 : RUN update-ca-certificates
--> Using cache
--> 87a3834a277
Step 6/12 : RUN zypper --gpg-auto-import-keys ref -
--> Using cache
--> 63b3c403a9b0
Step 7/12 : RUN zypper ref && zypper --non-interactive install libhugetlbfs libhugetlbfs-devel gcc11-c++ numactl ethtool gcc make knod wget patch pciutils python3-vim curl cmake unzip iputils libtai-devel git git-core net-tools gawk
--> Using cache
--> c81729973a0b
Step 8/12 : ENV DIR_WIRELESS_SDK TARGET_JSA=avx512 CPA_DIR=/opt/flexran/libs/cpa_XMAN_DIR=/opt/flexran/xman DIR_WIRELESS_SDK_ROOT=/opt/flexran/sdk SDK_BUILD=build-pv_x512-lcx DIR_WIRELESS_SDK=/opt/flexran/sdk/build-avx512-lcx FLEXMAN_SDK=/opt/flexran/sdk/build-avx512-lcx/install DIR_WIRELESS_Fwk=/opt/flexran/framework DIR_WIRELESS_TEST_4G=/opt/flexran/tests/lte DIR_WIRELESS_TEST_5G=/opt/flexran/tests/mR5g DIR_WIRELESS_TABLES=/opt/flexran/bin/nR5g/gnb/li/table
--> Using cache
--> 63b3c403a9b0
Step 9/12 : WORKDIR /var/
--> Using cache
--> 1d212feef8d5
Step 10/12 : COPY . ./flexran
--> 855bb1b0ef15
Step 11/12 : COPY oneopi /opt/oneopi
--> 6cd2c027f234
Step 12/12 : COPY docker_entry.sh .
--> a3bd9dcf855
Successfully built a3bd9dcf855
Successfully tagged flexran.docker.registry/flexran_vdu:latest

```

- Tag docker image

```
docker tag flexran.docker.registry/flexran_vdu:latest flexran.docker.registry/flexran_vdu:22.07
```

```

$ podman
XR12-B:/var/flexran # docker images
REPOSITORY          TAG      IMAGE ID   CREATED        SIZE
flexran.docker.registry/flexran_vdu    22.07   a3bd9dcf855  18 minutes ago  3.28GB
flexran.docker.registry/flexran_vdu    latest   a3bd9dcf855  18 minutes ago  3.28GB
<none>              <none>   da59789acc20  4 hours ago   731MB
registry.suse.com/suse/sle15         15.3    70f6a29ec59d  4 days ago    117MB
rancher/rancher-agent               v2.6.2   615d5b746927  10 months ago   495MB
rancher/hyperkube                  v1.21.5-rancher1 327c8c5ff7708  12 months ago   1.9GB
rancher/rke-tools                  v0.1.78  6eeaa0b8da2c  13 months ago   264MB
rancher/mirrored-coreos-etcd       v3.4.16-rancher1 532c4733c665  16 months ago   83.9MB

```



Note

Another alternative and recommended tool to use is podman since it's daemonless and has integration with cockpit web console on SLE Micro. For that you need to replace 'docker build' command with podman in flexran_build_dockerfile.sh file with

```
podman build -t
```

For more details review the Podman guide > https://documentation.suse.com/sle-micro/5.1/pdf/article-podman_color_en.pdf

Prepare file to export to the target node and save docker as

```
docker save flexran.docker.registry/flexran_vdu:22.07 | gzip > flexranimage.tar.gz
```

5.2 Create an RKE2 cluster

Install a Rancher server

In this test deployment, SUSE Linux Enterprise Micro 5.2 (SLE Micro) was used as a server host for the Rancher server test deployment.

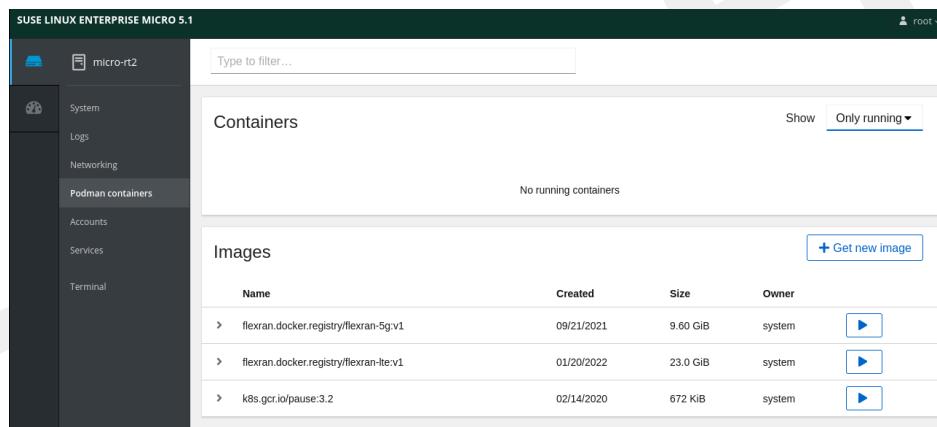
SUSE Linux Enterprise Micro is a lightweight and secure OS platform purpose built for containerized and virtualized workloads.

For more details on installation of SLE Micro, review > https://documentation.suse.com/sle-micro/5.2/pdf/book-deployment-slemicro_color_en.pdf

You can enable a cockpit console after a SLE Micro installation for easy management

```
systemctl enable --now cockpit.socket
```

and open console in the browser as <https://your-ip:9090/>



For more details review:

<https://documentation.suse.com/sle-micro/5.2/>

- Rancher installation steps

Install k3s

```
curl -sfL https://get.k3s.io | INSTALL_K3S_VERSION="v1.23.9+k3s1" \
INSTALL_K3S_SKIP_SELINUX_RPM=true INSTALL_K3S_EXEC='server --cluster-init --write-kubeconfig-mode=644' sh -s -
```

Install certificates

```
kubectl apply --validate=false -f https://github.com/cert-manager/cert-manager/releases/download/v1.7.1/cert-manager.crds.yaml
helm repo add jetstack https://charts.jetstack.io
```

```

helm repo update
export KUBECONFIG=/etc/rancher/k3s/k3s.yaml
helm install cert-manager jetstack/cert-manager --namespace cert-manager --create-namespace --version v1.7.1

```

Verify

```
kubectl get pods --namespace cert-manager
```

```
rancher-server2:/opt # kubectl get pods --namespace cert-manager
NAME                               READY   STATUS    RESTARTS   AGE
cert-manager-76d44b459c-jxm67     1/1    Running   0          8m38s
cert-manager-cainjector-9b679cc6-rs4vc 1/1    Running   0          8m38s
cert-manager-webhook-57c994b6b9-x6xc9 1/1    Running   0          8m38s
```

Install Rancher

```

helm repo add rancher-stable https://releases.rancher.com/server-charts/stable
kubectl create namespace cattle-system
export HOSTNAME="rancher-server2.isv.suse"
export RANCHER_VERSION="2.6.5"
helm install rancher rancher-stable/rancher --namespace cattle-system --set
hostname=rancher-server2.isv.suse --set version=2.6.5 --set replicas=1

```

Go to Rancher url and login

For more details on Rancher installation, review > https://documentation.suse.com/trd/kubernetes/pdf/kubernetes_ri_rancher-k3s-slemicro_color_en.pdf

- Create a custom rke2 cluster

From the Rancher server create a custom cluster > switch to rke2

Copy registration script to a new node to add it to the cluster

Cluster: flexran-rke2 (Reconciling)
Namespace: fleet-default Age: 3 secs
This resource is currently in a transitioning state, but there isn't a detailed message available.
Description: Intel FlexRan cluster
Provisioner: RKE2
Machines Provisioning Log Registration Snapshots Conditions Related Resources
Step 1
Node Role
Choose what roles the node will have in the cluster. The cluster needs to have at least one node with each role.
 etcd Control Plane Worker
Show Advanced
Step 2
Registration Command
Run this command on each of the existing Linux machines you want to register.
curl --insecure -fL https://rancher-server2.isv.suse:443/system-agent-install.sh | sudo sh -s - --server https://rancher-server2.isv.suse:443 --label 'cattle.io/os=linux' --token rp55dcwlvsmvnxnfznqvhmlhj6vnqmxx5m4hk5sd1xh4dff8f7t4 --ca-checksum 170ee5728747cebee9633b7c6ebb3686749b4b4a791a1343fb54bc382cff0b8 --etcd --controlplane --worker
 Insecure: Select this to skip TLS verification if your server has a self-signed certificate.

Verify if machines got provisioned

Cluster: flexran-rke2 (Reconciling)
Namespace: fleet-default Age: 3 secs
This resource is currently in a transitioning state, but there isn't a detailed message available.
Description: Intel FlexRan cluster
Provisioner: RKE2
Machines Provisioning Log Registration Snapshots Conditions Related Resources
Step 1
Node Role
Choose what roles the node will have in the cluster. The cluster needs to have at least one node with each role.
 etcd Control Plane Worker
Show Advanced
Step 2
Registration Command
Run this command on each of the existing Linux machines you want to register.
curl --insecure -fL https://rancher-server2.isv.suse:443/system-agent-install.sh | sudo sh -s - --server https://rancher-server2.isv.suse:443 --label 'cattle.io/os=linux' --token rp55dcwlvsmvnxnfznqvhmlhj6vnqmxx5m4hk5sd1xh4dff8f7t4 --ca-checksum 170ee5728747cebee9633b7c6ebb3686749b4b4a791a1343fb54bc382cff0b8 --etcd --controlplane --worker
 Insecure: Select this to skip TLS verification if your server has a self-signed certificate.

```
kubectl get nodes
NAME      STATUS    ROLES          AGE      VERSION
xr12-a    Ready     control-plane,etcd,master,worker   7d21h   v1.23.10+rke2r1
xr12-c    Ready     control-plane,etcd,master,worker   7d20h   v1.23.10+rke2r1
```

In this test case we used 2 Dell XR12 nodes with Sle Micro 5.2 RT installed as part of the RKE2 cluster. Both target nodes should have dpdk with a patch and Intel oneAPI installed.

For core isolation on Sle Micro RT, install 'tuned' package with additional dependencies.

```
transactional-update pkg install tuned.rpm python3-configobj.rpm python3-linux-procfs.rpm
python3-pyudev.rpm virt-what.rpm
```



Note

For this test, SLES 15 repositories were used with 'curl' commands to download packages locally. For a large scale deployment a local repository can be made with required RPMs.

Modify /etc/default/grub to the required tuned parameters with isolcpu and run transactional-update grub.cfg to save changes and reboot.



Note

When setting up CPU Manager for Kubernetes* (CMK*) it should be based on isolcpu settings in GRUB. Make sure that all required plugins for Kubernetes for your test are installed on tested nodes as described in section 4 of Intel's document 575834-15.0



Note

It's not recommended to add a FlexRAN™ development node to the RKE2 cluster. Instead, move image to the FlexRAN™ RKE2 cluster, either manually or with a repo.

During our RKE2 cluster deployment, Rancher provides an option to select Multus and Calico as default plugins, so no needs to install them manually.

5.3 Build SR-IOV Network Device Plugin

The setup details for virtual or physical functions of the SR-IOV Network Device Plugins can be found at > <https://github.com/k8snetworkplumbingwg/sriov-network-device-plugin>

```
cd /root/go/src/github.com/intel/  
~/go/src/github.com/intel # git clone https://github.com/intel/sriov-network-device-  
plugin  
cd sriov-network-device-plugin/  
git checkout v3.5.1  
mkdir bin  
cp ~/go/bin/golint bin/  
~/go/src/github.com/intel/sriov-network-device-plugin # make  
make image
```

Tag with

```
docker tag ghcr.io/k8snetworkplumbingwg/sriov-network-device-plugin:latest nfvpe/sriov-device-plugin:v3.5
```

REPOSITORY	TAG	IMAGE ID	CREATED	SIZE
nfvpe/sriov-device-plugin	v3.5	2b4f0d8d3133	7 minutes ago	49MB
ghcr.io/k8snetworkplumbingwg/sriov-network-device-plugin	latest	2b4f0d8d3133	7 minutes ago	49MB
<none>	<none>	11ab97ff9dc6	7 minutes ago	1.04GB
flexran.docker.registry/flexran_vdu	22.07	a3bd9dcfe855	2 days ago	3.28GB
flexran.docker.registry/flexran_vdu	latest	a3bd9dcfe855	2 days ago	3.28GB
<none>	<none>	da59789acc20	2 days ago	731MB
registry.suse.com/suse/sle15	15.3	70f6a29e59d	6 days ago	117MB
golang	1.18-alpine	b68eed002951	8 days ago	328MB
alpine	3	9c6f07244728	5 weeks ago	5.54MB
rancher/rancher-agent	v2.6.2	615d5b746927	11 months ago	495MB
rancher/hyperkube	v1.21.5-rancher1	327c8c5ff7b8	12 months ago	1.96B
rancher/rke-tools	v0.1.78	6eea0d8da2c	14 months ago	264MB
rancher/mirrored-coreos-etcd	v3.4.16-rancher1	532c4733c665	16 months ago	83.9MB

Save with

```
docker save nfvpe/sriov-device-plugin:v3.5|gzip > sriov-device-plugin.tar.gz
```

5.4 Creating FlexRAN™ Pods

```
kubectl label nodes xr12-b testnode=worker1
```

NAME	STATUS	ROLES	AGE	VERSION	LABELS
xr12-a	Ready	control-plane,etcd,master,worker	2d1h	v1.23.10+rke2r1	beta.kubernetes.io/arch=amd64,beta.kubernetes.io/instance-type=rke2,beta.kubernetes.io/os=linux,cattle.io/os=linux,egress.rke2.io/cluster=true,kubernetes.io/arch=amd64,kubernetes.io/hostname=xr12-a,kubernetes.io/os=linux,node-role.kubernetes.io/control-plane=true,node-role.kubernetes.io/etcd=true,node-role.kubernetes.io/master=true,node-role.kubernetes.io/worker=true,node.kubernetes.io/instance-type=rke2,plan.upgrade.cattle.io/system-agent-upgrader=3116a77386dbd2c53715c761885d4e41068b054f7aaaf35c0db989315,rke.cattle.io/machine=887d1931-261c-4a51-9f9a-19f51a3c1107,testnode=worker1
xr12-b	Ready	control-plane,etcd,master,worker	2d1h	v1.23.10+rke2r1	beta.kubernetes.io/arch=amd64,beta.kubernetes.io/instance-type=rke2,beta.kubernetes.io/os=linux,cattle.io/os=linux,egress.rke2.io/cluster=true,kubernetes.io/arch=amd64,kubernetes.io/hostname=xr12-b,kubernetes.io/os=linux,node-role.kubernetes.io/control-plane=true,node-role.kubernetes.io/etcd=true,node-role.kubernetes.io/master=true,node-role.kubernetes.io/worker=true,node.kubernetes.io/instance-type=rke2,plan.upgrade.cattle.io/system-agent-upgrader=3116a77386dbd2c53715c761885d4e41068b054f7aaaf35c0db989315,rke.cattle.io/machine=3f6c951a-40af-4744-beab-2c3a5f175907,testnode=worker1
xr12-c	Ready	control-plane,etcd,master,worker	2d1h	v1.23.10+rke2r1	beta.kubernetes.io/arch=amd64,beta.kubernetes.io/instance-type=rke2,beta.kubernetes.io/os=linux,cattle.io/os=linux,egress.rke2.io/cluster=true,kubernetes.io/arch=amd64,kubernetes.io/hostname=xr12-c,kubernetes.io/os=linux,node-role.kubernetes.io/control-plane=true,node-role.kubernetes.io/etcd=true,node-role.kubernetes.io/master=true,node-role.kubernetes.io/worker=true,node.kubernetes.io/instance-type=rke2,plan.upgrade.cattle.io/system-agent-upgrader=3116a77386dbd2c53715c761885d4e41068b054f7aaaf35c0db989315,rke.cattle.io/machine=94a6057a-5359-4e23-abf9-7f72a77272ab

- Configure FEC and FVL SRIOV

To reconfigure pf_bb_config run

```
pkill pf_bb_config
modprobe vfio-pci enable_sriov=1 disable_idle_d3=1
insmod /var/dpdk/dpdk-kmods/linux/igb_uio/igb_uio.ko
/var/dpdk/dpdk-21.11/usertools/dpdk-devbind.py -b igb_uio 18:00.0
```

where 18:00.0 is acc pf address

Check available accelerator cards

```
lspci|grep acc
18:00.0 Processing accelerators: Intel Corporation Device 0d5c
```

Add 4 VFs to acc

```
echo 4 > /sys/bus/pci/devices/0000:18:00.0/max_vfs
```

Verify

```
xR12-B:/var/dpdk/dpdk-21.11/usertools # dpdk-devbind.py -s
Network devices using kernel driver
=====
0000:1b:00.0 'BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet 1751' if=em1 drv=bnxt_en unused=igb_uio,vfio-pci
0000:1b:00.1 'BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet 1751' if=em2 drv=bnxt_en unused=igb_uio,vfio-pci
0000:1b:00.2 'BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet 1751' if=em3 drv=bnxt_en unused=igb_uio,vfio-pci
0000:1b:00.3 'BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet 1751' if=em4 drv=bnxt_en unused=igb_uio,vfio-pci
0000:51:00.0 'Ethernet Controller E810-C for QSFP 1592' if=p2p1drv=ice unused=igb_uio,vfio-pci *Active*
0000:51:00.1 'Ethernet Controller E810-C for QSFP 1592' if=p2p2drv=ice unused=igb_uio,vfio-pci
0000:8a:00.0 'Ethernet Controller X710 for 10GBASE-T 15ff' if=p4p1drv=i40e unused=igb_uio,vfio-pci *Active*
0000:8a:00.1 'Ethernet Controller X710 for 10GBASE-T 15ff' if=p4p2drv=i40e unused=igb_uio,vfio-pci

Baseband devices using DPDK-compatible driver
=====
0000:18:00.0 'Device 0d5c' drv=igb_uio unused=vfio-pci

Other Baseband devices
=====
0000:19:00.0 'Device 0d5d' unused=igb_uio,vfio-pci
0000:19:00.1 'Device 0d5d' unused=igb_uio,vfio-pci
0000:19:00.2 'Device 0d5d' unused=igb_uio,vfio-pci
0000:19:00.3 'Device 0d5d' unused=igb_uio,vfio-pci
```

4 new created

```
lspci|grep acc
18:00.0 Processing accelerators: Intel Corporation Device 0d5c
19:00.0 Processing accelerators: Intel Corporation Device 0d5d
19:00.1 Processing accelerators: Intel Corporation Device 0d5d
19:00.2 Processing accelerators: Intel Corporation Device 0d5d
19:00.3 Processing accelerators: Intel Corporation Device 0d5d
```

```
Network devices using DPDK-compatible driver
=====
0000:51:01.0 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=lavf,igb_uio
0000:51:01.1 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=lavf,igb_uio
0000:51:01.2 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=lavf,igb_uio
0000:51:01.3 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=lavf,igb_uio
0000:51:01.4 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=lavf,igb_uio
0000:51:01.5 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=lavf,igb_uio
0000:51:01.6 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=lavf,igb_uio
0000:51:01.7 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=lavf,igb_uio
0000:51:01.8 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=lavf,igb_uio
0000:51:01.9 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=lavf,igb_uio
0000:51:01.10 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=lavf,igb_uio
0000:51:01.11 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=lavf,igb_uio
0000:51:01.12 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=lavf,igb_uio
0000:51:01.13 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=lavf,igb_uio

Network devices using kernel driver
=====
0000:1b:00.0 'BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet 1751' if=em1 drv=bnxt_en unused=igb_uio,vfio-pci
0000:1b:00.1 'BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet 1751' if=em2 drv=bnxt_en unused=igb_uio,vfio-pci
0000:1b:00.2 'BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet 1751' if=em3 drv=bnxt_en unused=igb_uio,vfio-pci
0000:1b:00.3 'BCM57504 NetXtreme-E 10Gb/25Gb/40Gb/50Gb/100Gb/200Gb Ethernet 1751' if=em4 drv=bnxt_en unused=igb_uio,vfio-pci
0000:51:00.0 'Ethernet Controller E810-C for QSFP 1592' if=p2p1drv=ice unused=igb_uio,vfio-pci *Active*
0000:51:00.1 'Ethernet Controller E810-C for QSFP 1592' if=p2p2drv=ice unused=igb_uio,vfio-pci
0000:51:00.2 'Ethernet Controller X710 for 10GBASE-T 15ff' if=p4p1drv=i40e unused=igb_uio,vfio-pci *Active*
0000:51:00.3 'Ethernet Controller X710 for 10GBASE-T 15ff' if=p4p2drv=i40e unused=igb_uio,vfio-pci

Baseband devices using DPDK-compatible driver
=====
0000:18:00.0 'Device 0d5c' drv=igb_uio unused=vfio-pci
0000:19:00.0 'Device 0d5d' drv=vfio-pci unused=igb_uio
0000:19:00.1 'Device 0d5d' drv=vfio-pci unused=igb_uio
0000:19:00.2 'Device 0d5d' drv=vfio-pci unused=igb_uio
0000:19:00.3 'Device 0d5d' drv=vfio-pci unused=igb_uio
```

```
7: p2p1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc mq state UP mode DEFAULT group default qlen 1000
    link/ether b4:96:91:b4:4d:08 brd ff:ff:ff:ff:ff:ff
      vf 0    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff, spoof checking on, link-state auto, trust off
      vf 1    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff, spoof checking on, link-state auto, trust off
      vf 2    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff, spoof checking on, link-state auto, trust off
      vf 3    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff, spoof checking on, link-state auto, trust off
      vf 4    link/ether 92:8a:e3:5e:d9:c8 brd ff:ff:ff:ff:ff:ff, spoof checking on, link-state auto, trust off
      vf 5    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff, spoof checking on, link-state auto, trust off
      altname enp8s0f0
8: p4p2: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN mode DEFAULT group default qlen 1000
    link/ether b4:96:91:e3:ba:00 brd ff:ff:ff:ff:ff:ff
      altname enp13s0f1
9: p2p2: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN mode DEFAULT group default qlen 1000
    link/ether b4:96:91:b4:4d:09 brd ff:ff:ff:ff:ff:ff
      vf 0    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff, spoof checking on, link-state auto, trust off
      vf 1    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff, spoof checking on, link-state auto, trust off
      vf 2    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff, spoof checking on, link-state auto, trust off
      vf 3    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff, spoof checking on, link-state auto, trust off
      vf 4    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff, spoof checking on, link-state auto, trust off
      vf 5    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff, spoof checking on, link-state auto, trust off
      altname enp8s0f1
```

Modify configMap as following

```
vi ~/go/src/github.com/intel/sriov-network-device-plugin/deployments
```

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: sriovdp-config
  namespace: kube-system
data:
  config.json: |
    {
      "resourceList": [
        {
          "resourceName": "intel_sriov_odu",
          "selectors": {
            "vendors": ["8086"],
            "devices": ["1889"],
            "drivers": ["enp8is0f0"]
          }
        },
        {
          "resourceName": "intel_sriov_oru",
          "selectors": {
            "vendors": ["8086"],
            "devices": ["1889"],
            "drivers": ["vfio-pci"],
            "pfNames": ["enp8is0f1"]
          }
        },
        {
          "resourceName": "intel_fec_5g",
          "deviceType": "accelerator",
          "selectors": {
            "vendors": ["8086"],
            "devices": ["0d5d"]
          }
        },
        {
          "resourceName": "mlnx_sriov_rdma",
          "selectors": {
            "vendors": ["15b3"],
            "devices": ["1017"],
            "drivers": ["mlx5_core"],
            "isRdma": true
          }
        }
      ]
    }
```

```
kubectl create -f configMap.yaml
```

Modify /var/flexran/build/docker/flexran_testmac_mode.yaml according to your specs

```
kubectl create -f flexran_testmac_mode.yaml
```

```
XR12-B:/var/flexran/build/docker # kubectl get pods
NAME           READY   STATUS    RESTARTS   AGE
flexran-binary-release  2/2     Running   0          110s
testpod1       1/1     Running   0          16h
```

5.5 Testing FlexRAN™ Timer Mode in Containers

To demonstrate a simple functionality:

In the 1st terminal run

```
kubectl exec -it flexran-binary-release -c flexran-l1app -- bash  
Start l1.sh -e
```

In the 2nd terminal run

```
kubectl exec -it flexran-binary-release -c flexran-testmac -- bash
```



Note

Make sure that your dpdk directory mapped in the yaml file.

Other tests such as xRAN Mode and a Helm Chart test can be run as well as described in section 5.2 and 5.3 of Intel document 575834-15.0 [Installation Guide Software Release v22.07]

As a simplified solution, a pre-configured Intel® FlexRAN™ helm chart as well as all required cni plugins, can be posted on Rancher Marketplace to simplify deployment at a large scale.

6 Summary

This deployment guide demonstrated a working example of how to preconfigure and create Intel® FlexRAN™ container images and deploy it on a Rancher RKE2 kubernetes cluster.

I don't like it..Probably need to add something else here...

7 Reference

- [https://github.com/intel/FlexRAN ↗](https://github.com/intel/FlexRAN)
- [https://www.intel.com/content/www/us/en/developer/videos/how-radio-access-network-is-being-virtualized-and-the-role-of-flexran.html?wapkw=FlexRan ↗](https://www.intel.com/content/www/us/en/developer/videos/how-radio-access-network-is-being-virtualized-and-the-role-of-flexran.html?wapkw=FlexRan)
- [https://www.intel.com/content/www/us/en/developer/topic-technology/edge-5g/tools/flexran.html?wapkw=FlexRan ↗](https://www.intel.com/content/www/us/en/developer/topic-technology/edge-5g/tools/flexran.html?wapkw=FlexRan)

- <https://www.intel.com/content/www/us/en/communications/5g-get-your-infrastructure-ready-guide.html>
- <https://docs.rke2.io/install/quickstart/>
- https://documentation.suse.com/trd/kubernetes/pdf/kubernetes_ri_rancher-k3s-slemicro_color_en.pdf
- <https://documentation.suse.com/sle-rt/15-SP3/>
- https://documentation.suse.com/sles/15-SP3/pdf/book-container_color_en.pdf
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0. PREAMBLE

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