Technical Reference Documentation
Getting Started

Rancher by SUSE

Intel® FlexRAN™ - SUSE Reference Solution Cloud-Native Setup

FlexRAN™ Deployment Guide on SUSE platform

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 the steps to build and configure Intel® FlexRAN™ 22.07 on SUSE Linux Enterprise 15 SP3 Real-Time (SLES 15 SP3 RT) and deploy a virtualized radio access network (vRAN) reference architecture based on FlexRAN™ containers on a Rancher Kubernetes Engine v2 (RKE2) cluster deployed on SUSE Linux Enterprise Micro 5.2 Real Time (SLE Micro RT) as a SUSE/Intel® reference design for telecommunications (telco).

Contents

1 Introduction

1.1 Motivation

Intel® FlexRAN™ is a reference implementation for cloud enabled wireless access virtual network functions (VNFs). It shows how to efficiently implement wireless access loads through flexible software architecture, Intel® Xeon® Scalable processors using Intel® Advanced Vector Extensions 512 (Intel® AVX 512) instruction set, and optimized network functions virtualization infrastructure (NFVi) with Intel-specific patches for the Data Plane Development Kit (DPDK).

With this *cloud-native setup*, you can simplify the installation and configuration of Intel® FlexRAN™, enabling you to focus on site-specific vRAN customizations vRAN.

1.2 Scope

In this guide, you learn 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 a RKE2 or K3s Kubernetes cluster with SUSE Rancher Server to manage this deployment.

1.3 Audience

This document is intended for developers and/or engineers in the telecommunications (telco) sector looking to build and test an Intel® FlexRAN™ test and/or proof-of-concept (PoC) environment with a SUSE stack combining real-time OS and Kubernetes orchestration and management.

2 Prerequisites

This section describes the hardware and software environment used to deploy Intel® FlexRAN™.

2.1 Access to Intel® FlexRAN™, Intel® oneAPI, and Intel® DPDK patches

Access to FlexRAN™ software and documentation is available to customers at Intel's Resource & Documentation Center (RDC) website. https://www.intel.com/content/www/us/en/documentation-resources/developer.html

If unable to access the link, please contact your Intel Field Application Engineer (FAR) for access accounts and credentials.

Intel® oneAPI as well as the Intel® patch for DPDK will be required to build FlexRAN™.

The platforms used for this guide had Intel® integrated GPU and as such required the installation of Intel® GPU drivers.

2.2 Hardware

This section lists the hardware configuration used as FlexRAN™ configuration and physical development nodes.

Component	Specification
Processor	Intel® Xeon® Silver 4316 @ 2.30Ghz
Memory	128 GB RAM
Network	Intel® vRAN ACC100-based accelerator Intel® E810 100Gb Ethernet controller
Storage	480GB SSD SATA Read Intensive 6Gbps 960GB Data Center NVMe

Note

For more details on server components, see 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)*.

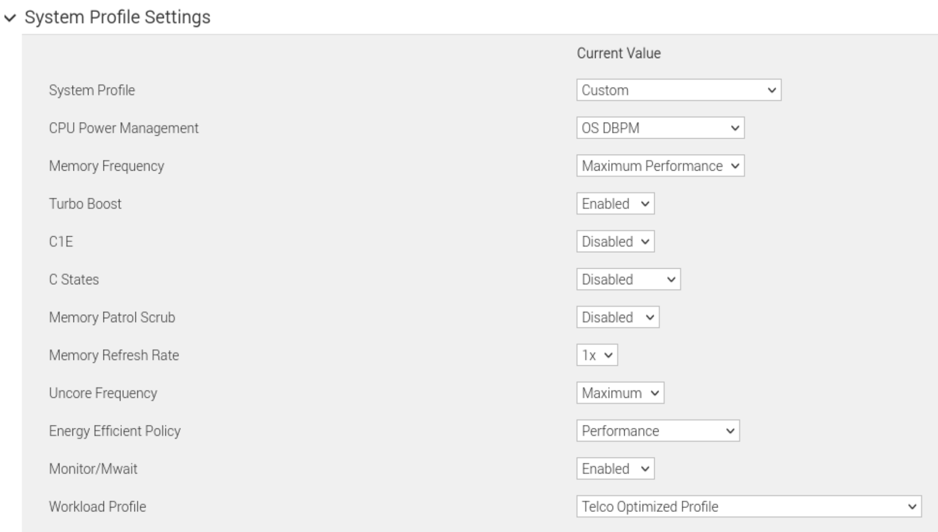
2.3 BIOS Configuration

A server's system BIOS provides runtime services for operating systems and performs hardware initialization during the booting process.

BIOS settings can influence how hardware behaves under different workloads.

Among the most important BIOS settings for implementing Intel® FlexRAN™ are the CPU p-states (optimization of the voltage and CPU fequency during operation) and c-states (optimization of the power consumption if a core does not have to execute any instructions).

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



For CPU power management, use a profile that allows for the OS to manipulate processor frequencies, such as *OS DBPM* or a similar control setting to allow the operating system to manipulate processor frequencies.

Other options such as a *Custom* profile with a *Telco Optimized* or *Maximum Performance* profile may be available, depending on the BIOS version.

Note

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.: 640685)*.

2.4 OS requirements

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

For the setup documented in this guide, we used a bare metal node as a development host running SUSE Linux Enterprise 15 SP3 Real-Time to preconfigure and test FlexRAN™ functionality and to build a container image before importing the container into a Rancher Kubernetes cluster (RKE2).

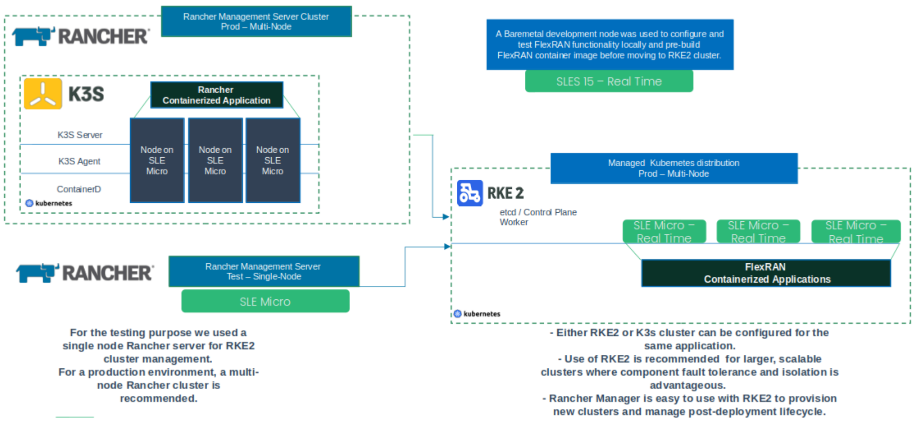


FIGURE 1: TEST SETUP DIAGRAM

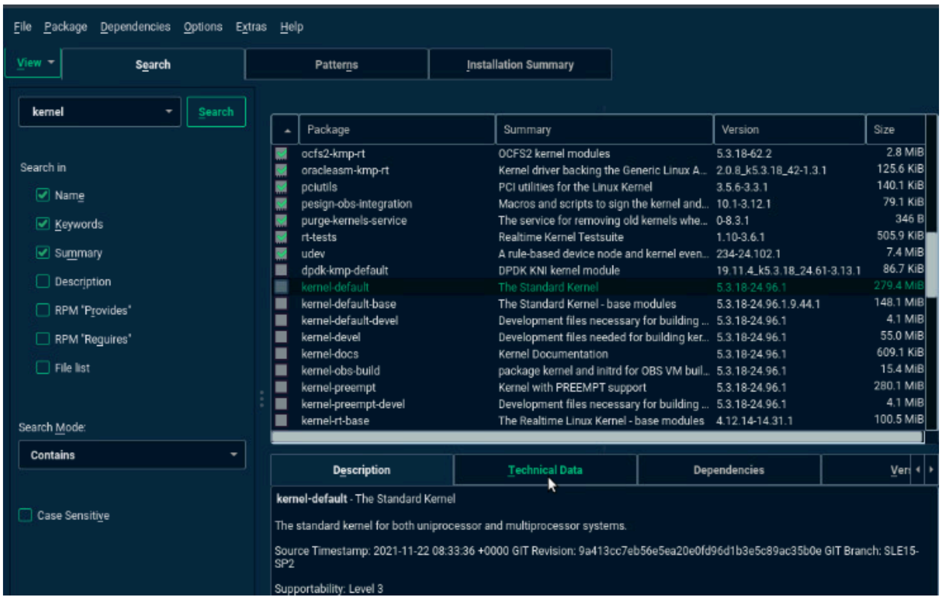
SUSE Linux Enterprise Real Time is a real time operating system designed to reduce latency and increase the predictability and reliability of time-sensitive, business-critical applications.

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

2.4.1 Install SUSE Linux Enterprise Server 15 Real Time

Please refer to the SLES Setup Guide for step-by-step OS installation instructions: https://documentation.suse.com/sle-rt/15-SP3/

- When installing SLES 15 RT, during the installation make sure to unmark *kernel-default*.



- Verify *kernel-rt* is selected:

Note

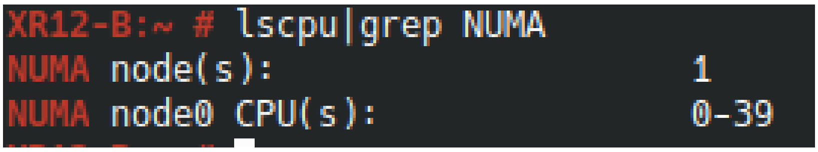
Add sufficient space to the /opt or /var directories since they will be used for most Intel® components and containers. We recommend 200 Gb of storage for these directories. Do not install FlexRAN™ under the root directory.

2.4.2 Real Time configuration

Isolate CPU cores with the following steps:

- Verify that *tuned* installed:

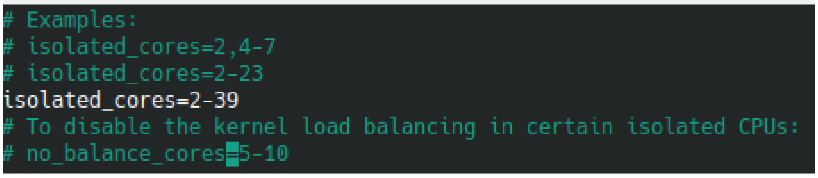
```
zypper in tuned*
```



In our installation setup, we have 1 socket and 40 cores.

- Add isolated cores to the configuration

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

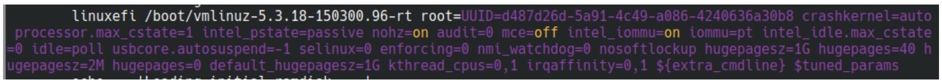


- Activate RT profile

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

- For UEFI modify /boot/efi/EFI/sle_rt/grub.cfg as follows:

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



Note

Settings are dependent on the number of CPUs and isolated cores. Please review section 2.4.3 of Intel's FlexRAN Cloud-Native Setup guide (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-r
t 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 enf
orcing=0 nmi_watchdog=0 nosoftlockup hugepagesz=1G hugepages=40 hugepagesz=2M hugepages=0 default_hugepagesz=1G kt
hread_cpus=0,1 irqaffinity=0,1 skew_tick=1 nohz=on nohz_full=2-39 rcu_nocbs=2-39 nosoftlockup isolcpus=2-39
```

2.5 Set CPU Frequency

The 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	LLC (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
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	3.1	3.1	2.9	2.9	2.7	2.7	2.7	2.7	2.6	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	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	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	3.1	3.1	2.9	2.9	2.6	2.6	2.6	2.6	2.5	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	3.2	3.2	3.2	3.2	3.1	3.1	2.8	2.8	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	3.3	3.3	3.2	3.2	3.0	3.0	3.0	3.0	2.8	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	3.1	3.1	2.9	2.9	2.6	2.6	2.6	2.6	2.5	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	3.1	3.1	2.9	2.9	2.6	2.6	2.6	2.6	2.5	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	3.0	3.0	2.7	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	3.2	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	3.1	3.1	2.9	2.9	2.8	2.8	2.7	2.7	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	3.2	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	3.1	3.1	3.0	3.0	2.8	2.8	2.7	2.7										
5317	12	18	150	2.3	3.4	3.4	3.4	3.4	3.4	3.4	3.3	3.3	3.3	3.3	3.2	3.2														

For this configuration setup, an Intel® Xeon® 4316 processor with 2.6 GHz was used.

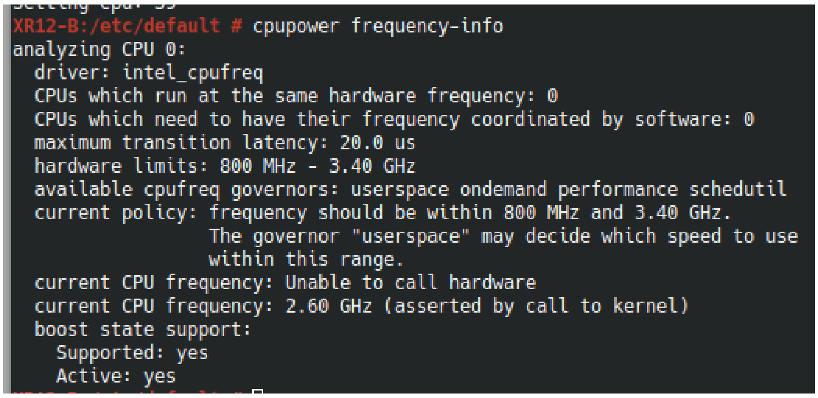
There are two options to setup your CPU frequency:

- **Use cpupower tool**

By running

```
cpupower frequency-info
```

you can check available frequencies for your CPU and drivers.



```
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 configuration example the intel_cpufreq driver was used. The userspace governor is available with the older acpi-cpufreq driver (which would 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 is 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.

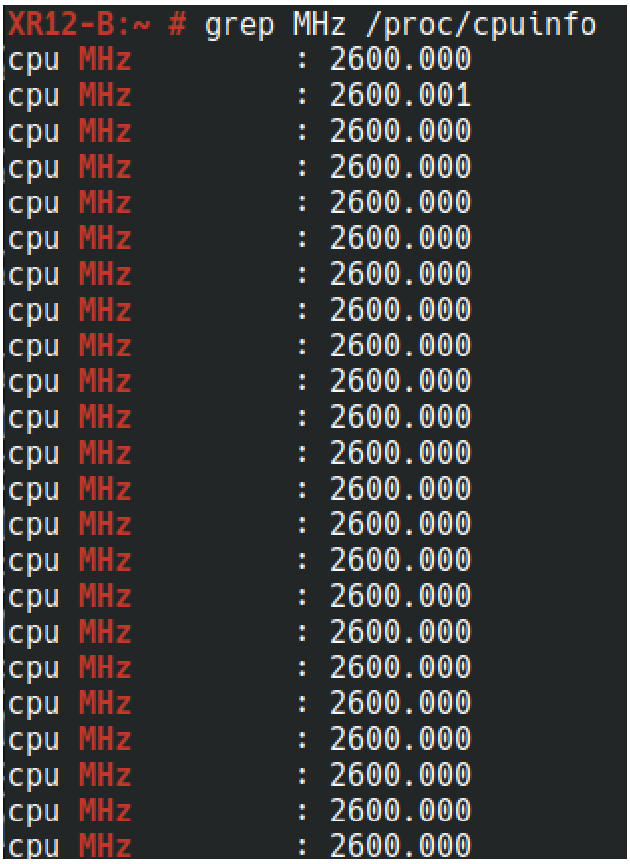
- Verify that settings applied by running:

```
turbostat -i 1
```

```
^CCore  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:

```
XR12-B:~ # cpupower monitor -m 'Mperf'
    | 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
cpu MHz         : 2600.000
cpu MHz         : 2600.000
cpu MHz         : 2600.000
cpu MHz         : 2600.000
cpu MHz         : 2600.000
cpu MHz         : 2600.000
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cpu MHz         : 2600.000
cpu MHz         : 2600.000
cpu MHz         : 2600.000
cpu MHz         : 2600.000
cpu MHz         : 2600.000
cpu MHz         : 2600.000
```

- **The second option 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 were 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	QXRX	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*:

```
XR12-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, please review [SLE RT Hardware Testing] https://documentation.suse.com/sle-rt/15-SP3/pdf/article-hardware-testing_color_en.pdf ↗

2.6 Install Intel® oneAPI

Install Intel® GPU drivers since our platform has an Intel® GPU.

The installation of the drivers also eliminate potential prerequisite failure for oneAPI.

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
```

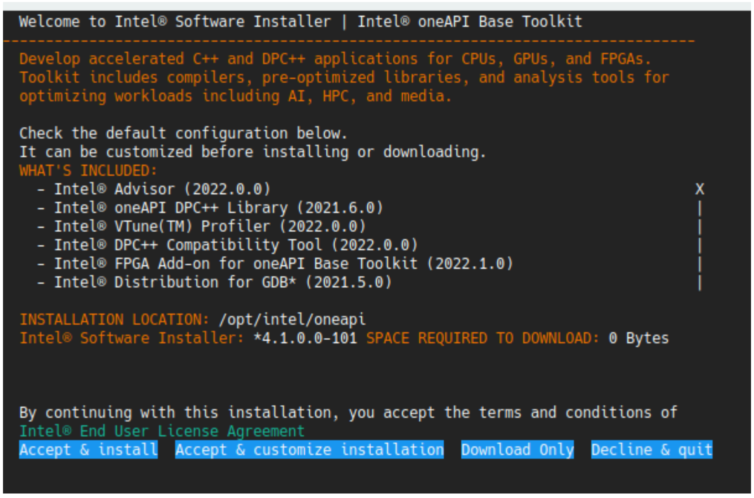
Download and install Intel® oneAPI

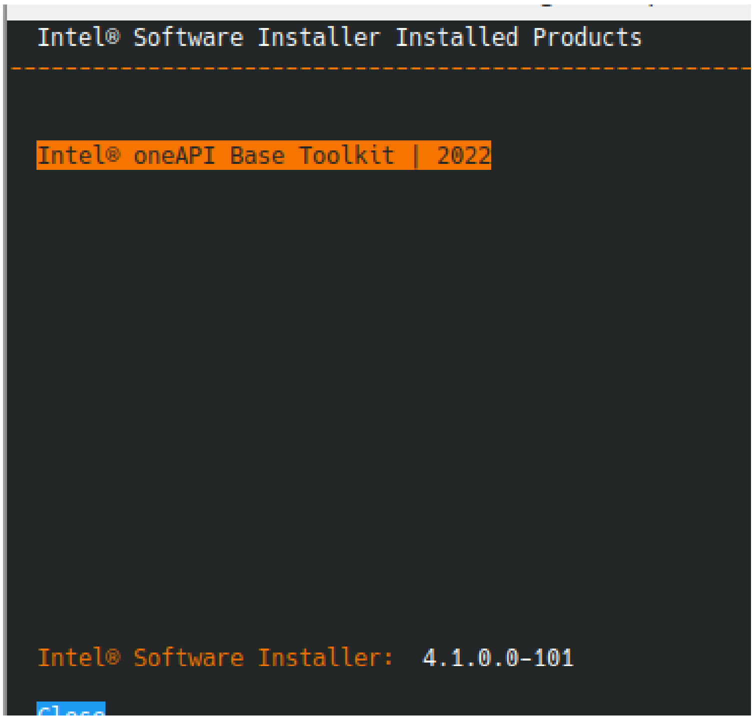
```
wget https://registrationcenter-download.intel.com/akdlm/irc_nas/18236/
l_BaseKit_p_2021.4.0.3422_offline.sh

bash l_BaseKit_p_2021.4.0.3422_offline.sh
```

Note

Make sure that the installation directory has enough space. Intel® oneAPI utilizes approximately 40Gb of space.


Welcome to Intel® Software Installer | Intel® oneAPI Base Toolkit
Develop accelerated C++ and DPC++ applications for CPUs, GPUs, and FPGAs.
Toolkit includes compilers, pre-optimized libraries, and analysis tools for
optimizing workloads including AI, HPC, and media.
Check the default configuration below.
It can be customized before installing or downloading.
WHAT'S INCLUDED:
- Intel® Advisor (2022.0.0)
- Intel® oneAPI DPC++ Library (2021.6.0)
- Intel® VTune(TM) Profiler (2022.0.0)
- Intel® DPC++ Compatibility Tool (2022.0.0)
- Intel® FPGA Add-on for oneAPI Base Toolkit (2022.1.0)
- Intel® Distribution for GDB* (2021.5.0)
INSTALLATION LOCATION: /opt/intel/oneapi
Intel® Software Installer: *4.1.0.0-101 SPACE REQUIRED TO DOWNLOAD: 0 Bytes
By continuing with this installation, you accept the terms and conditions of
Intel® End User License Agreement
Accept & install
Accept & customize installation
Download Only
Decline & quit


Intel® Software Installer Installed Products
Intel® oneAPI Base Toolkit | 2022
Intel® Software Installer: 4.1.0.0-101

- Source the environment 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
:: dnnl -- 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

For complete installation details, please review the 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
```

3.2 Download and Install DPDK

Note

Don't use /root directory for the installation. Intel's DPDK patch 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:

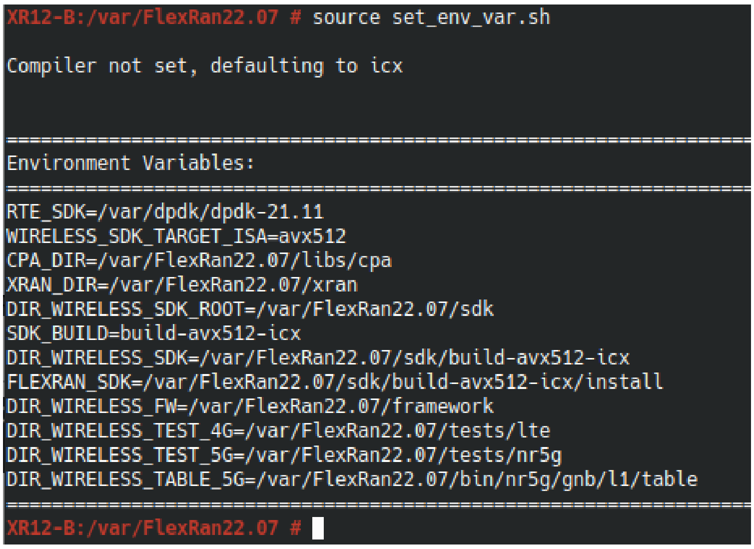
```
patch -p1 < dpdk_patch_21.11.patch
```

3.3 Download and install FlexRAN™

Download FlexRAN™ release pursuant to *Intel® FlexRAN™ Software Reference Solution Release Announcement* - 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
```



3.4 Compile SDK

- Get *gcc11-c++*:

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

- Export PKG_CONFIG_PATH:

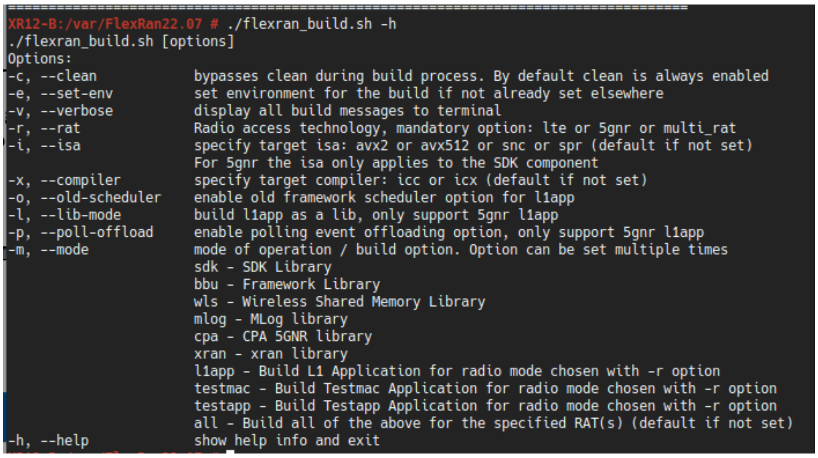
```
export PKG_CONFIG_PATH=$DIR_WIRELESS_SDK/pkgcfg:$PKG_CONFIG_PATH
```

- Source 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 l1app
-l, --lib-mode         build l1app as a lib, only support 5gnr l1app
-p, --poll-offload     enable polling event offloading option, only support 5gnr l1app
-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
                       l1app - 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 for 5G New Radio (5gnr) solution:

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

- Compile for Long Term Evolution (LTE) solution:

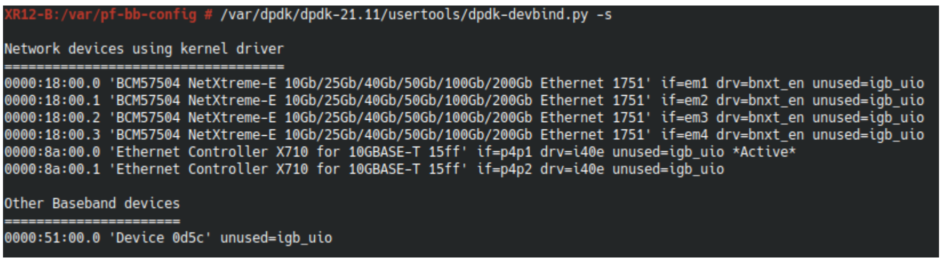
```
./flexran_build.sh -x icx -e -r lte -i avx512
```

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
```



When using Mount Bryce (ACC100) dedicated accelerator card, follow the instructions at https://github.com/intel/pf-bb-config

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

`For Physical Function (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 Virtual Function (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
```

- Check available interfaces:

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

```
XR12-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=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

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 (LTE) 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:

```
XR12-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
```

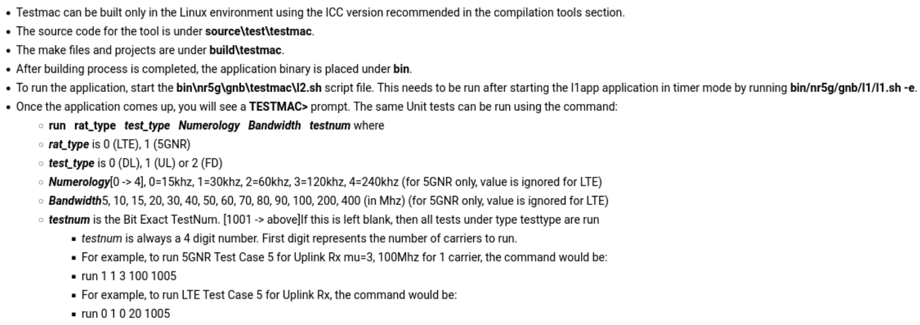
```
XR12-B:/var/dpdk/dpdk-21.11/app/test-bbdev # /var/dpdk/dpdk-21.11/build/app/dpdk-test-bbdev -c F0 -a 52:00.0 -- -c validation -v ./ldpc_dec_d
efault.data
FlexRAN SDK bblib_lte_ldpc_decoder version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
FlexRAN SDK bblib_lte_ldpc_encoder version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
FlexRAN SDK bblib_lte_LDPC_ratematch version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
FlexRAN SDK bblib_lte_rate_dematching_5gnr version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
FlexRAN SDK bblib_lte_turbo version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
FlexRAN SDK bblib_lte_crc version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
FlexRAN SDK bblib_lte_rate_matching version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
FlexRAN SDK bblib_common version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
FlexRAN SDK bblib_srs_fft_cestimate_5gnr version jenkins-FlexRAN-github-SDK-REL-113-g11d71e41
EAL: Detected CPU lcores: 40
EAL: Detected NUMA nodes: 1
EAL: Detected static linkage of DPDK
EAL: Multi-process socket /var/run/dpdk/rte/mp_socket
EAL: Selected IOVA mode 'PA'
EAL: Probe PCI driver: intel_acc100_vf (8086:d5d) 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: 38332 cycles, 23.9575 us
        max: 42418 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 the 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 (5GNR)
  - ***test_type*** is 0 (DL), 1 (UL) or 2 (FD)
  - ***Numerology***[0 -> 4], 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. [1001 -> 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 0 20 1005

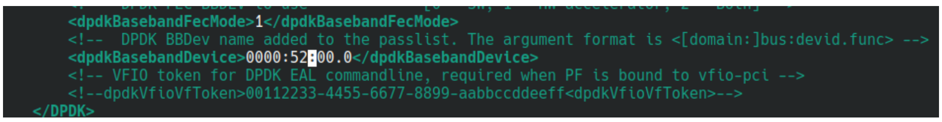
Note

Always source FlexRAN™ environment 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 accelertor) 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 *FlexRAN 5GNR Reference Solution 22.07 PHY Software Documentation* Document #603577 **TestMac** section:

- 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 (5GNR)
  - ***test_type*** is 0 (DL), 1 (UL) or 2 (FD)
  - ***Numerology***[0 -> 4], 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. [1001 -> 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 0 20 1005

The connection should be established in the 1st terminal once you'll run l2.sh from the 2nd terminal:

```
timer_reg_proc_symbol: nSymbol: 6, pProc: 0x8d2570, lpData: (nil)
timer_reg_proc_symbol: nSymbol: 10, pProc: 0x8d25a0, lpData: (nil)
timer_reg_proc_symbol: nSymbol: 1, pProc: 0x8d25d0, lpData: (nil)
timer_reg_proc_symbol: nSymbol: 3, pProc: 0x8d2600, lpData: (nil)
nr5g_gnb_urllc_register_call_backs: nTimerMode[1] nUrllcMiniSlotMask[0]
timer_main_thread:        [PID:  29386] binding on [CPU  2] [PRIO: 96] [POLICY:  1]
                          Numerology: [     3], numSlotsPerSubframe: [ 8], ttiPeriod: [ 125 usecs]
                         Period (usecs):    357    714   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     NO     NO     NO     NO     NO     NO
  NO     NO     NO
                          Instance 2  :     NO     NO     NO     NO     NO     NO     NO     NO     NO     NO     NO
  NO     NO     NO

ebbu_pool_update_frame_slot_sym_num: PhyId[0] nSlotIdx[7997] frame,slot[1023,78] gNumSlotPerSfn[80]
ebbu_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 test case 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_100mhx_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 Cnt :   8200  8200
    TTI Min :      1     0
    TTI Avg :     33    33
    TTI Max :     96    96
----------------------------------------------------------------------------------------------------------------
```

```
~~~~--------~~~~--------~~~~------~~~~~~-
==== l1app [Time:    0Hr  0Min 20Sec ] NumCarrier: 2 NumBbuCores: 3. Tti2Tti Time: [500.00..504.15..510.00] usces
----------------------------------------------------------------------------------------------------------------
--------------------------------
                  |                usecs              |            % of TTI
    Latency       |      Min        Avg         Max |       Min         Avg         Max
    --------------|---------------------------------|-----------------------------
    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
 |      0 Db
      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 CPU 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.

- Create 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 CPUSPEC(7-11) with 2 tasks running
 USER       PID  PPID SPPr TASK NAME
 -------- ----- ----- ---- ---------
 root      9319  9304 Soth ./l1app --cfgfile=phycfg_timer.xml
 root      9444  9436 Soth ./testmac DIR_WIRELESS_TEST_4G=/var/FlexRan22.07/...
```

To move all siblings from pid use -–*threads* option:

```
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 configuration

```
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!
```

and from the 1st terminal run:

```
./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
P: - | NFLOOR: - | NDEMOD_CW: - | DL_BW: - | UL_BW: - |


wls_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 ./l1app --cfgfile=phycfg_timer.xml
 root     13727 13711 Soth ./l1app --cfgfile=phycfg_timer.xml
 root     13728 13711 Soth ./l1app --cfgfile=phycfg_timer.xml
 root     13729 13711 Soth ./l1app --cfgfile=phycfg_timer.xml
 root     13765 13711 Soth ./l1app --cfgfile=phycfg_timer.xml
 root     13766 13711 Soth ./l1app --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_mu1_100mhz_mmimo_32x32_hton.cfg
```

If using a *taskset*, from terminal 1 run:

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

and from terminal 2 run:

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

5 Deploy FlexRAN™ on Container through Kubernetes

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

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

The main document 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 environment 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
```

5.1.1 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 the 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 ethto
ol gcc make kmod wget patch iproute2 pciutils python vim cmake unzip iputils libaio1 libaio-devel git
git-core net-tools gawk
ENV WIRELESS_SDK_TARGET_ISA=avx512 CPA_DIR=/opt/flexran/libs/cpa XRAN_DIR=/opt/flexran/xran DIR_WIRELE
SS_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_TABL
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 iputils libaio1 libaio-devel git git-core ne
t-tools gawk
ENV WIRELESS_SDK_TARGET_ISA=avx512 CPA_DIR=/opt/flexran/libs/cpa XRAN_DIR=/opt/flexran/xran DIR_WIRELE
SS_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_TABL
E_5G=/opt/flexran/bin/nr5g/gnb/l1/table

WORKDIR /var/
```

Note

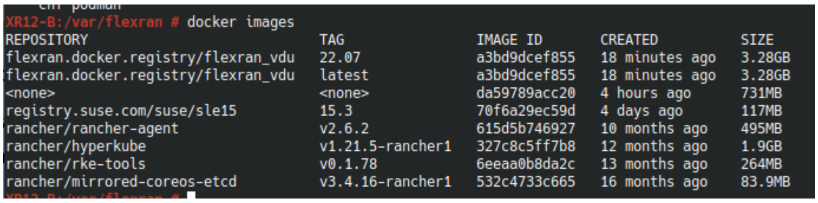
Modify according to your local setup. If local RMT server is used, you need to post rmt-server.crt file on your RMT server in the location which can be reachable from url. So, on the local RMT server copy */etc/rmt/ssl/rmt-server.crt* file to the */usr/share/rmt/public/repo* directory, which creates 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
```

- Tag a docker image:

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



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 and run:

```
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

5.2.1 Install SUSE Linux Enterprise Micro

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

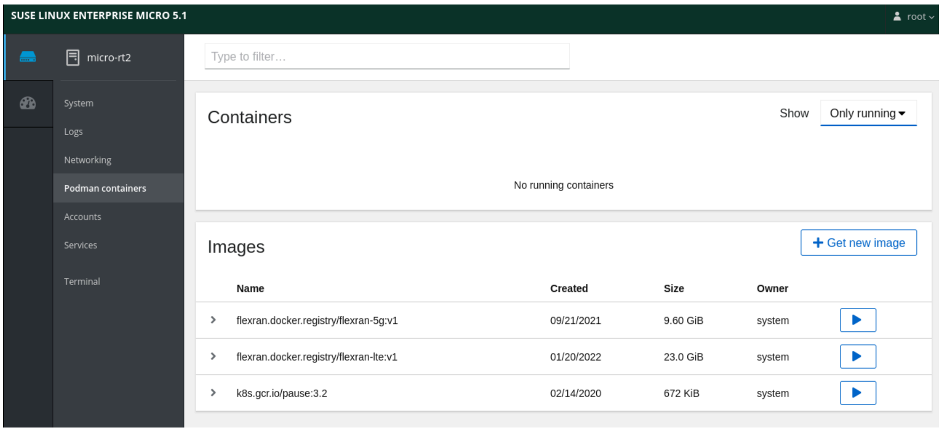
SUSE Linux Enterprise Micro is a lightweight and secure OS platform purpose built for containerized and virtualized workloads.

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

After installing a SLE Micro you can enable a cockpit console 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/

5.2.2 Install a Rancher server

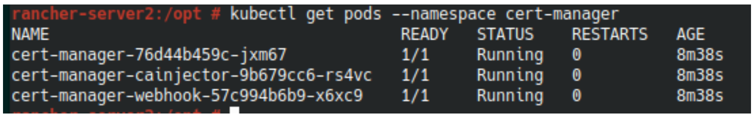
`Install K3s:`

```
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 and verify:

```
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
```

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



Install Rancher:

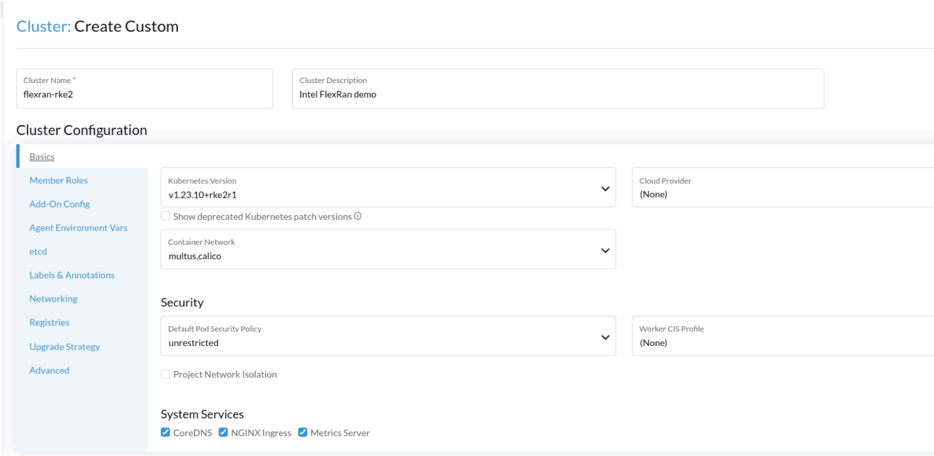
```
helm repo add rancher-stable https://releases.rancher.com/server-charts/stable
kubectl create namespace cattle-system
export HOSTNAME="rancher-server2.isv.suse"
export RANCHER_VERSION="2.6.5"
helm install rancher rancher-stable/rancher --namespace cattle-system --set
 hostname=rancher-server2.isv.suse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

Go to Rancher url and login.

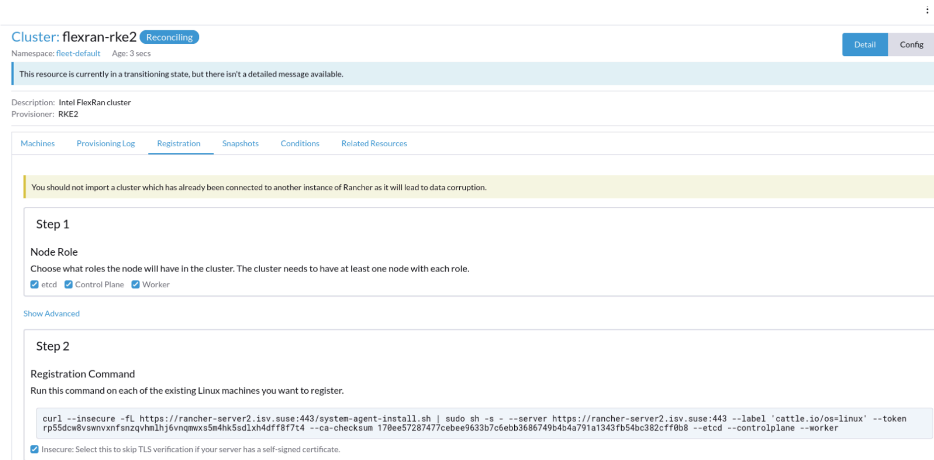
For more details on Rancher installation, review > https://documentation.suse.com/trd/kubernetes/pdf/kubernetes_ri_rancher-k3s-slemicro_color_en.pdf

5.2.3 Create a custom RKE2 cluster

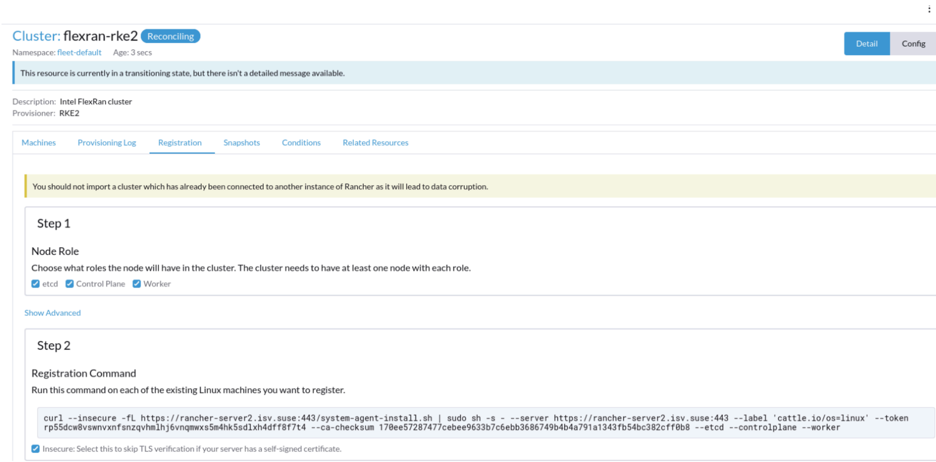
- From the Rancher server create a custom cluster > switch to rke2



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



- Verify if machines got provisioned:




```
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 2 Dell XR12 nodes were used 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.

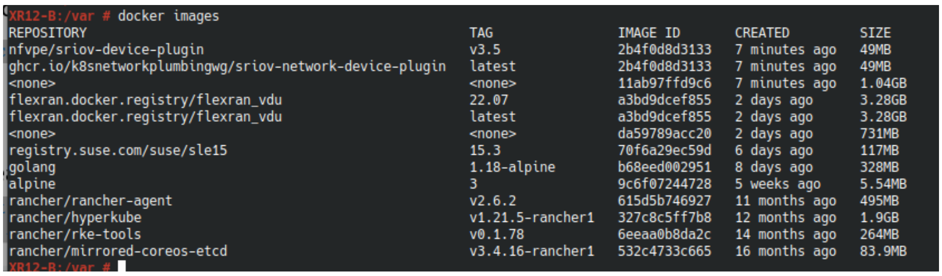
5.3 Build SR-IOV Network Device Plugin

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
```



```
XR12-B:/var # docker images
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>               11ab97ffd9c6   7 minutes ago    1.04GB
flexran.docker.registry/flexran_vdu                      22.07                a3bd9dcef855   2 days ago       3.28GB
flexran.docker.registry/flexran_vdu                      latest               a3bd9dcef855   2 days ago       3.28GB
<none>                                                   <none>               da59789acc20   2 days ago       731MB
registry.suse.com/suse/sle15                             15.3                 70f6a29ec59d   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    1.9GB
rancher/rke-tools                                        v0.1.78              6eeaa0b8da2c   14 months ago    264MB
rancher/mirrored-coreos-etcd                             v3.4.16-rancher1     532c4733c665   16 months ago    83.9MB
XR12-B:/var #
```

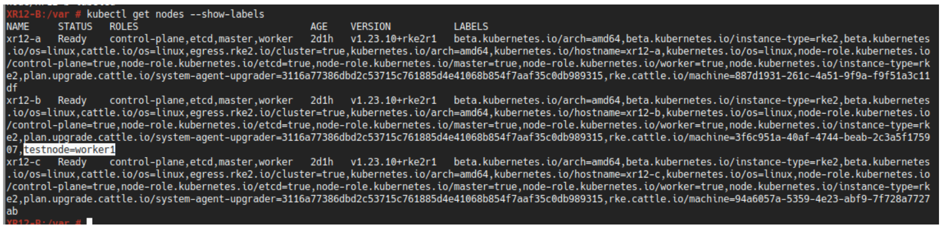
Save with:

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

5.4 Create FlexRAN™ Pods

Label nodes as:

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



- 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

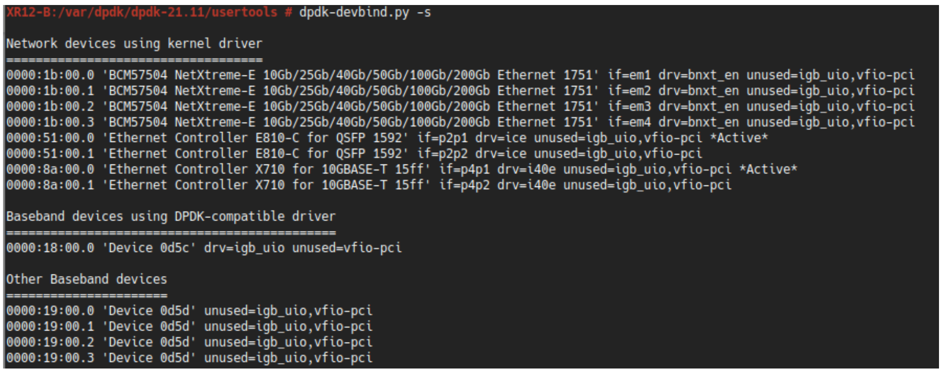
Check available accelerator cards:

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

Add 4 VFs to acc:

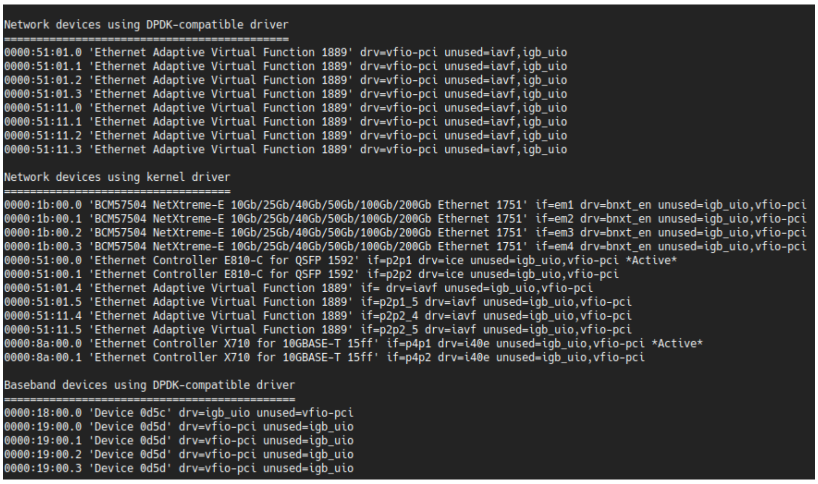
```
echo 4 > /sys/bus/pci/devices/0000:18:00.0/max_vfs
```

Verify:



In the below example 4 new were created:

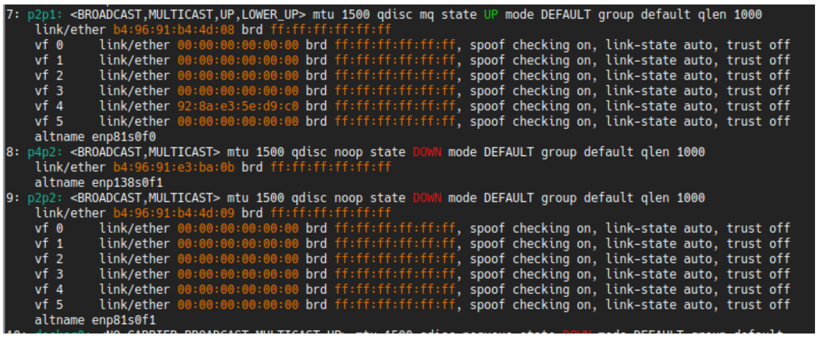
```
lspci|grep acc
18:00.0 Processing accelerators: Intel Corporation Device 0d5c
19:00.0 Processing accelerators: Intel Corporation Device 0d5d
19:00.1 Processing accelerators: Intel Corporation Device 0d5d
19:00.2 Processing accelerators: Intel Corporation Device 0d5d
19:00.3 Processing accelerators: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



```
Network devices using DPDK-compatible driver
============================================
0000:51:01.0 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=iavf,igb_uio
0000:51:01.1 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=iavf,igb_uio
0000:51:01.2 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=iavf,igb_uio
0000:51:01.3 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=iavf,igb_uio
0000:51:11.0 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=iavf,igb_uio
0000:51:11.1 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=iavf,igb_uio
0000:51:11.2 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=iavf,igb_uio
0000:51:11.3 'Ethernet Adaptive Virtual Function 1889' drv=vfio-pci unused=iavf,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=p2p1 drv=ice unused=igb_uio,vfio-pci *Active*
0000:51:00.1 'Ethernet Controller E810-C for QSFP 1592' if=p2p2 drv=ice unused=igb_uio,vfio-pci
0000:51:01.4 'Ethernet Adaptive Virtual Function 1889' if= drv=iavf unused=igb_uio,vfio-pci
0000:51:01.5 'Ethernet Adaptive Virtual Function 1889' if=p2p1_5 drv=iavf unused=igb_uio,vfio-pci
0000:51:11.4 'Ethernet Adaptive Virtual Function 1889' if=p2p2_4 drv=iavf unused=igb_uio,vfio-pci
0000:51:11.5 'Ethernet Adaptive Virtual Function 1889' if=p2p2_5 drv=iavf unused=igb_uio,vfio-pci
0000:8a:00.0 'Ethernet Controller X710 for 10GBASE-T 15ff' if=p4p1 drv=i40e unused=igb_uio,vfio-pci *Active*
0000:8a:00.1 'Ethernet Controller X710 for 10GBASE-T 15ff' if=p4p2 drv=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:c0 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 enp81s0f0
8: p4p2: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN mode DEFAULT group default qlen 1000
    link/ether b4:96:91:e3:ba:0b brd ff:ff:ff:ff:ff:ff
    altname enp138s0f1
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 enp81s0f1
```

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": ["enp81s0f0"]
                }
            },
            {
                "resourceName": "intel_sriov_oru",
                "selectors": {
                    "vendors": ["8086"],
                    "devices": ["1889"],
                    "drivers": ["vfio-pci"],
                    "pfNames": ["enp81s0f1"]
                }
            },
            {
                "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 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

Building, testing, and deploying a properly configured Intel® FlexRAN™ implementation can show the benefits of VNFs and vRAN with Intel® Xeon® Scalable Processors and Intel® Advanced Vector Extensions.

SUSE provides all the elements for an open-source, enterprise-grade, software-defined stack for cloud-native orchestration and management. SUSE Linux Enterprise (with Real Time extensions), SUSE Linux Enterprise Micro Real Time, Rancher Kubernetes Engine v2 (RKE2) and Rancher Management were used and illustrated as key ingredients to simplify the deployment of Intel® FlexRAN™.

7 Reference

- 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/topic-technology/edge-5g/tools/flexran.html?wapkw=FlexRan
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