

# Autour de free5GC

(stage 3)

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**Résumée** Ce document présente l'architecture 5GC autour du projet open source free5GC, afin de permettre aux étudiants du master2 RSA d'appréhender et de développer les acquis dans le vaste monde de la 5G. Cela leur permet d'aborder par la pratique les multiples facettes de cette nouvelle génération du réseau mobile. Ils pourront porter un regard transverse sur les aspects IT, réseau, protocoles et sécurité.

Afin de faciliter ce développement, une présentation et un mode opératoire est détaillé pour l'installation de free5gc en mode docker dans un environnement Linux, Ubuntu de préférence.

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## 1. Introduction

Ce document est une version intermediaire.

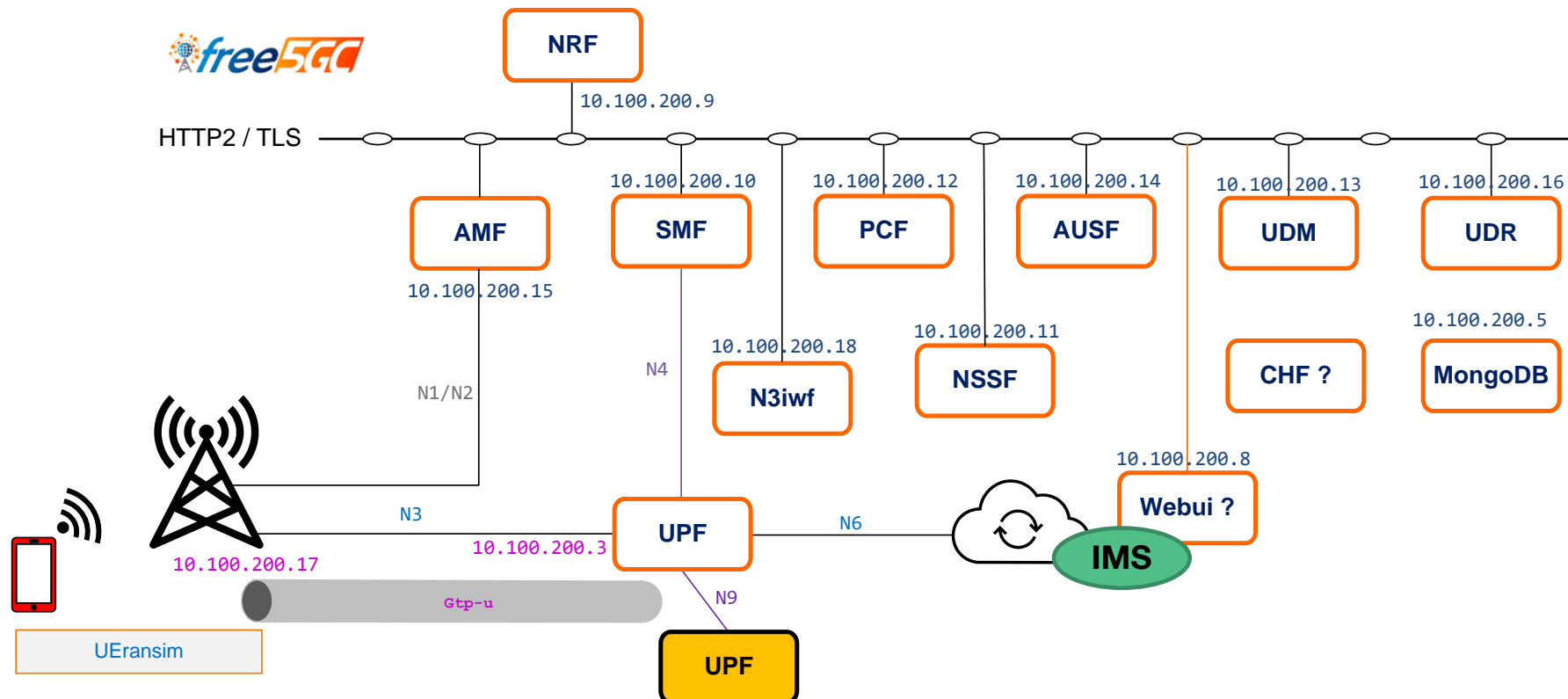
### 1.1. Reference Documents

Liste de documents de references.

N°	Title	Reference	Version
[1]	5G System; Principles and Guidelines for Services Definition; Stage 3	<a href="https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3345">https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3345</a>	R16
[2]	5G System; Network function repository services; Stage 3	<a href="https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3345">https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3345</a>	R16
[3]	What is free5GC	<a href="#">free5GC GitHub - free5gc/free5gc: Open source 5G core network base on 3GPP R15</a>	
[4]	Installation	<a href="#">GitHub - free5gc/free5gc-compose</a>	
[5]	Prérequis	<a href="#">GitHub - free5gc/gtp5g: GTP-U Linux Kernel Module</a>	
[6]			
[7]			
[8]			
[9]			
[10]			
[11]			

## 2. Free5GC Stage3

### 2.1. Architecture / Découverte de l'environnement par défaut



Après installation du free5GC, nous découvrons les adresses IP attribuées à chaque NF (Network Function).

### 2.1.1. Environnement docker free5GC

# docker ps				
CONTAINER ID	IMAGE	COMMAND NAMES	CREATED	STATUS
10dbfe99162c	free5gc/ueransim:latest	"./nr-gnb -c ./confi..."	3 days ago	Up 9 hours
ueransim				
153291f3d3db	free5gc/n3iwf:v3.2.1	"sh -c './n3iwf-ipse..."	3 days ago	Up 3 days
n3iwf				
794118c9b550	free5gc/udr:v3.2.1	"./udr -c ./config/u..."	3 days ago	Up 3 days
8000/tcp		udr		
67280abad745	free5gc/ausf:v3.2.1	"./ausf -c ./config/..."	3 days ago	Up 3 days
8000/tcp		ausf		
59a3c33019c7	free5gc/pcf:v3.2.1	"./pcf -c ./config/p..."	3 days ago	Up 3 days
8000/tcp		pcf		
292b61646f6f	free5gc/amf:v3.2.1	"./amf -c ./config/a..."	3 days ago	Up 3 days
8000/tcp		amf		
5cf88448c6f8	free5gc/udm:v3.2.1	"./udm -c ./config/u..."	3 days ago	Up 3 days
8000/tcp		udm		
a892447b6467	free5gc/nssf:v3.2.1	"./nssf -c ./config/..."	3 days ago	Up 3 days
8000/tcp		nssf		
364edd392325	free5gc/smf:v3.2.1	"./smf -c ./config/s..."	3 days ago	Up 3 days
8000/tcp		smf		
6081cb56fe40	free5gc/webui:v3.2.1	"./webui -c ./config..."	3 days ago	Up 3 days
0.0.0.0:5000->5000/tcp, :::5000->5000/tcp		webui		
830691d6530e	free5gc/nrf:v3.2.1	"./nrf -c ./config/n..."	3 days ago	Up 3 days
8000/tcp		nrf		
b36272648bb6	mongo	"docker-entrypoint.s..."	3 days ago	Up 3 days
27017/tcp		mongod		
f75c82d3e00f	free5gc/upf:v3.2.1	"bash -c './upf-ipta..."	3 days ago	Up 3 days
upf				

## 3. Free5GC : Installation mode docker

Suivez les instructions décrites dans [GitHub - free5gc/free5gc-compose](#)

### 3.1. Prérequis / Module GTP5G (N4)

Utilitaire pour l'interface (appelé aussi reference point) N4, protocole PFCP entre les fonction SMF et UPF.

**Suivez les commandes suivantes :**

```
git clone https://github.com/free5gc/gtp5g.git && cd gtp5g
make clean && make
```

décrites dans [GitHub - free5gc/gtp5g: GTP-U Linux Kernel Module](#)

### 3.1.1. Environnement testé et fonctionnel

Le mieux est d'avoir un environnement **Ubuntu**, avec une version de noyau compatible avec le paquet "**linux-headers-`uname -r`**"

Le module GTP5G dépend d'un autre module noyau « `udp_tunnel` »

Les commandes pour installer et avoir des informations sur les modules sont listées ci-dessous :

```
modprobe -vvv [module]
depmod
lsmod
insmod [/MODULE_PATH/module_file.ko]
modinfo [module]
rmmod [module]

Exemples:
insmod /lib/modules/5.10.0-26-amd64/kernel/drivers/net/gtp5g.ko
insmod /lib/modules/5.10.0-13-amd64/kernel/net/ipv4/udp_tunnel.ko
modprobe -vvv udp_tunnel
modprobe -vvv gtp5g
modinfo gtp5g
modinfo udp_tunnel
```

#### Commandes Modules :

Pour la version du noyau dans un système compatible

```
# uname -r
```

```
5.15.0-76-generic
```

```
# modinfo udp_tunnel
```

```
filename:    /lib/modules/5.15.0-76-generic/kernel/net/ipv4/udp_tunnel.ko
license:     GPL
license:     GPL
srcversion:  4BB7341A13767E0DBF73A20
depends:
retpoline:   Y
intree:      Y
name:        udp_tunnel
vermagic:    5.15.0-76-generic SMP mod_unload modversions
sig_id:      PKCS#7
signer:      Build time autogenerated kernel key
sig_key:     34:18:5F:0B:C9:D8:70:BD:91:78:CF:85:0F:BC:DA:EF:0F:4E:60:FB
sig_hashalgo: sha512
signature:   24:E8:7F:95:9C:BB:FF:8A:F7:BD:C4:4C:2C:58:78:7B:48:94:9E:79:
              A1:23:13:6C:FA:FB:2D:D6:6D:E7:2C:A1:7C:24:03:90:DC:A5:F9:05:
              64:4D:33:0F:18:E0:FA:A7:7A:BE:67:9F:F3:AD:BE:6B:3D:3D:B2:56:
              DF:C4:7C:AF:EE:3D:36:DF:37:B8:31:F9:F8:07:04:07:B4:04:BD:66:
              ...
              8A:80:EA:88:C2:EA:33:45:F7:D2:3C:36:D5:EA:75:23:03:5A:62:B6:
              44:0C:39:DA:05:92:64:46:7A:9E:2C:20:46:51:C4:D8:B2:C5:CC:09:
              3E:2D:5B:A6:6A:02:D1:B4:51:AF:D7:07:DC:B3:0B:AA:0A:BB:B2:3F:
              DE:8B:62:92:DD:CE:60:83:CB:7D:CD:4B
```

```
# modinfo gtp5g
```

```
filename: /lib/modules/5.15.0-76-generic/kernel/drivers/net/gtp5g.ko
alias: net-pf-16-proto-16-family-gtp5g
alias: rtnl-link-gtp5g
version: 0.8.3
description: Interface for 5G GTP encapsulated traffic
```

author: Muthuraman <muthuramane.cs03g@g2.nctu.edu.tw>

author: Yao-Wen Chang <yaowenowo@gmail.com>

license: GPL

srcversion: 5A86308DFFB318255D09DF6

depends: udp\_tunnel

retpoline: Y

name: gtp5g

vermagic: 5.15.0-76-generic SMP mod\_unload modversions

```
# lsmod | grep gtp5g
```

```
gtp5g 118784 0
```

```
udp_tunnel 20480 2 gtp5g,sctp
```

```
# lsmod | grep udp_tunnel
```

```
ip6_udp_tunnel 16384 1 sctp
```

```
udp_tunnel 20480 2 gtp5g,sctp
```

```
# tail /lib/modules/5.15.0-76-generic/modules.dep | grep gtp5g
```

```
kernel/drivers/net/gtp5g.ko: kernel/net/ipv4/udp_tunnel.ko
```

### 3.1.2. Exemple de non compatibilité sur un environnement Debian

Le mieux ici serait d'upgrader la version du noyau pour une version compatible en 5.10.0-26-amd64 par exemple ?

#### Commandes Modules :

Pour la version du noyau dans un système non compatible

```
# uname -r
5.10.0-13-amd64
```

Le package "linux-headers-5.10.0-13-amd64" n'existe pas et ne peut donc pas être installé ni mis-à-jour.

```
# apt-cache search linux-header* | grep linux-headers-
linux-headers-5.10.0-22-amd64 - Header files for Linux 5.10.0-22-amd64
linux-headers-5.10.0-22-cloud-amd64 - Header files for Linux 5.10.0-22-cloud-amd64
linux-headers-5.10.0-22-common - Common header files for Linux 5.10.0-22
linux-headers-5.10.0-22-common-rt - Common header files for Linux 5.10.0-22-rt
linux-headers-5.10.0-22-rt-amd64 - Header files for Linux 5.10.0-22-rt-amd64
linux-headers-5.10.0-26-amd64 - Header files for Linux 5.10.0-26-amd64
linux-headers-5.10.0-26-cloud-amd64 - Header files for Linux 5.10.0-26-cloud-amd64
linux-headers-5.10.0-26-common - Common header files for Linux 5.10.0-26
linux-headers-5.10.0-26-common-rt - Common header files for Linux 5.10.0-26-rt
linux-headers-5.10.0-26-rt-amd64 - Header files for Linux 5.10.0-26-rt-amd64
linux-headers-amd64 - Header files for Linux amd64 configuration (meta-package)
linux-headers-cloud-amd64 - Header files for Linux cloud-amd64 configuration (meta-package)
linux-headers-rt-amd64 - Header files for Linux rt-amd64 configuration (meta-package)
linux-headers-5.10.0-25-amd64 - Header files for Linux 5.10.0-25-amd64
linux-headers-5.10.0-25-cloud-amd64 - Header files for Linux 5.10.0-25-cloud-amd64
linux-headers-5.10.0-25-common - Common header files for Linux 5.10.0-25
linux-headers-5.10.0-25-common-rt - Common header files for Linux 5.10.0-25-rt
linux-headers-5.10.0-25-rt-amd64 - Header files for Linux 5.10.0-25-rt-amd64
```

Extrait de la commande :

```
modprobe -vvv gtp5g
```

```
modprobe: INFO: ../libkmod/libkmod-module.c:892 kmod_module_insert_module() Failed to insert
module '/lib/modules/5.10.0-13-amd64/kernel/drivers/net/gtp5g.ko': Exec format error
modprobe: ERROR: could not insert 'gtp5g': Exec format error
```

```
# modprobe -vvv udp_tunnel
```

```

modprobe: INFO: ../libkmod/libkmod.c:365 kmod_set_log_fn() custom logging function
0x560c79b6e6f0 registered
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-13-
amd64/modules.dep.bin
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-13-
amd64/modules.alias.bin
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-13-
amd64/modules.symbols.bin
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-13-
amd64/modules.builtin.alias.bin
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-13-
amd64/modules.builtin.bin
modprobe: DEBUG: ../libkmod/libkmod-module.c:556 kmod_module_new_from_lookup() input
alias=udp_tunnel, normalized=udp_tunnel
modprobe: DEBUG: ../libkmod/libkmod-module.c:562 kmod_module_new_from_lookup() lookup
modules.dep udp_tunnel
modprobe: DEBUG: ../libkmod/libkmod.c:595 kmod_search_moddep() use mmaped index 'modules.dep'
modname=udp_tunnel
modprobe: DEBUG: ../libkmod/libkmod.c:403 kmod_pool_get_module() get module name='udp_tunnel'
found=(nil)
modprobe: DEBUG: ../libkmod/libkmod.c:411 kmod_pool_add_module() add 0x560c7a925fb0
key='udp_tunnel'
modprobe: DEBUG: ../libkmod/libkmod-module.c:202 kmod_module_parse_depline() 0 dependencies
for udp_tunnel
modprobe: DEBUG: ../libkmod/libkmod-module.c:589 kmod_module_new_from_lookup() lookup
udp_tunnel=0, list=0x560c7a925ba0
modprobe: DEBUG: ../libkmod/libkmod.c:500 lookup_built_in_file() use mmaped index
'modules.builtin' modname=udp_tunnel
modprobe: DEBUG: ../libkmod/libkmod-module.c:468 kmod_module_unref() kmod_module
0x560c7a925fb0 released
modprobe: DEBUG: ../libkmod/libkmod.c:419 kmod_pool_del_module() del 0x560c7a925fb0
key='udp_tunnel'
modprobe: INFO: ../libkmod/libkmod.c:332 kmod_unref() context 0x560c7a9254e0 released

# modprobe -vvv gtp5g
modprobe: INFO: ../libkmod/libkmod.c:365 kmod_set_log_fn() custom logging function
0x557d2bc3e6f0 registered
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-13-
amd64/modules.dep.bin
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-13-
amd64/modules.alias.bin
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-13-
amd64/modules.symbols.bin
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-13-
amd64/modules.builtin.alias.bin
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-13-
amd64/modules.builtin.bin
modprobe: DEBUG: ../libkmod/libkmod-module.c:556 kmod_module_new_from_lookup() input
alias=gtp5g, normalized=gtp5g
modprobe: DEBUG: ../libkmod/libkmod-module.c:562 kmod_module_new_from_lookup() lookup
modules.dep gtp5g
modprobe: DEBUG: ../libkmod/libkmod.c:595 kmod_search_moddep() use mmaped index 'modules.dep'
modname=gtp5g
modprobe: DEBUG: ../libkmod/libkmod.c:403 kmod_pool_get_module() get module name='gtp5g'
found=(nil)
modprobe: DEBUG: ../libkmod/libkmod.c:411 kmod_pool_add_module() add 0x557d2d98df30
key='gtp5g'
modprobe: DEBUG: ../libkmod/libkmod-module.c:410 kmod_module_new_from_path() stat
/lib/modules/5.10.0-13-amd64/kernel/net/ipv4/udp_tunnel.ko: No such file or directory
modprobe: ERROR: ../libkmod/libkmod-module.c:191 kmod_module_parse_depline()
ctx=0x557d2d98d4e0 path=/lib/modules/5.10.0-13-amd64/kernel/net/ipv4/udp_tunnel.ko error=No
such file or directory
modprobe: DEBUG: ../libkmod/libkmod-module.c:589 kmod_module_new_from_lookup() lookup
gtp5g=0, list=0x557d2d98dba0
modprobe: DEBUG: ../libkmod/libkmod.c:500 lookup_built_in_file() use mmaped index
'modules.builtin' modname=gtp5g
modprobe: DEBUG: ../libkmod/libkmod-module.c:1760 kmod_module_get_initstate() could not open
'/sys/module/gtp5g/initstate': No such file or directory
modprobe: DEBUG: ../libkmod/libkmod-module.c:1770 kmod_module_get_initstate() could not open
'/sys/module/gtp5g': No such file or directory
modprobe: DEBUG: ../libkmod/libkmod.c:595 kmod_search_moddep() use mmaped index 'modules.dep'
modname=gtp5g
modprobe: DEBUG: ../libkmod/libkmod-module.c:410 kmod_module_new_from_path() stat
/lib/modules/5.10.0-13-amd64/kernel/net/ipv4/udp_tunnel.ko: No such file or directory
modprobe: ERROR: ../libkmod/libkmod-module.c:191 kmod_module_parse_depline()
ctx=0x557d2d98d4e0 path=/lib/modules/5.10.0-13-amd64/kernel/net/ipv4/udp_tunnel.ko error=No
such file or directory
modprobe: DEBUG: ../libkmod/libkmod-module.c:1404 kmod_module_get_options() modname=snd_pcsp
mod->name=gtp5g mod->alias=(null)
modprobe: DEBUG: ../libkmod/libkmod-module.c:1404 kmod_module_get_options()
modname=snd_usb_audio mod->name=gtp5g mod->alias=(null)

```

```

modprobe: DEBUG: ../libkmod/libkmod-module.c:1404 kmod_module_get_options() modname=cx88_alsa
mod->name=gtp5g mod->alias=(null)
modprobe: DEBUG: ../libkmod/libkmod-module.c:1404 kmod_module_get_options()
modname=snd_atiixp_modem mod->name=gtp5g mod->alias=(null)
modprobe: DEBUG: ../libkmod/libkmod-module.c:1404 kmod_module_get_options()
modname=snd_intel8x0m mod->name=gtp5g mod->alias=(null)
modprobe: DEBUG: ../libkmod/libkmod-module.c:1404 kmod_module_get_options()
modname=snd_via82xx_modem mod->name=gtp5g mod->alias=(null)
modprobe: DEBUG: ../libkmod/libkmod-module.c:1404 kmod_module_get_options() modname=bonding
mod->name=gtp5g mod->alias=(null)
modprobe: DEBUG: ../libkmod/libkmod-module.c:1404 kmod_module_get_options() modname=dummy
mod->name=gtp5g mod->alias=(null)
modprobe: DEBUG: ../libkmod/libkmod-module.c:1760 kmod_module_get_initstate() could not open
'/sys/module/gtp5g/initstate': No such file or directory
modprobe: DEBUG: ../libkmod/libkmod-module.c:1770 kmod_module_get_initstate() could not open
'/sys/module/gtp5g': No such file or directory
modprobe: DEBUG: ../libkmod/libkmod-module.c:750 kmod_module_get_path() name='gtp5g'
path='/lib/modules/5.10.0-13-amd64/kernel/drivers/net/gtp5g.ko'
modprobe: DEBUG: ../libkmod/libkmod-module.c:750 kmod_module_get_path() name='gtp5g'
path='/lib/modules/5.10.0-13-amd64/kernel/drivers/net/gtp5g.ko'
insmod /lib/modules/5.10.0-13-amd64/kernel/drivers/net/gtp5g.ko
modprobe: DEBUG: ../libkmod/libkmod-module.c:750 kmod_module_get_path() name='gtp5g'
path='/lib/modules/5.10.0-13-amd64/kernel/drivers/net/gtp5g.ko'
modprobe: INFO: ../libkmod/libkmod-module.c:892 kmod_module_insert_module() Failed to insert
module '/lib/modules/5.10.0-13-amd64/kernel/drivers/net/gtp5g.ko': Exec format error
modprobe: ERROR: could not insert 'gtp5g': Exec format error
modprobe: DEBUG: ../libkmod/libkmod-module.c:468 kmod_module_unref() kmod_module
0x557d2d98df30 released
modprobe: DEBUG: ../libkmod/libkmod.c:419 kmod_pool_del_module() del 0x557d2d98df30
key='gtp5g'
modprobe: INFO: ../libkmod/libkmod.c:332 kmod_unref() context 0x557d2d98d4e0 released

```

### 3.1.3. Résolution avec upgrade de la version kernel

Le mieux ici serait d'upgrader la version du noyau **pour une version compatible en 5.10.0-26-amd64** par exemple ?

```

apt install linux-image-5.10.0-26-amd64
reboot

# uname -a
Linux [ServerName] 5.10.0-26-amd64 #1 SMP Debian 5.10.197-1 (2023-09-29) x86_64 GNU/Linux

[projet_PATH]/gtp5g# make
make -C /lib/modules/5.10.0-26-amd64/build M=/[projet_PATH]/gtp5g modules
make[1]: on entre dans le répertoire « /usr/src/linux-headers-5.10.0-26-amd64 »
CC [M] /[projet_PATH]/gtp5g/src/gtp5g.o
CC [M] /[projet_PATH]/gtp5g/src/log.o
CC [M] /[projet_PATH]/gtp5g/src/util.o
CC [M] /[projet_PATH]/gtp5g/src/gtpu/dev.o
CC [M] /[projet_PATH]/gtp5g/src/gtpu/encap.o
CC [M] /[projet_PATH]/gtp5g/src/gtpu/hash.o
CC [M] /[projet_PATH]/gtp5g/src/gtpu/link.o
CC [M] /[projet_PATH]/gtp5g/src/gtpu/net.o
CC [M] /[projet_PATH]/gtp5g/src/gtpu/pktinfo.o
CC [M] /[projet_PATH]/gtp5g/src/genl/genl.o
CC [M] /[projet_PATH]/gtp5g/src/genl/genl_version.o
CC [M] /[projet_PATH]/gtp5g/src/genl/genl_pdr.o
CC [M] /[projet_PATH]/gtp5g/src/genl/genl_far.o
CC [M] /[projet_PATH]/gtp5g/src/genl/genl_qer.o
CC [M] /[projet_PATH]/gtp5g/src/genl/genl_urr.o
CC [M] /[projet_PATH]/gtp5g/src/genl/genl_report.o
CC [M] /[projet_PATH]/gtp5g/src/genl/genl_bar.o
CC [M] /[projet_PATH]/gtp5g/src/pfcp/api_version.o
CC [M] /[projet_PATH]/gtp5g/src/pfcp/pdr.o
CC [M] /[projet_PATH]/gtp5g/src/pfcp/far.o
CC [M] /[projet_PATH]/gtp5g/src/pfcp/qer.o
CC [M] /[projet_PATH]/gtp5g/src/pfcp/urr.o
CC [M] /[projet_PATH]/gtp5g/src/pfcp/bar.o
CC [M] /[projet_PATH]/gtp5g/src/pfcp/seid.o
CC [M] /[projet_PATH]/gtp5g/src/proc.o
LD [M] /[projet_PATH]/gtp5g/gtp5g.o
MODPOST /[projet_PATH]/gtp5g/Module.symvers
CC [M] /[projet_PATH]/gtp5g/gtp5g.mod.o
LD [M] /[projet_PATH]/gtp5g/gtp5g.ko
make[1]: on quitte le répertoire « /usr/src/linux-headers-5.10.0-26-amd64 »
[projet_PATH]/gtp5g# make install
cp gtp5g.ko /lib/modules/5.10.0-26-amd64/kernel/drivers/net

```



```
modprobe udp_tunnel
/sbin/depmod -a
modprobe gtp5g
echo "gtp5g" >> /etc/modules
```

#### # modinfo gtp5g

```
filename:      /lib/modules/5.10.0-26-amd64/kernel/drivers/net/gtp5g.ko
alias:         net-pf-16-protocol-16-family-gtp5g
alias:         rtnl-link-gtp5g
version:       0.8.3
description:   Interface for 5G GTP encapsulated traffic
author:        Muthuraman <muthuramane.cs03g@g2.nctu.edu.tw>
author:        Yao-Wen Chang <yaowenowo@gmail.com>
license:       GPL
srcversion:    5A86308DFFB318255D09DF6
depends:        udp_tunnel
retpoline:     Y
name:          gtp5g
vermagic:      5.10.0-26-amd64 SMP mod_unload modversions
```

#### # modinfo udp\_tunnel

```
filename:      /lib/modules/5.10.0-26-amd64/kernel/net/ipv4/udp_tunnel.ko
license:       GPL
license:       GPL
depends:
retpoline:     Y
intree:        Y
name:          udp_tunnel
vermagic:      5.10.0-26-amd64 SMP mod_unload modversions
sig_id:        PKCS#7
signer:        Debian Secure Boot CA
sig_key:       32:A0:28:7F:84:1A:03:6F:A3:93:C1:E0:65:C4:3A:E6:B2:42:26:43
sig_hashalgo:  sha256
signature:     50:6F:20:E8:61:83:31:A9:CD:B1:86:CB:A4:78:9A:E9:1C:E1:D3:A6:
               37:CB:23:FF:14:18:7F:FB:C4:9C:AE:EF:96:1A:2C:C3:E6:EF:CF:96:
               F2:C3:00:55:89:51:49:93:6A:27:AC:C5:8F:10:58:31:2B:7F:1D:EC:
               [...]
               3B:E7:AA:35:E7:2F:B0:74:07:28:BF:59:15:CC:6E:FA:B6:1E:B8:47:
               19:0C:4A:4E:25:EC:19:DA:F0:EB:B0:FE:EB:F9:0A:B1:81:96:93:EC:
               98:B0:88:FB:40:65:48:A3:A1:7F:18:F6:5B:4F:5E:3D
```

#### # modprobe -vvv udp\_tunnel

```
modprobe: INFO: ../libkmod/libkmod.c:365 kmod_set_log_fn() custom logging function
0x56527673a6f0 registered
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-26-
amd64/modules.dep.bin
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-26-
amd64/modules.alias.bin
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-26-
amd64/modules.symbols.bin
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-26-
amd64/modules.builtin.alias.bin
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-26-
amd64/modules.builtin.bin
modprobe: DEBUG: ../libkmod/libkmod-module.c:556 kmod_module_new_from_lookup() input
alias=udp_tunnel, normalized=udp_tunnel
modprobe: DEBUG: ../libkmod/libkmod-module.c:562 kmod_module_new_from_lookup() lookup
modules.dep udp_tunnel
modprobe: DEBUG: ../libkmod/libkmod.c:595 kmod_search_moddep() use mmaped index 'modules.dep'
modname=udp_tunnel
modprobe: DEBUG: ../libkmod/libkmod.c:403 kmod_pool_get_module() get module name='udp_tunnel'
found=(nil)
modprobe: DEBUG: ../libkmod/libkmod.c:411 kmod_pool_add_module() add 0x56527733a0a0
key='udp_tunnel'
modprobe: DEBUG: ../libkmod/libkmod-module.c:202 kmod_module_parse_depline() 0 dependencies
for udp_tunnel
modprobe: DEBUG: ../libkmod/libkmod-module.c:589 kmod_module_new_from_lookup() lookup
udp_tunnel=0, list=0x565277339c90
modprobe: DEBUG: ../libkmod/libkmod.c:500 lookup_builtin_file() use mmaped index
'modules.builtin' modname=udp_tunnel
modprobe: DEBUG: ../libkmod/libkmod-module.c:468 kmod_module_unref() kmod_module
0x56527733a0a0 released
modprobe: DEBUG: ../libkmod/libkmod.c:419 kmod_pool_del_module() del 0x56527733a0a0
key='udp_tunnel'
modprobe: INFO: ../libkmod/libkmod.c:332 kmod_unref() context 0x5652773394e0 released
```

#### # modprobe -vvv gtp5g

```
modprobe: INFO: ../libkmod/libkmod.c:365 kmod_set_log_fn() custom logging function
0x5575d3ac96f0 registered
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-26-
amd64/modules.dep.bin
```

```

modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-26-
amd64/modules.alias.bin
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-26-
amd64/modules.symbols.bin
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-26-
amd64/modules.builtin.alias.bin
modprobe: DEBUG: ../libkmod/libkmod-index.c:757 index_mm_open() file=/lib/modules/5.10.0-26-
amd64/modules.builtin.bin
modprobe: DEBUG: ../libkmod/libkmod-module.c:556 kmod_module_new_from_lookup() input
alias=gtp5g, normalized=gtp5g
modprobe: DEBUG: ../libkmod/libkmod-module.c:562 kmod_module_new_from_lookup() lookup
modules.dep gtp5g
modprobe: DEBUG: ../libkmod/libkmod.c:595 kmod_search_moddep() use mmaped index 'modules.dep'
modname=gtp5g
modprobe: DEBUG: ../libkmod/libkmod.c:403 kmod_pool_get_module() get module name='gtp5g'
found=(nil)
modprobe: DEBUG: ../libkmod/libkmod.c:411 kmod_pool_add_module() add 0x5575d479c020
key='gtp5g'
modprobe: DEBUG: ../libkmod/libkmod.c:403 kmod_pool_get_module() get module name='udp_tunnel'
found=(nil)
modprobe: DEBUG: ../libkmod/libkmod.c:403 kmod_pool_get_module() get module name='udp_tunnel'
found=(nil)
modprobe: DEBUG: ../libkmod/libkmod.c:411 kmod_pool_add_module() add 0x5575d479c1d0
key='udp_tunnel'
modprobe: DEBUG: ../libkmod/libkmod-module.c:196 kmod_module_parse_depline() add dep:
/lib/modules/5.10.0-26-amd64/kernel/net/ipv4/udp_tunnel.ko
modprobe: DEBUG: ../libkmod/libkmod-module.c:202 kmod_module_parse_depline() 1 dependencies
for gtp5g
modprobe: DEBUG: ../libkmod/libkmod-module.c:589 kmod_module_new_from_lookup() lookup
gtp5g=0, list=0x5575d479bc90
modprobe: DEBUG: ../libkmod/libkmod.c:500 lookup_builtin_file() use mmaped index
'modules.builtin' modname=gtp5g
modprobe: DEBUG: ../libkmod/libkmod-module.c:468 kmod_module_unref() kmod_module
0x5575d479c020 released
modprobe: DEBUG: ../libkmod/libkmod.c:419 kmod_pool_del_module() del 0x5575d479c020
key='gtp5g'
modprobe: DEBUG: ../libkmod/libkmod-module.c:468 kmod_module_unref() kmod_module
0x5575d479c1d0 released
modprobe: DEBUG: ../libkmod/libkmod.c:419 kmod_pool_del_module() del 0x5575d479c1d0
key='udp_tunnel'
modprobe: INFO: ../libkmod/libkmod.c:332 kmod_unref() context 0x5575d479b4e0 released

```

### 3.2. Mode OP : installation free5gc/free5gc-compose

Assurez vous de trouvez une verion de noyau compatible pour le module GTP5G, pour PFCP sur l'interface N4.

Assurez vous de faire les commande apt update et upgrade au préalable pour les histoires de proxy.  
Travaillez dans votre répertoire **projet**

```

apt update
apt upgrade

```

Intérogez avec les commandes « ls -la » et « docker images », histoire de savoir ce qu'il y a à certaines étapes

Suivez les commandes suivantes :

```

mkdir projet && cd projet
git clone https://github.com/free5gc/free5gc-compose.git
cd free5gc-compose/
cd base/
git clone https://github.com/free5gc/free5gc-compose.git
cd ..
make all

```

à cette étape des clés de sécurités [sha256](#) sont transférés, échangés, installés ?? Des erreurs s'affichent... mais ne prêtez pas plus attention !

Une extraction des résultats de cette étape est réalisée et présentée ci-après.

*Rappel : intérogez avec les commandes « ls -la » et « docker images », histoire de savoir ce qu'il y a à certaines étapes*

```
docker images
```

```
docker compose -f docker-compose-build.yaml build
```

*Cette étape a l'air d'être en échec ... Mais pas de panique ! Car « **Docker build** » signifie dans la documentation docker : "Build an image from a Dockerfile"*

```
docker images
```

*A la place, installez les images des NF avec la commande « **docker pull** » directement à partir du répertoire «free5g» comme ci-dessous :*

*Construction des images ueransim, webui et mongodb*

```
docker pull free5gc/ueransim
```

```
docker pull free5gc/webui
```

```
docker pull mongo
```

```
docker images
```

*Construction des images des NF*

```
docker pull free5gc/amf
```

```
docker pull free5gc/ausf
```

```
docker pull free5gc/nrf
```

```
docker pull free5gc/pcf
```

```
docker pull free5gc/pcf
```

```
docker pull free5gc/smf
```

```
docker pull free5gc/udm
```

```
docker pull free5gc/udr
```

```
docker pull free5gc/upf
```

```
docker images
```

*Chargez les instances des NF avec la ligne de commande ci-dessous (-d pour le mode « daemon »):*

```
docker-compose -f docker-compose.yaml up -d
```

```
docker ps
```

*à cette étape si vous voyez les instances tourner avec « STATUS UP », c'est gagné !!! comme présenté en 1.1.1. Environnement docker free5gc.*

### 3.2.1. Etape après « make all » / sha256

```
# make all
docker build -t 'free5gc'/'base':'latest' ./base
[+] Building 23.0s (5/6)
=> [internal] load .dockerignore
0.0s
=> => transferring context: 2B
0.0s
=> [internal] load build definition from Dockerfile
0.0s
=> => transferring dockerfile: 734B
0.0s
=> [internal] load metadata for docker.io/library/golang:1.18.10-bullseye
1.6s
=> [1/3] FROM docker.io/library/golang:1.18.10-bullseye@sha256:2cf761b45e5e3f150e332e60275cd092fb50b05fff4feec0a2856a09f9fe6b2b
19.9s
=> => resolve docker.io/library/golang:1.18.10-bullseye@sha256:2cf761b45e5e3f150e332e60275cd092fb50b05fff4feec0a2856a09f9fe6b2b
0.0s
=> => sha256:2cf761b45e5e3f150e332e60275cd092fb50b05fff4feec0a2856a09f9fe6b2b 1.86kB / 1.86kB
0.0s
=> => sha256:740324e52de766f230ad7113fac9028399d6e03af34883de625dc2230ef7927e 1.80kB / 1.80kB
0.0s
=> => sha256:c37a56a6d65476eabfb50e74421f16f415093e2d1bdd7f83e8bbb4b1a3eb2109 7.12kB / 7.12kB
0.0s
```

```

=> => sha256:bbeef03cda1f5d6c9e20c310c1c91382a6b0a1a2501c3436b28152f13896f082 55.03MB / 55.03MB
6.7s
=> => sha256:f049f75f014ee8fec2d4728b203c9cbee0502ce142aec030f874aa28359e25f1 5.16MB / 5.16MB
0.7s
=> => sha256:56261d0e6b05ece42650b14830960db5b42a9f23479d868256f91d96869ac0c2 10.88MB / 10.88MB
1.0s
=> => sha256:9bd150679dbdb02d9d4df4457d54211d6ee719ca7bc77747a7be4cd99ae03988 54.58MB / 54.58MB
7.1s
=> => sha256:bfc6b68b5bd105d3f88a2c15354cff6c253bedc41d83c1da28b3d686c37cd9103 85.98MB / 85.98MB
8.1s
=> => extracting sha256:bbeef03cda1f5d6c9e20c310c1c91382a6b0a1a2501c3436b28152f13896f082
1.6s
=> => sha256:06d0c5d18ef41fa1c2382bd2afd189a01ebfff4910b868879b6dcfeef46bc003 141.98MB / 141.98MB
14.5s
=> => sha256:cc7973a07a5b4a44399c5d36fa142f37bb343bb123a3736357365fd9040ca38a 156B / 156B
7.2s
=> => extracting sha256:f049f75f014ee8fec2d4728b203c9cbee0502ce142aec030f874aa28359e25f1
0.2s
=> => extracting sha256:56261d0e6b05ece42650b14830960db5b42a9f23479d868256f91d96869ac0c2
0.2s
=> => extracting sha256:9bd150679dbdb02d9d4df4457d54211d6ee719ca7bc77747a7be4cd99ae03988
1.8s
=> => extracting sha256:bfc6b68b5bd105d3f88a2c15354cff6c253bedc41d83c1da28b3d686c37cd9103
2.3s
=> => extracting
sha256:06d0c5d18ef41fa1c2382bd2afd189a01ebfff4910b868879b6dcfeef46bc003
5.1s
=> => extracting sha256:cc7973a07a5b4a44399c5d36fa142f37bb343bb123a3736357365fd9040ca38a
0.0s
=> ERROR [2/3] RUN apt-get update      && apt-get -y install gcc cmake autoconf libtool pkg-config
libmnl-dev libyaml-dev apt-transport-https ca-certificates 1.5s
-----
> [2/3] RUN apt-get update      && apt-get -y install gcc cmake autoconf libtool pkg-config libmnl-
dev libyaml-dev apt-transport-https ca-certificates && curl -o-
https://raw.githubusercontent.com/nvm-sh/nvm/master/install.sh | bash      && bash -c 'source
 ~/.bashrc && nvm install --lts && npm install -g yarn'      && bash -c 'source ~/.bashrc && ln -s
$(which node) $(which yarn) /usr/bin/'
#5 0.436 Err:1 http://deb.debian.org/debian bullseye InRelease
#5 0.436 Could not connect to debian.map.fastlydns.net:80 (199.232.170.132). - connect (111:
Connection refused) Unable to connect to deb.debian.org:http:
#5 0.436 Err:2 http://deb.debian.org/debian-security bullseye-security InRelease
#5 0.436 Unable to connect to deb.debian.org:http:
#5 0.436 Err:3 http://deb.debian.org/debian bullseye-updates InRelease
#5 0.436 Unable to connect to deb.debian.org:http:
#5 0.438 Reading package lists...
#5 0.451 W: Failed to fetch http://deb.debian.org/debian/dists/bullseye/InRelease Could not connect
to debian.map.fastlydns.net:80 (199.232.170.132). - connect (111: Connection refused) Unable to
connect to deb.debian.org:http:
#5 0.451 W: Failed to fetch http://deb.debian.org/debian-security/dists/bullseye-security/InRelease
Unable to connect to deb.debian.org:http:
#5 0.451 W: Failed to fetch http://deb.debian.org/debian/dists/bullseye-updates/InRelease Unable to
connect to deb.debian.org:http:
#5 0.451 W: Some index files failed to download. They have been ignored, or old ones used instead.
#5 0.460 Reading package lists...
#5 0.469 Building dependency tree...
#5 0.470 Reading state information...
#5 0.472 Package autoconf is not available, but is referred to by another package.
#5 0.472 This may mean that the package is missing, has been obsoleted, or
#5 0.472 is only available from another source
#5 0.472
#5 0.472 Package libtool is not available, but is referred to by another package.
#5 0.472 This may mean that the package is missing, has been obsoleted, or
#5 0.472 is only available from another source
#5 0.472
#5 0.473 E: Unable to locate package cmake
#5 0.473 E: Package 'autoconf' has no installation candidate
#5 0.473 E: Package 'libtool' has no installation candidate
#5 0.473 E: Unable to locate package libmnl-dev
#5 0.473 E: Unable to locate package libyaml-dev
-----
process "/bin/sh -c apt-get update      && apt-get -y install gcc cmake autoconf libtool pkg-config
libmnl-dev libyaml-dev apt-transport-https ca-certificates && curl -o-
https://raw.githubusercontent.com/nvm-sh/nvm/master/install.sh | bash      && bash -c 'source
 ~/.bashrc && nvm install --lts && npm install -g yarn'      && bash -c 'source ~/.bashrc && ln -s
$(which node) $(which yarn) /usr/bin/'" did not complete successfully: exit code: 100
make: *** [Makefile:9 : base] Erreur 1

```

### 3.3. NF (autre que le NRF) enregistrement auprès du NRF

Ci-dessous le schéma extrait du 29.510 pour NFRegister

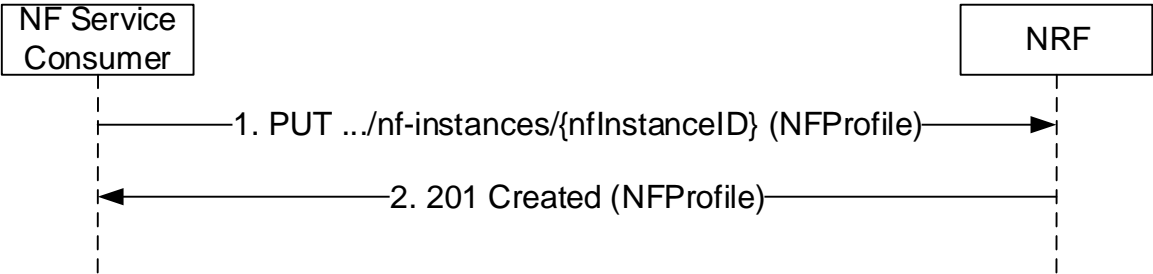


Figure 5.2.2.2-1: NF Instance Registration

Ci-dessous le schéma extrait du 29.510 pour NFRegister

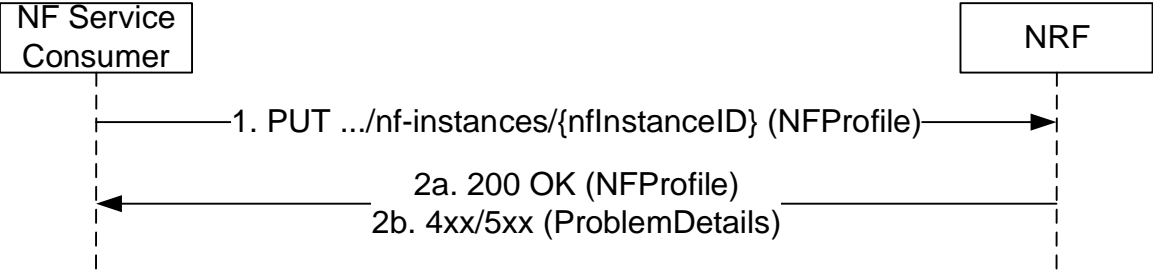


Figure 5.2.2.3.1-1: NF Profile Complete Replacement

## 4. Annex

Retrouvez les spécifications 3GPP respectives de chaque fonction (TS 29.5XX avec 5XX pour la fonction NRF : 510 par exemple, SMF : 502, UDM : 503, UDR : 504, PCF : 507...).

### ANNEX A: HTTP METHODS OVERVIEW (29.510)

**Table 6.1.3.1-1: Resources and methods overview**

Resource name	Resource URI	HTTP method or custom operation	Description
nf-instances (Store)	{apiRoot}/nnrf-nfm/v1/nf-instances	GET	Read a collection of NF Instances.
		OPTIONS	Discover the communication options supported by the NRF for this resource.
nf-instance (Document)	{apiRoot}/nnrf-nfm/v1/nf-instances/{nfInstanceId}	GET	Read the profile of a given NF Instance.
		PUT	Register in NRF a new NF Instance, or replace the profile of an existing NF Instance, by providing an NF profile.
		PATCH	Modify the NF profile of an existing NF Instance.
		DELETE	Deregister from NRF a given NF Instance.
subscriptions (Collection)	{apiRoot}/nnrf-nfm/v1/subscriptions	POST	Creates a new subscription in NRF to newly registered NF Instances.
subscription (Document)	{apiRoot}/nnrf-nfm/v1/subscriptions/{subscriptionID}	PATCH	Updates an existing subscription in NRF.
		DELETE	Deletes an existing subscription from NRF.
Notification Callback	{nfStatusNotificationUri}	POST	Notify about newly created NF Instances, or about changes of the profile of a given NF Instance.

### ANNEX B: RFC 4122

UUID version 4: "4947a69a-f61b-4bc1-b9da-47c9c5d14b64"

### ANNEX C: FREE5GC-COMPOSE PRIVNET

```
# docker inspect free5gc-compose_privnet
[
  {
    "Name": "free5gc-compose_privnet",
    "Id": "8c1dfe071020326fcb5f1f8290a425ca03c9da87c56663cb03d02936ad5ad6b8",
    "Created": "2023-12-10T13:18:40.72648054Z",
    "Scope": "local",
    "Driver": "bridge",
    "EnableIPv6": false,
    "IPAM": {
      "Driver": "default",
      "Options": null,
      "Config": [
        {
          "Subnet": "10.100.200.0/24"
        }
      ]
    },
    "Internal": false,
    "Attachable": true,
    "Ingress": false,
    "ConfigFrom": {
```

```
"Network": ""
},
"ConfigOnly": false,
"Containers": {
  "10dbfe99162ccedfd4fee80d2e96511c4830947f245a73d744aa8d7abbc1901f": {
    "Name": "ueransim",
    "EndpointID": "2c7fe4bdbbff9be30a6e26ebb0e6088a8768ea379689225499c1639834424af43",
    "MacAddress": "02:42:0a:64:c8:11",
    "IPv4Address": "10.100.200.17/24",
    "IPv6Address": ""
  },
  "153291f3d3db15e4eee80f18756c14d1945517819ef23ebb20bee12f2a585edc": {
    "Name": "n3iwf",
    "EndpointID": "25215fd7f26788f96743abdba71d216ac18397d96251d6b9d0492d20d5468f48",
    "MacAddress": "02:42:0a:64:c8:12",
    "IPv4Address": "10.100.200.18/24",
    "IPv6Address": ""
  },
  "292b61646f6f3ace7db455a72a5de31ac050d8de1ed61a651d48f239578b37b3": {
    "Name": "amf",
    "EndpointID": "0259aced509e960e33f17a57472240f0efc40bd482c3871654b2bd4d2c72af2b",
    "MacAddress": "02:42:0a:64:c8:0f",
    "IPv4Address": "10.100.200.15/24",
    "IPv6Address": ""
  },
  "2f769706c38363135611ece57572e1e97b772ab615b8ce5eb568e1e5b0f09ace": {
    "Name": "otip-mediataffic",
    "EndpointID": "26666d3fb17dfd8ee850840f2733170448b253c5a3a6dd8182e77640ac0df6b9",
    "MacAddress": "02:42:0a:64:c8:04",
    "IPv4Address": "10.100.200.4/24",
    "IPv6Address": ""
  },
  "364edd392325ae707f17fed6e056dff6f136a71dafa8d2a13c769ac1b22eb7e0": {
    "Name": "smf",
    "EndpointID": "9f2a38f25aea206bd8604fd19194158e1a3e3e807c5cb694943d8905f179fdc2",
    "MacAddress": "02:42:0a:64:c8:0a",
    "IPv4Address": "10.100.200.10/24",
    "IPv6Address": ""
  },
  "59a3c33019c7fa7c90e267dd77156117050c0899f8cd140519180716d3a66c49": {
    "Name": "pcf",
    "EndpointID": "d3dc9c8c0003b6a4b89cb8b61ad61c1a8ab79b64ee4f8c4d4b79d4d639e943df",
    "MacAddress": "02:42:0a:64:c8:0c",
    "IPv4Address": "10.100.200.12/24",
    "IPv6Address": ""
  },
  "5c9dda1287bb510fd5d2824d83677f0bd449cf17cc539ffcbf163e33dfaeca90": {
    "Name": "otip",
    "EndpointID": "a4a066f51f4a0e372136ef47cd890c1f05a05e46d1daa7217bce99cdeeb76ec8",
    "MacAddress": "02:42:0a:64:c8:02",
    "IPv4Address": "10.100.200.2/24",
    "IPv6Address": ""
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    "IPv4Address": "10.100.200.13/24",
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  "6081cb56fe4019fdd560552b461a8a34a688e3d446f41c2bacbd1ff207c7b963": {
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  "67280abad745c9b5f8b5512f373e94d1a2f082d4b30298af809d382db925f750": {
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  }
}
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      "IPv6Address": ""
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    "830691d6530e2ca39c6ee648416ed2605865d6da620a6b01918a6f7519a1382c": {
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      "IPv4Address": "10.100.200.9/24",
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    "a892447b646759e44806f579c08fa58e3cdf08179216b006438eb4c31b82a993": {
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      "IPv4Address": "10.100.200.11/24",
      "IPv6Address": ""
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      "EndpointID": "ca23e3b687c899cff2c359644ba3fe32c47e1f545afe44cf50bdb22e29df17e6",
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      "IPv4Address": "10.100.200.6/24",
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      "MacAddress": "02:42:0a:64:c8:07",
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      "IPv6Address": ""
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      "IPv6Address": ""
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  },
  "Labels": {
    "com.docker.compose.network": "privnet",
    "com.docker.compose.project": "free5gc-compose",
    "com.docker.compose.version": "1.29.2"
  }
}

```