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Toward Experimentation-as-a-Service in 5G/6G: The Plaza6G Prototype for AI-Assisted Trials

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We use this protocol and it's working

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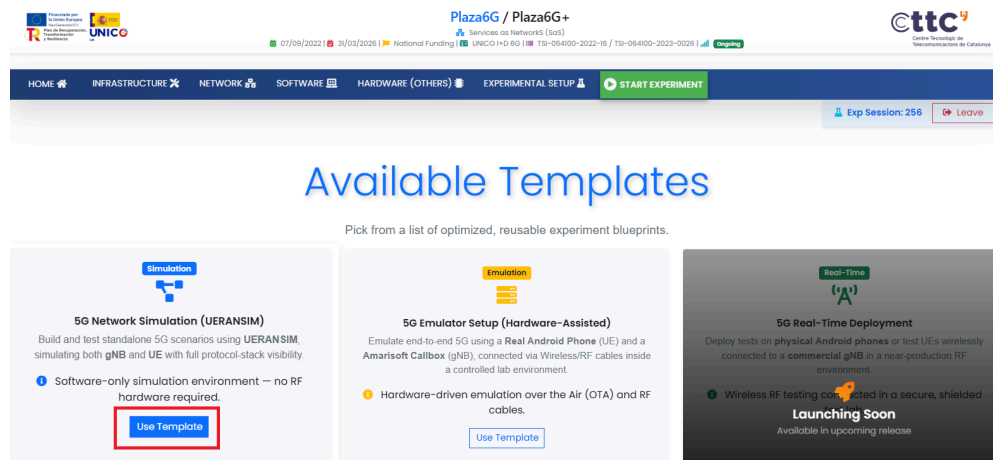
Abstract

This protocol outlines a reproducible experiment that was evaluated using the Plaza6G testbed framework. The experiment involves comparing the performance of three simulated open-source 5G core networks: Open5GS, Free5GC, and OpenAirInterface. These networks are deployed as virtualised network templates through Plaza6G's Experimentation-as-a-Service platform. Each simulated template is configured with the virtual machines (VMs) required to support a basic 5G core network, including a Core VM, a gNB VM and a User Equipment (UE) VM. The experiment uses the open-source tool iPerf3 to measure throughput under TCP and UDP conditions, considering uplink and downlink communications. Apart from the minimum number of VMs, a Data Network Node (DNN) VM has been provided to act as the iPerf3 server while the UE is the iPerf3 client. The procedure outlines every step, from selecting templates and launching virtual environments, to retrieving assigned 5G IP addresses and executing iPerf3 commands for different configurations. This experimental workflow enables the comparative analysis of virtualised 5G systems, supports automated network experimentation, CI/CD integration, and reproducible performance evaluation laying the groundwork for 6G-oriented research and open wireless testbed federation.

Select the 5G Core template (flavor)

- 1 First of all, in Plaza6G official web site you need to select one of our 5G templates including: Open5GS (<https://open5gs.org/open5gs/docs/guide/01-quickstart>), Free5GC (<https://free5gc.org/guide/#free5gc-installation-guide>) and OpenAirInterface (https://gitlab.eurecom.fr/oai/cn5g/oai-cn5g-fed/-/blob/master/docs/DEPLOY_SA5G_BASIC_DEPLOYMENT.md).

Note: Our simulated templates include the default configuration for each project.



Select 5G simulated templates

Topology & Networking

- VMs connected over an internal bridge network (e.g. `br-sim`)
- UERANSIM connects via NGAP & GTP-U to the 5GC
- Predefined static IPs and hostnames included

i This is a fully virtualized testbed with no RF or physical components required.

Add Data Network (DN) VM?

Yes

1. Add DNN VM

Select 5G Core

-- Select Core -- **2. Select the flavor**

-- Select Core --

Open5GS

Free5GC

OpenAirInterface(OAI)

UERANSIM

3. Launch template

Launch Template

Close

Set up the 5G template

Open terminal access for both UE and DNN machines

- Once the 5G environment has been successfully set, you can access to the UE and DNN machines

The screenshot shows the protocols.io interface. On the left, a sidebar contains 'Blogs', 'Contact', 'Setup Experiment', 'My Experiments' (highlighted with a red box), 'Access via SSH', and 'Open Terminal'. The main area displays 'Vm Snapshots' with a table of VMs. The table has columns for VM Name, OS, IP Address, Username, Password, Hostname, SSH Port, RDP Port, Status, and Actions. The 'DNN-242' VM is highlighted with a red box, and its 'Access' button is also highlighted with a red box.

VM Name	OS	IP Address	Username	Password	Hostname	SSH Port	RDP Port	Status	Actions
O5G-Core-242	OS: Ubuntu 22.04	IP Address: 192.168.140.6	Username: ubuntu	Password: ubuntu	Hostname: 10.114.111	SSH Port: 47381	RDP Port: None	Active	Access, Results
UERAN-UE-242	OS: Ubuntu 22.04	IP Address: 192.168.140.2	Username: ubuntu	Password: ubuntu	Hostname: 10.114.111	SSH Port: 41411	RDP Port: None	Active	Access, Results
UERAN-gNB-242	OS: Ubuntu 22.04	IP Address: 192.168.140.4	Username: ubuntu	Password: ubuntu	Hostname: 10.114.111	SSH Port: 47269	RDP Port: None	Active	Access, Results
DNN-242	OS: Ubuntu 22.04	IP Address: 192.168.140.5	Username: ubuntu	Password: ubuntu	Hostname: 10.114.111	SSH Port: 41324	RDP Port: 46043	Active	Access, Results

Open the terminal in UE and DNN VMs.

Start iperf tests



- 3 The iperf test uses the linux package "iperf3". An iperf test allows you to determine the bandwidth (Mbps/Gbps), latency (ms), jitter (for UDP tests), Percentage of packet loss (for UDP tests), among others. The DNN will be the iperf server, while UE will be the iperf client.

Configuration set up:

	A	B	C	D	E
	Open5G Project	UE_5G_IP_address	DNN_IP_address	Window Time (s)	Max Theoretical Bandwidth (Mbps)
	Oepn5GS	10.45.0.2	192.168.140.5	120	400
	Free5GC	10.70.0.1	192.168.141.4	120	250
	OAI	12.1.1.100	192.168.142.3	120	300

The experiment has been repeated for the 3 5G projects.

- 3.1 Download iperf3 in both machines:

Command

Installs iperf3 in ubuntu OS (Ubuntu 22.04)

Install iperf3

```
sudo apt update
sudo apt install iperf3 -y
```

- 3.2 Set up the iperf server (DNN):

**Command**

Launches iperf3 in server mode with default port

Iperf3 server

```
iperf3 -s
```

3.3 Verify the 5G ip address in UE

Command

Retrieves the IP address assigned by the 5G core (SMF) to the UE. (Ubuntu 22.04)

5G IP address

```
ip -4 addr show uesimtun0 | awk /inet / {print $2} | cut -d/ -f1
```

3.4 Launch the iperf in client (UE) mode attached to the 5G interfaz

Command

Launches iperf client: TCP, UpLink, directed to DNN server, attached to the 5G IP address. (Ubuntu 22.04)

Launch iperf client TCP UL

```
iperf3 -c <DNN_IP_address> -B <UE_5G_IP_address> -t <window_time>
```

Command

Launches iperf client: TCP, DownLink, directed to DNN server, attached to the 5G IP address. (Ubuntu 22.04)

Launch iperf client TCP DL

```
iperf3 -c <DNN_IP_address> -B <UE_5G_IP_address> -t <window_time> -R
```

Command

Launches iperf client: UDP, UpLink, directed to DNN server, attached to the 5G IP address. (Ubuntu 22.04)

Launch iperf client UDP UL

```
iperf3 -c <DNN_IP_address> -B <UE_5G_IP_address> -u -t <window_time> -b <Max_theoretical_bandwidth>Mbps
```

Command

Launches iperf client: UDP, DownLink, directed to DNN server, attached to the 5G IP address. (Ubuntu 22.04)

Launch iperf client UDP DL

```
iperf3 -c <DNN_IP_address> -B <UE_5G_IP_address> -t <window_time> -b <Max_theoretical_bandwidth>Mbps -R
```

Example of expected outputs

4 This section briefly depicts the expected outputs for iperf tests using a 10 s. window.

4.1 Examples:



> Terminal for: UERAN-UE-242

```
ubuntu@open5gs-ue:~$ iperf3 -c 192.168.140.5 -B 10.45.0.2 -t 10
Connecting to host 192.168.140.5, port 5201
[ 5] local 10.45.0.2 port 50125 connected to 192.168.140.5 port 5201
[ ID] Interval           Transfer     Bitrate      Retr  Cwnd
[ 5]  0.00-1.00        sec   22.9 MBytes  192 Mbits/sec  123   92.1 KBytes
[ 5]  1.00-2.00        sec   30.3 MBytes  254 Mbits/sec   55   88.2 KBytes
[ 5]  2.00-3.00        sec   23.7 MBytes  199 Mbits/sec   74   115 KBytes
[ 5]  3.00-4.00        sec   26.2 MBytes  220 Mbits/sec   61   93.5 KBytes
[ 5]  4.00-5.00        sec   30.0 MBytes  252 Mbits/sec   23   77.7 KBytes
[ 5]  5.00-6.00        sec   32.5 MBytes  273 Mbits/sec  109   113 KBytes
[ 5]  6.00-7.00        sec   30.0 MBytes  252 Mbits/sec  101   96.1 KBytes
[ 5]  7.00-8.00        sec   23.8 MBytes  199 Mbits/sec   41   85.6 KBytes
[ 5]  8.00-9.00        sec   25.0 MBytes  210 Mbits/sec   35   111 KBytes
[ 5]  9.00-10.00       sec   25.0 MBytes  210 Mbits/sec   58   94.8 KBytes
-----
[ ID] Interval           Transfer     Bitrate      Retr
[ 5]  0.00-10.00       sec   269 MBytes  226 Mbits/sec  680
[ 5]  0.00-10.04       sec   266 MBytes  222 Mbits/sec
                                     sender
                                     receiver

iperf Done.
```

Open5GS, TCP, Up Link, 10 seconds, client.

> Terminal for: DNN-242

```
ubuntu@DNN-242:~$ iperf3 -s
-----
Server listening on 5201
-----
Accepted connection from 192.168.140.6, port 54289
[ 5] local 192.168.140.5 port 5201 connected to 192.168.140.6 port 50125
[ ID] Interval           Transfer     Bitrate
[ 5]  0.00-1.00        sec   19.4 MBytes  163 Mbits/sec
[ 5]  1.00-2.00        sec   29.3 MBytes  246 Mbits/sec
[ 5]  2.00-3.00        sec   24.4 MBytes  205 Mbits/sec
[ 5]  3.00-4.00        sec   26.1 MBytes  219 Mbits/sec
[ 5]  4.00-5.00        sec   29.8 MBytes  250 Mbits/sec
[ 5]  5.00-6.00        sec   32.2 MBytes  270 Mbits/sec
[ 5]  6.00-7.00        sec   30.0 MBytes  251 Mbits/sec
[ 5]  7.00-8.00        sec   23.7 MBytes  199 Mbits/sec
[ 5]  8.00-9.00        sec   24.8 MBytes  208 Mbits/sec
[ 5]  9.00-10.00       sec   25.0 MBytes  209 Mbits/sec
[ 5] 10.00-10.04       sec    1.36 MBytes  283 Mbits/sec
-----
[ ID] Interval           Transfer     Bitrate
[ 5]  0.00-10.04       sec   266 MBytes  222 Mbits/sec
                                     receiver
-----
Server listening on 5201
-----
```

Open5GS, TCP, Up Link, 10 seconds, server.



> Terminal for: UERAN-UE-242

```
ubuntu@open5gs-ue:~$ iperf3 -c 192.168.140.5 -B 10.45.0.2 -t 10 -R
Connecting to host 192.168.140.5, port 5201
Reverse mode, remote host 192.168.140.5 is sending
[ 5] local 10.45.0.2 port 59873 connected to 192.168.140.5 port 5201
[ ID] Interval           Transfer             Bitrate
[ 5]  0.00-1.00      sec   29.1 MBytes       244 Mbits/sec
[ 5]  1.00-2.00      sec   24.0 MBytes       201 Mbits/sec
[ 5]  2.00-3.00      sec   29.7 MBytes       249 Mbits/sec
[ 5]  3.00-4.00      sec   31.3 MBytes       263 Mbits/sec
[ 5]  4.00-5.00      sec   26.8 MBytes       225 Mbits/sec
[ 5]  5.00-6.00      sec   27.3 MBytes       229 Mbits/sec
[ 5]  6.00-7.00      sec   35.0 MBytes       293 Mbits/sec
[ 5]  7.00-8.00      sec   29.5 MBytes       248 Mbits/sec
[ 5]  8.00-9.00      sec   25.6 MBytes       215 Mbits/sec
[ 5]  9.00-10.00     sec   34.2 MBytes       287 Mbits/sec
-----
[ ID] Interval           Transfer             Bitrate      Retr      sender
[ 5]  0.00-10.04      sec   293 MBytes       245 Mbits/sec  661
[ 5]  0.00-10.00      sec   293 MBytes       245 Mbits/sec                receiver

iperf Done.
```

Open5GS, TCP, Down Link, 10 seconds, client.

> Terminal for: DNN-242

```
ubuntu@DNN-242:~$ iperf3 -s
-----
Server listening on 5201
-----
Accepted connection from 192.168.140.6, port 53791
[ 5] local 192.168.140.5 port 5201 connected to 192.168.140.6 port 59873
[ ID] Interval           Transfer             Bitrate      Retr  Cwnd
[ 5]  0.00-1.00      sec   28.7 MBytes       241 Mbits/sec    67   109 KBytes
[ 5]  1.00-2.00      sec   24.1 MBytes       202 Mbits/sec    90   92.1 KBytes
[ 5]  2.00-3.00      sec   28.7 MBytes       241 Mbits/sec    34   143 KBytes
[ 5]  3.00-4.00      sec   32.3 MBytes       271 Mbits/sec   123   77.7 KBytes
[ 5]  4.00-5.00      sec   26.7 MBytes       224 Mbits/sec    44   105 KBytes
[ 5]  5.00-6.00      sec   26.7 MBytes       224 Mbits/sec    46   112 KBytes
[ 5]  6.00-7.00      sec   35.1 MBytes       295 Mbits/sec    85   103 KBytes
[ 5]  7.00-8.00      sec   29.7 MBytes       249 Mbits/sec    49   111 KBytes
[ 5]  8.00-9.00      sec   25.9 MBytes       217 Mbits/sec    19   104 KBytes
[ 5]  9.00-10.00     sec   33.8 MBytes       283 Mbits/sec   103   116 KBytes
[ 5] 10.00-10.04      sec    1.30 MBytes       277 Mbits/sec     1   81.6 KBytes
-----
[ ID] Interval           Transfer             Bitrate      Retr      sender
[ 5]  0.00-10.04      sec   293 MBytes       245 Mbits/sec  661
```

Open5GS, TCP, Down Link, 10 seconds, server.



> Terminal for: UERAN-UE-242

```
ubuntu@open5gs-ue:~$ iperf3 -c 192.168.140.5 -B 10.45.0.2 -t 10 -u -b 400Mbps
Connecting to host 192.168.140.5, port 5201
[ 5] local 10.45.0.2 port 52162 connected to 192.168.140.5 port 5201
[ ID] Interval      Transfer    Bitrate      Total Datagrams
[ 5] 0.00-1.00    sec  47.7 MBytes  400 Mbits/sec  37068
[ 5] 1.00-2.00    sec  47.7 MBytes  400 Mbits/sec  37097
[ 5] 2.00-3.00    sec  47.7 MBytes  400 Mbits/sec  37087
[ 5] 3.00-4.00    sec  47.7 MBytes  400 Mbits/sec  37088
[ 5] 4.00-5.00    sec  47.7 MBytes  400 Mbits/sec  37095
[ 5] 5.00-6.00    sec  47.7 MBytes  400 Mbits/sec  37093
[ 5] 6.00-7.00    sec  47.7 MBytes  400 Mbits/sec  37088
[ 5] 7.00-8.00    sec  47.7 MBytes  400 Mbits/sec  37097
[ 5] 8.00-9.00    sec  47.7 MBytes  400 Mbits/sec  37094
[ 5] 9.00-10.00   sec  47.7 MBytes  400 Mbits/sec  37092
-----
[ ID] Interval      Transfer    Bitrate      Jitter    Lost/Total Datagrams
[ 5] 0.00-10.00   sec  477 MBytes  400 Mbits/sec  0.000 ms  0/370899 (0%) sender
[ 5] 0.00-10.04   sec  435 MBytes  364 Mbits/sec  0.025 ms  32140/370899 (8.7%) receiver
iperf Done.
```

Open5GS, UDP, Up Link, 10 seconds, client.

> Terminal for: DNN-242

```
ubuntu@DNN-242:~$ iperf3 -s
Server listening on 5201
-----
Accepted connection from 192.168.140.6, port 43009
[ 5] local 192.168.140.5 port 5201 connected to 192.168.140.6 port 52162
[ ID] Interval      Transfer    Bitrate      Jitter    Lost/Total Datagrams
[ 5] 0.00-1.00    sec  41.3 MBytes  347 Mbits/sec  0.048 ms  3289/35448 (9.3%)
[ 5] 1.00-2.00    sec  44.4 MBytes  372 Mbits/sec  0.075 ms  1905/36427 (5.2%)
[ 5] 2.00-3.00    sec  40.3 MBytes  338 Mbits/sec  0.026 ms  6500/37814 (17%)
[ 5] 3.00-4.00    sec  41.4 MBytes  347 Mbits/sec  0.017 ms  4893/37063 (13%)
[ 5] 4.00-5.00    sec  40.9 MBytes  343 Mbits/sec  0.014 ms  5232/37083 (14%)
[ 5] 5.00-6.00    sec  43.2 MBytes  362 Mbits/sec  0.040 ms  3538/37117 (9.5%)
[ 5] 6.00-7.00    sec  46.2 MBytes  388 Mbits/sec  0.018 ms  1162/37107 (3.1%)
[ 5] 7.00-8.00    sec  44.2 MBytes  370 Mbits/sec  0.006 ms  2709/37060 (7.3%)
[ 5] 8.00-9.00    sec  45.3 MBytes  380 Mbits/sec  0.015 ms  1831/37079 (4.9%)
[ 5] 9.00-10.00   sec  46.7 MBytes  392 Mbits/sec  0.059 ms  759/37096 (2%)
[ 5] 10.00-10.04  sec  1.65 MBytes  322 Mbits/sec  0.025 ms  322/1605 (20%)
-----
[ ID] Interval      Transfer    Bitrate      Jitter    Lost/Total Datagrams
[SUM] 0.0-10.0 sec  1650 datagrams received out-of-order
[ 5] 0.00-10.04   sec  435 MBytes  364 Mbits/sec  0.025 ms  32140/370899 (8.7%) receiver
```

Open5GS, UDP, Up Link, 10 seconds, server.

➤ Terminal for: UERAN-UE-242

```
ubuntu@open5gs-ue:~$ iperf3 -c 192.168.140.5 -B 10.45.0.2 -t 10 -u -b 400Mbps -R
Connecting to host 192.168.140.5, port 5201
Reverse mode, remote host 192.168.140.5 is sending
[ 5] local 10.45.0.2 port 48356 connected to 192.168.140.5 port 5201
[ ID] Interval            Transfer        Bitrate        Jitter    Lost/Total Datagrams
[ 5] 0.00-1.00 sec      45.7 MBytes    383 Mbits/sec   0.053 ms  19541/55070 (35%)
[ 5] 1.00-2.00 sec      42.5 MBytes    357 Mbits/sec   0.020 ms  3958/37028 (11%)
[ 5] 2.00-3.00 sec      45.6 MBytes    383 Mbits/sec   0.019 ms  1702/37187 (4.6%)
[ 5] 3.00-4.00 sec      44.0 MBytes    369 Mbits/sec   0.022 ms  2910/37098 (7.8%)
[ 5] 4.00-5.00 sec      43.9 MBytes    368 Mbits/sec   0.058 ms  2600/36762 (7.1%)
[ 5] 5.00-6.00 sec      43.8 MBytes    367 Mbits/sec   0.036 ms  3378/37424 (9%)
[ 5] 6.00-7.00 sec      41.6 MBytes    349 Mbits/sec   0.022 ms  4739/37114 (13%)
[ 5] 7.00-8.00 sec      43.5 MBytes    365 Mbits/sec   0.042 ms  3189/37002 (8.6%)
[ 5] 8.00-9.00 sec      45.0 MBytes    378 Mbits/sec   0.034 ms  2123/37162 (5.7%)
[ 5] 9.00-10.00 sec     44.9 MBytes    377 Mbits/sec   0.032 ms  2100/37043 (5.7%)
-- -- -- -- --
[ ID] Interval            Transfer        Bitrate        Jitter    Lost/Total Datagrams
[ 5] 0.00-10.49 sec      500 MBytes     400 Mbits/sec   0.000 ms  0/389036 (0%) sender
[SUM] 0.0-10.5 sec     195 datagrams received out-of-order
[ 5] 0.00-10.00 sec      440 MBytes     370 Mbits/sec   0.032 ms  46240/388890 (12%) receiver
iperf Done.
```

Open5GS, UDP, Down Link, 10 seconds, client.

➤ Terminal for: DNN-242

```
ubuntu@DNN-242:~$ iperf3 -s
-----
Server listening on 5201
-----
Accepted connection from 192.168.140.6, port 53703
[ 5] local 192.168.140.5 port 5201 connected to 192.168.140.6 port 48356
[ ID] Interval            Transfer        Bitrate        Total Datagrams
[ 5] 0.00-1.00 sec      47.6 MBytes     400 Mbits/sec   37061
[ 5] 1.00-2.00 sec      47.7 MBytes     400 Mbits/sec   37106
[ 5] 2.00-3.00 sec      47.7 MBytes     400 Mbits/sec   37095
[ 5] 3.00-4.00 sec      47.7 MBytes     400 Mbits/sec   37106
[ 5] 4.00-5.00 sec      47.7 MBytes     400 Mbits/sec   37091
[ 5] 5.00-6.00 sec      47.7 MBytes     400 Mbits/sec   37070
[ 5] 6.00-7.00 sec      47.7 MBytes     400 Mbits/sec   37103
[ 5] 7.00-8.00 sec      47.7 MBytes     400 Mbits/sec   37092
[ 5] 8.00-9.00 sec      47.7 MBytes     400 Mbits/sec   37079
[ 5] 9.00-10.00 sec     47.7 MBytes     400 Mbits/sec   37089
[ 5] 10.00-10.49 sec    23.3 MBytes     400 Mbits/sec   18144
-- -- -- -- --
[ ID] Interval            Transfer        Bitrate        Jitter    Lost/Total Datagrams
[ 5] 0.00-10.49 sec      500 MBytes     400 Mbits/sec   0.000 ms  0/389036 (0%) sender
```

Open5GS, UDP, Down Link, 10 seconds, server.

Protocol references

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