[Smart5Grid]

Smart5Grid Open Experimentation Platform, NetApp concept & particularities in Smart5Grid, NetApp controller, Pilots progress

5G-PPP WG Trials
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Smart5Grid

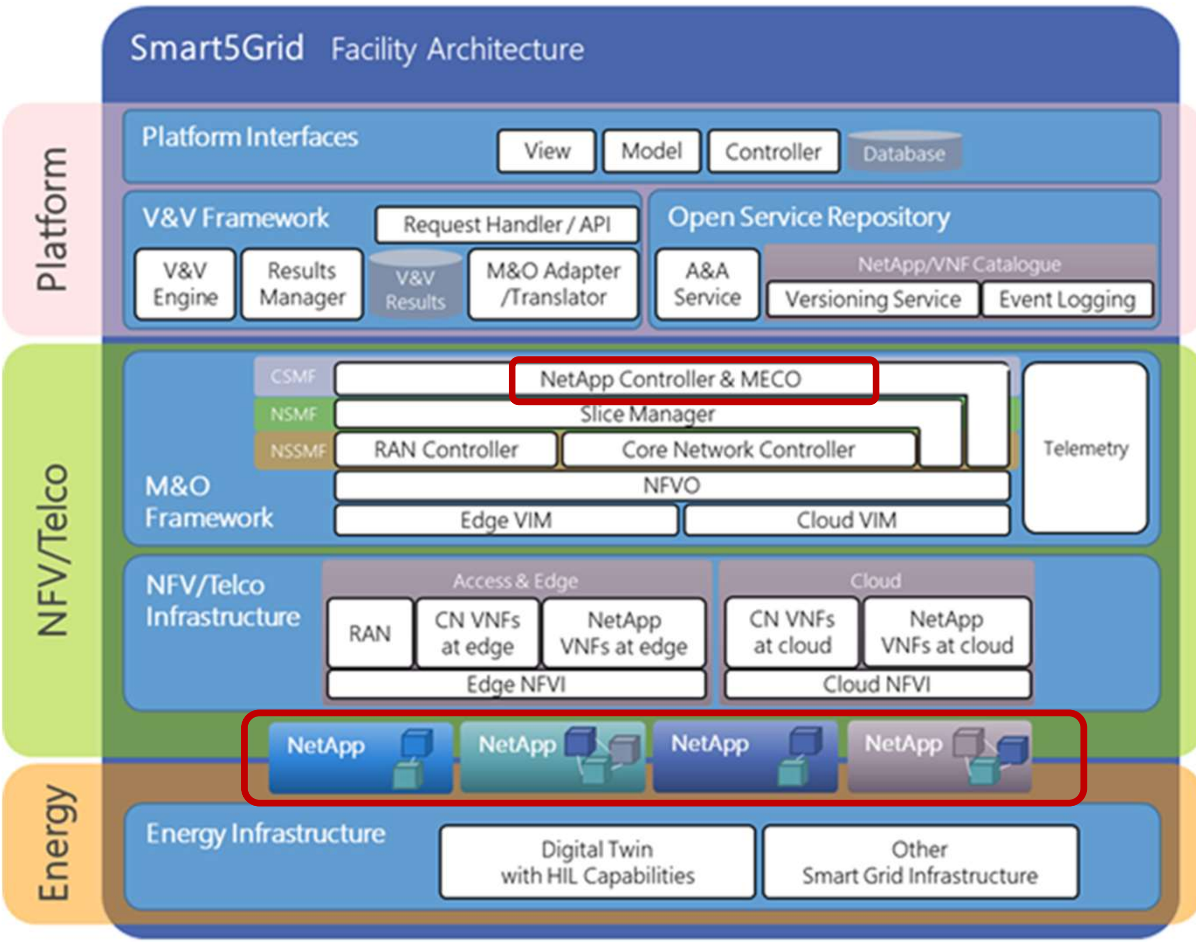
Demonstration of **5G** solutions for **SMART** energy **GRID**s of the future

Outline

- Smart5Grid Platform overview
- NetApp concept in the Smart5Grid project
- Role of the NetApp controller
- Preliminary results from connectivity tests (UC4)

Smart5Grid Open Experimentation Platform

Architecture



Scope:
Offer an open-source platform where NetApp developers and 3rd parties could:

- Create, verify and validate NetApps (internal or from 3rd parties)
- Experiment with the NetApps in a controlled testing environment (OSR and V&V)
- Control the placement between edge and cloud via a NetApp controller and MECO & execute life-cycle management:
  - Deployment, placement, monitoring, re-deployment, and deletion

Smart5Grid NetApps

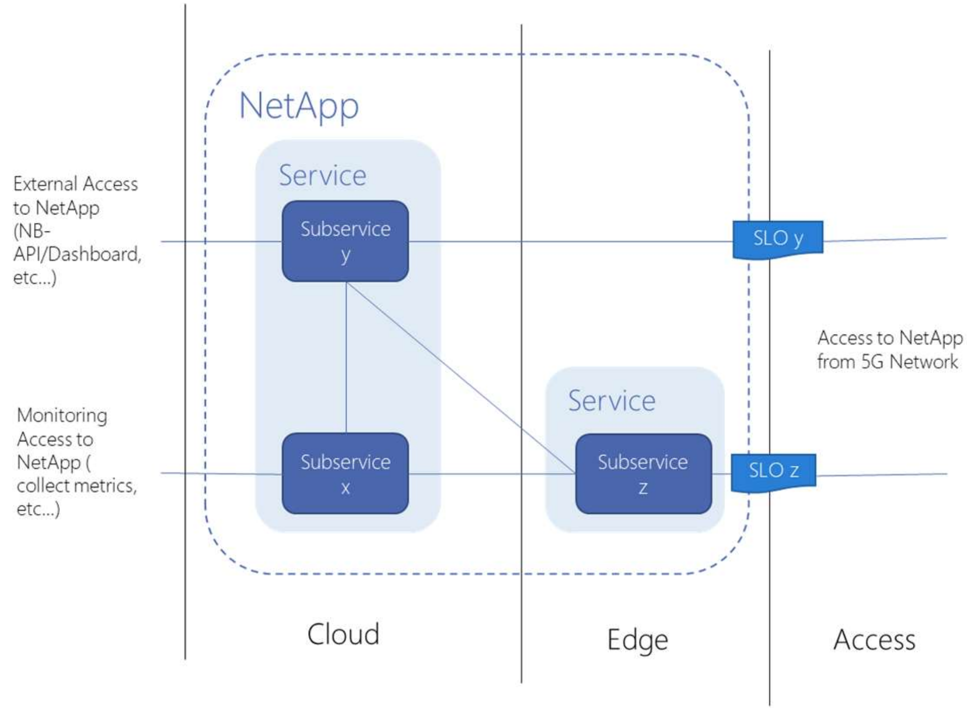
Concept Definition

- Provide a solution for developers to create vertical applications
- While abstracting the complexities of the network.
- Reducing the level of networking expertise required

Composed of a *chain of Network Services (NS) / Helm-charts*, which may be also composed of subservices (Virtual Network Function (VNF) / Docker image)

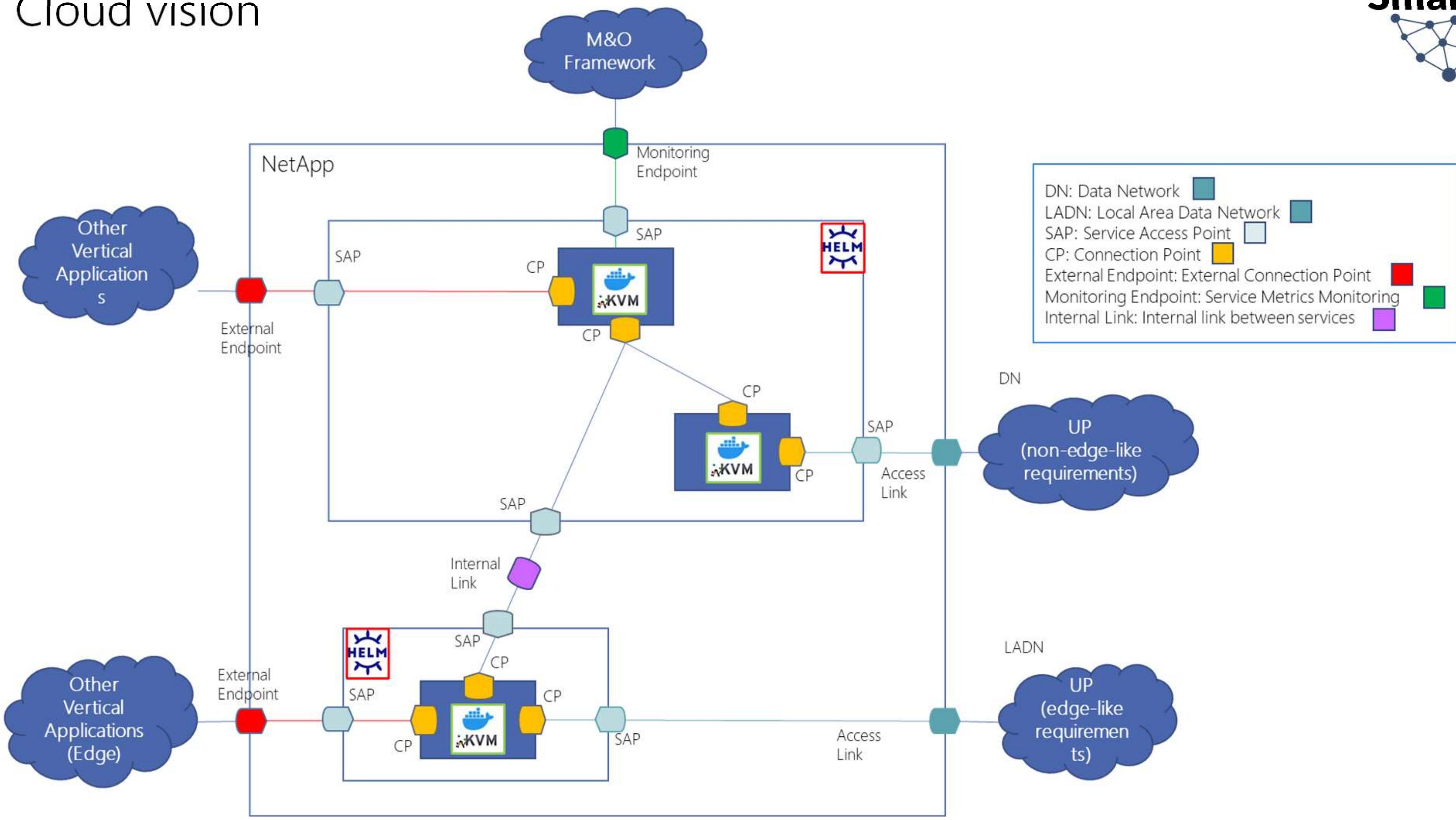
Able to leverage 5G and edge infrastructure by formally specifying its deployment and performance requirements in its so-called NetApp descriptor.

By splitting the functionality of the NetApp into decoupled VNFs, the reutilization of software functions is encouraged, but also, whenever possible from an implementation point of view, the opportunity to take advantage of the cloud/edge infrastructure depending on the application needs.



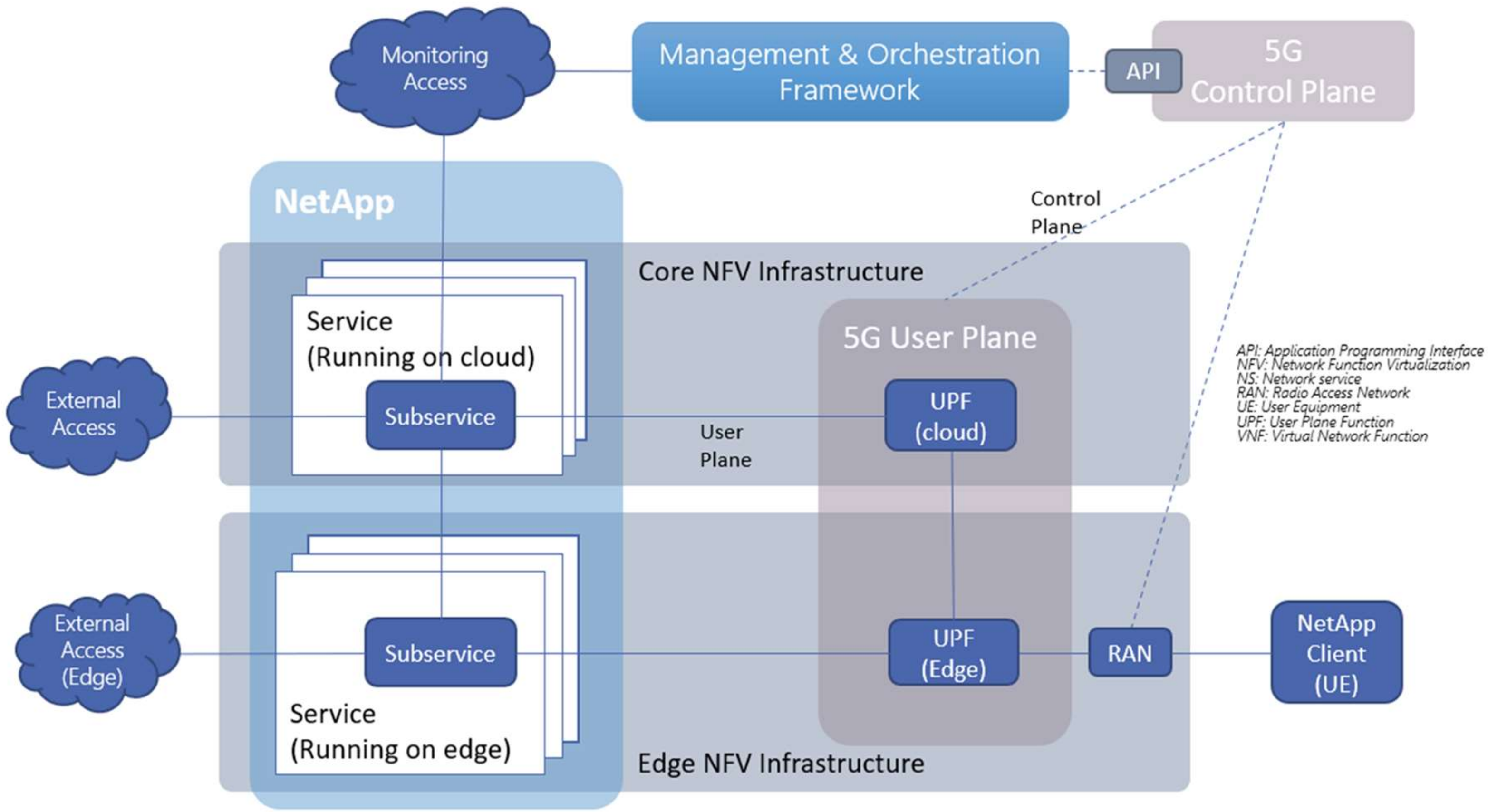
Smart5Grid NetApps

Extended- Cloud vision



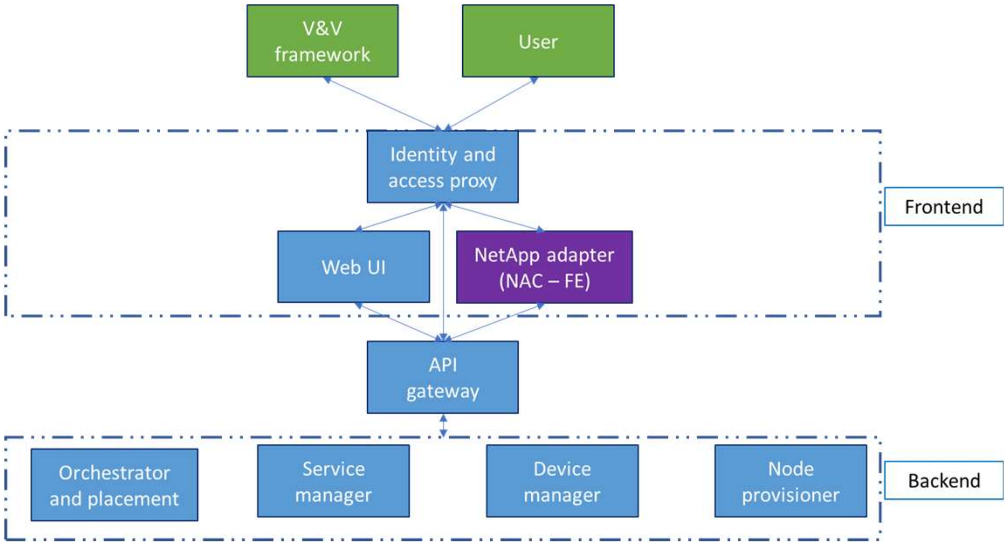
Smart5Grid NetApps

Integration with 5G Network



Smart5Grid NAC & MECO

NearbyOne as NAC and MECO Vs NAC telco-oriented (UC2)

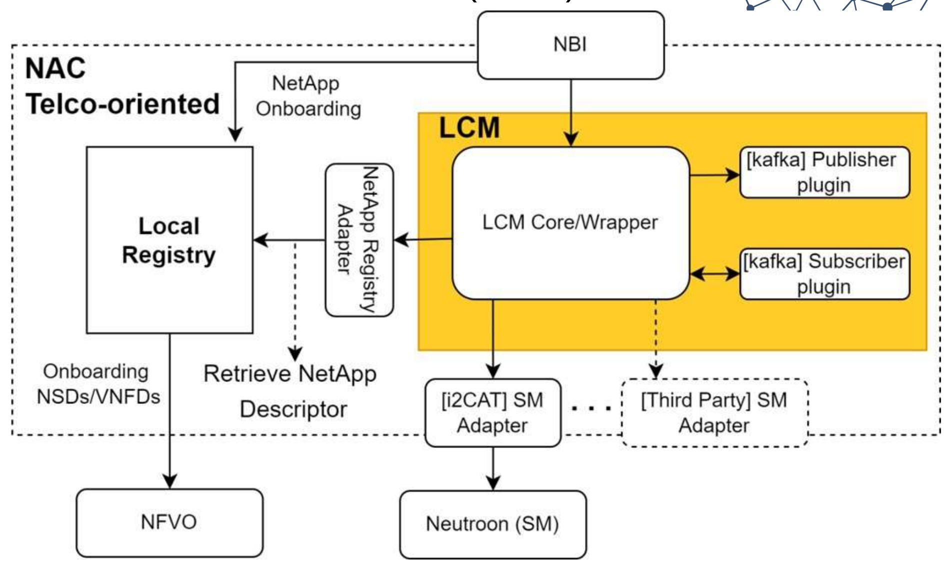


Cloud oriented: based on Helm Charts – the de-facto standard packaging system for Kubernetes.

Commercial product: also used by other Telcos and 5G Core providers.

Multi-cloud and multi-organization: one unique instance for the edge infrastructure used in UC1 (Italy) and in UC3 & UC4 (Bulgaria)

Extended for Smart5Grid NetApps: on-board and manage their life cycle ([un]deploy, scale, migrate)



- NAC is completely abstracted from the network infrastructure and only interacts with the management components in charge of performing configuration operations over the infrastructure layer
- NAC is aligned with the slice management model defined by 3GPP, NAC on the Smart5Grid platform acts as a Communication Service Management Function (CSMF).
- In NAC's Southbound Interface (SBI), it interacts with Slice Manager which act as Network Slice Management Function (NSMF).

Greek-Bulgarian Pilot (UC4): Real-time Wide Area Monitoring

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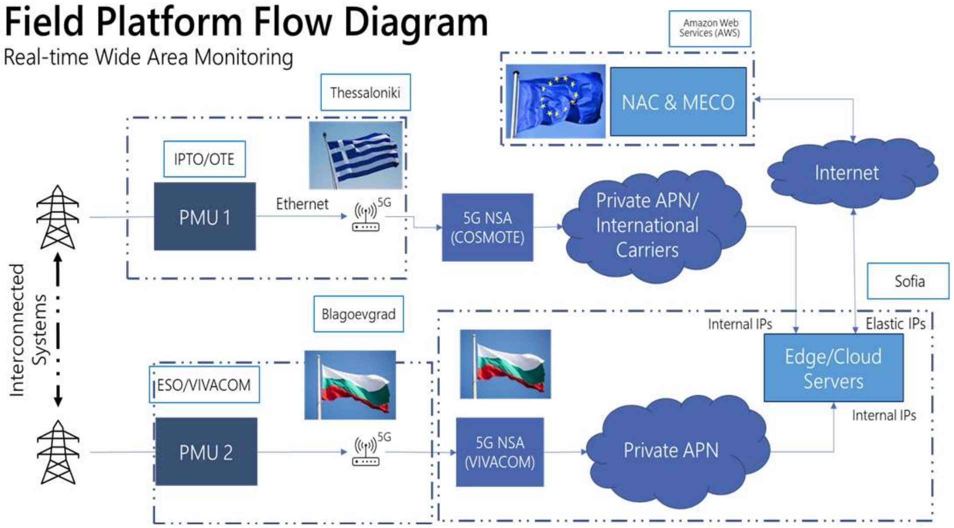
Field Platform Flow Diagram

Real-time Wide Area Monitoring



5G Network tests

- Connectivity test and initial KPIs tests via the 5G gateway to the edge-cloud server using public 5G NSA internet of COSMOTE and VivaCom using as UEs firstly PCs and then PMUs
- UDP data exchange using IPERF and both private and public APN 5G NSA via the 5G gateway via the 5G gateway to the edge-cloud server

PMU Tests

- Connectivity and validity tests using a PC with an opensource PDC
- Connectivity and validity tests via 5G gateway using a PC with an opensource PDC
- Validity tests with the manufacturer of the PMUs

Lessons Learned

Difficulties

- Coverage issues
- Security constrains
- Integration of 5G gateways with the PMUs
- Different security rules for each SIM card and location used

Solution adopted

- Use of different substation in another location
- Use of PMUs not connected to the TSOs' communication network
- Market research and specifications formation + more effort at the field
- Selection of certain locations for the testing

First Readings – Test Trial Scenario

Greek Side

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```
root@ipto:/usr/bin# iperf3 -s -V -p 3000
iperf 3.0.11
Linux [redacted]generic #145-Ubuntu SMP Fri Apr 13 13:47:23 UTC 2018 x86_64 x86_64 x86_64 GNU/Linux
-----------------------------------------------------------
Server listening on 3000
-----------------------------------------------------------
Time: Fri, 03 Jun 2022 12:23:08 GMT
Accepted connection from [redacted]
      Cookie: [redacted]
[  5] local [redacted] connected to [redacted]
Starting Test: protocol: UDP, 1 streams, 8192 byte blocks, omitting 0 seconds, 10 second test
[ ID] Interval           Transfer     Bandwidth       Jitter    Lost/Total Datagrams
[  5]   0.00-1.00   sec   104 KBytes   852 Kbits/sec  53.205 ms  0/13 (0%)
[  5]   1.00-2.00   sec   136 KBytes  1.11 Mbits/sec  22.405 ms  0/17 (0%)
[  5]   2.00-3.00   sec   120 KBytes   983 Kbits/sec  12.919 ms  0/15 (0%)
[  5]   3.00-4.00   sec   128 KBytes  1.05 Mbits/sec  12.739 ms  0/16 (0%)
[  5]   4.00-5.00   sec   136 KBytes  1.11 Mbits/sec  11.972 ms  0/17 (0%)
[  5]   5.00-6.00   sec   120 KBytes   983 Kbits/sec  12.436 ms  0/15 (0%)
[  5]   6.00-7.00   sec   128 KBytes  1.05 Mbits/sec  20.140 ms  0/16 (0%)
[  5]   7.00-8.00   sec   128 KBytes  1.05 Mbits/sec  20.887 ms  0/16 (0%)
[  5]   8.00-9.00   sec   128 KBytes  1.05 Mbits/sec  17.782 ms  0/16 (0%)
[  5]   9.00-10.00  sec   128 KBytes  1.05 Mbits/sec  14.148 ms  0/16 (0%)
[  5]  10.00-10.14  sec  16.0 KBytes   949 Kbits/sec  13.590 ms  0/2 (0%)
- - - - - - - - - - - - - - - - - - - - - - - - -
Test Complete. Summary Results:
[ ID] Interval           Transfer     Bandwidth       Jitter    Lost/Total Datagrams
[  5]   0.00-10.14  sec  1.25 MBytes  1.03 Mbits/sec  13.590 ms  0/159 (0%)
CPU Utilization: local/receiver 0.1% (0.1%u/0.0%s), remote/sender 0.9% (0.6%u/0.3%s)
```

Features

- *IPTO has managed to establish a first call from its Headquarters in Athens -> VIVACOM's EDGE/CLOUD server via COSMOTE's 5G NSA network*
- *PMU was not connected to the 5G Gateway Router*
- *Public Internet was used*
- *Latency criterion (40 msecs) was successfully passed although Data travelled from Athens IPTO site which is 500km away from the actual Thessaloniki site*

First Readings

Bulgarian Side

```
Time: Thu, 15 Sep 2022 05:04:19 GMT
Accepted connection from [redacted]
      Cookie: [redacted]
[  5] local [redacted] connected to [redacted]
Starting Test: protocol: UDP, 1 streams, 8192 byte blocks, omitting 0 seconds, 20 second test
[ ID] Interval          Transfer     Bandwidth       Jitter    Lost/Total Datagrams
[  5]   0.00-1.00   sec   120 KBytes   981 Kbits/sec  1805.378 ms  0/15 (0%)
[  5]   1.00-2.00   sec   128 KBytes  1.05 Mbits/sec  643.708 ms  0/16 (0%)
[  5]   2.00-3.00   sec   128 KBytes  1.05 Mbits/sec  230.096 ms  0/16 (0%)
[  5]   3.00-4.00   sec   128 KBytes  1.05 Mbits/sec  83.926 ms  0/16 (0%)
[  5]   4.00-5.00   sec   128 KBytes  1.05 Mbits/sec  32.083 ms  0/16 (0%)
[  5]   5.00-6.00   sec   128 KBytes  1.05 Mbits/sec  12.672 ms  0/16 (0%)
[  5]   6.00-7.00   sec   128 KBytes  1.05 Mbits/sec  5.542 ms  0/16 (0%)
[  5]   7.00-8.00   sec   128 KBytes  1.05 Mbits/sec  3.590 ms  0/16 (0%)
[  5]   8.00-9.00   sec   128 KBytes  1.05 Mbits/sec  2.133 ms  0/16 (0%)
[  5]   9.00-10.00  sec   128 KBytes  1.05 Mbits/sec  2.908 ms  0/16 (0%)
[  5]  10.00-11.00  sec   128 KBytes  1.05 Mbits/sec  2.208 ms  0/16 (0%)
[  5]  11.00-12.00  sec   128 KBytes  1.05 Mbits/sec  1.743 ms  0/16 (0%)
[  5]  12.00-13.00  sec   128 KBytes  1.05 Mbits/sec  2.520 ms  0/16 (0%)
[  5]  13.00-14.00  sec   128 KBytes  1.05 Mbits/sec  2.274 ms  0/16 (0%)
[  5]  14.00-15.00  sec   128 KBytes  1.05 Mbits/sec  2.773 ms  0/16 (0%)
[  5]  15.00-16.00  sec   128 KBytes  1.05 Mbits/sec  2.095 ms  0/16 (0%)
[  5]  16.00-17.00  sec   128 KBytes  1.05 Mbits/sec  1.722 ms  0/16 (0%)
[  5]  17.00-18.00  sec   120 KBytes   983 Kbits/sec  1.766 ms  0/15 (0%)
[  5]  18.00-19.00  sec   136 KBytes  1.11 Mbits/sec  2.535 ms  0/17 (0%)
[  5]  19.00-20.00  sec   128 KBytes  1.05 Mbits/sec  1.903 ms  0/16 (0%)
[  5]  20.00-20.08  sec  8.00 KBytes   832 Kbits/sec  1.927 ms  0/1 (0%)
- - - - - - - - - - - - - - - - - - - - - - - - -
Test Complete. Summary Results:
[ ID] Interval          Transfer     Bandwidth       Jitter    Lost/Total Datagrams
[  5]   0.00-20.08  sec  2.50 MBytes  1.04 Mbits/sec  1.927 ms  0/320 (0%)
CPU Utilization: local/receiver 0.1% (0.0%u/0.1%s), remote/sender 0.2% (0.1%u/0.1%s)
iperf 3.0.11
Linux [redacted] #145-Ubuntu SMP Fri Apr 13 13:47:23 UTC 2018 x86_64 x86_64 x86_64 GNU/Linux
```

```
Pinging 212.72.214.206 with 32 bytes of data:
Reply from 212.72.214.206: bytes=32 time=13ms TTL=55
Reply from 212.72.214.206: bytes=32 time=13ms TTL=55
Reply from 212.72.214.206: bytes=32 time=12ms TTL=55
Reply from 212.72.214.206: bytes=32 time=17ms TTL=55
Reply from 212.72.214.206: bytes=32 time=9ms TTL=55
Reply from 212.72.214.206: bytes=32 time=10ms TTL=55
Reply from 212.72.214.206: bytes=32 time=12ms TTL=55
Reply from 212.72.214.206: bytes=32 time=12ms TTL=55
Reply from 212.72.214.206: bytes=32 time=17ms TTL=55
Reply from 212.72.214.206: bytes=32 time=14ms TTL=55

Ping statistics for 212.72.214.206:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 9ms, Maximum = 17ms, Average = 12ms
```

Features

- *PMU was not connected to the 5G Gateway Router*
- *Public Internet was used*
- *Latency criterion (40 msecs) was successfully passed*
- *Jitter often will be higher to start as a new flow requires additional processing compared to subsequent packets - e.g., OS has to work out where to send it, network equipment will need to work out the route and cache this etc.*

Thank you

Wishing all the best for our common success!