

Vertical Use Case: Real-time Wide Area Monitoring between Greece and Bulgaria – *Creating a complete Testing Plan for the developed Field Platform Validation Metrics (FPVMs)*

Presenters:

Mr. Michalis Rantopoulos (mrantopoul@cosmote.gr) – *Hellenic Telecommunications Organization S.A. (OTE)*

Dr. Ioannis Chochliouros (ichochliouros@oteresearch.gr) – *Hellenic Telecommunications Organization S.A. (OTE)*

Aim of the Smart5Grid Project



"The Smart5Grid 5G Experimental Platform aims to provide an experimentation environment for 3rd party developers to implement, verify and validate energy vertical applications as Network Applications, composed of a chain of VNFs.

These applications, once validated, will be hosted at and be accessible on an Open NetApp repository,

- encouraging the *reutilization of VNFs, and;*
- fostering the *introduction into the energy vertical market of start-ups and SMEs".*

Real-Time Wide Area Monitoring – UC#4 – Overview



- The **scope of UC#4** is the **real-time monitoring of a geographical wide area**, where **cross-border power exchanges take place**.
- The **interconnection flow between Greece and Bulgaria is monitored**, leveraging the advantages that the 5G communications infrastructure provides.
- To achieve the enhancement of the interconnected power system operation, **live monitoring of the interconnected power system flows is of vital importance**.

For that reason, **the PMU-PDC scheme** will be used, enabling high data number and granularity.

- **Phasor Measurement Units (PMUs)** measure grid current and voltage by amplitude and phase at several substations (nodes) of the transmission power system.
The high-precision time synchronization of the measurements from different substations allows for better monitoring of system's state and detection of dynamic events.
The PMUs are located in Thessaloniki (GR) and Blagoevgrad (BG) regions and will be used as the monitoring process of the RSC.
- **A virtual Phasor Data Concentrator (vPDC)** will be developed for the data gathering process *according to C37.244 standard*.

Real-Time Wide Area Monitoring – UC#4 – Motivation



- Higher share of renewable energy sources (RES) in the energy production mix significantly reduces the usage of fossil-dependent conventional power plants, thus leading to **CO₂ emissions' reduction**.
- However, the **high penetration of RES increases security issues**, due to their intermittent **stochastic nature** and the inverter-based grid connection.
- The **appearance of inter-area frequency oscillations** creates many issues such as power quality degradation, limitation of transmission system capacity and on several occasions, **it can even lead to system instability for the whole European Network**.

Real-Time Wide Area Monitoring –UC#4 – Scope

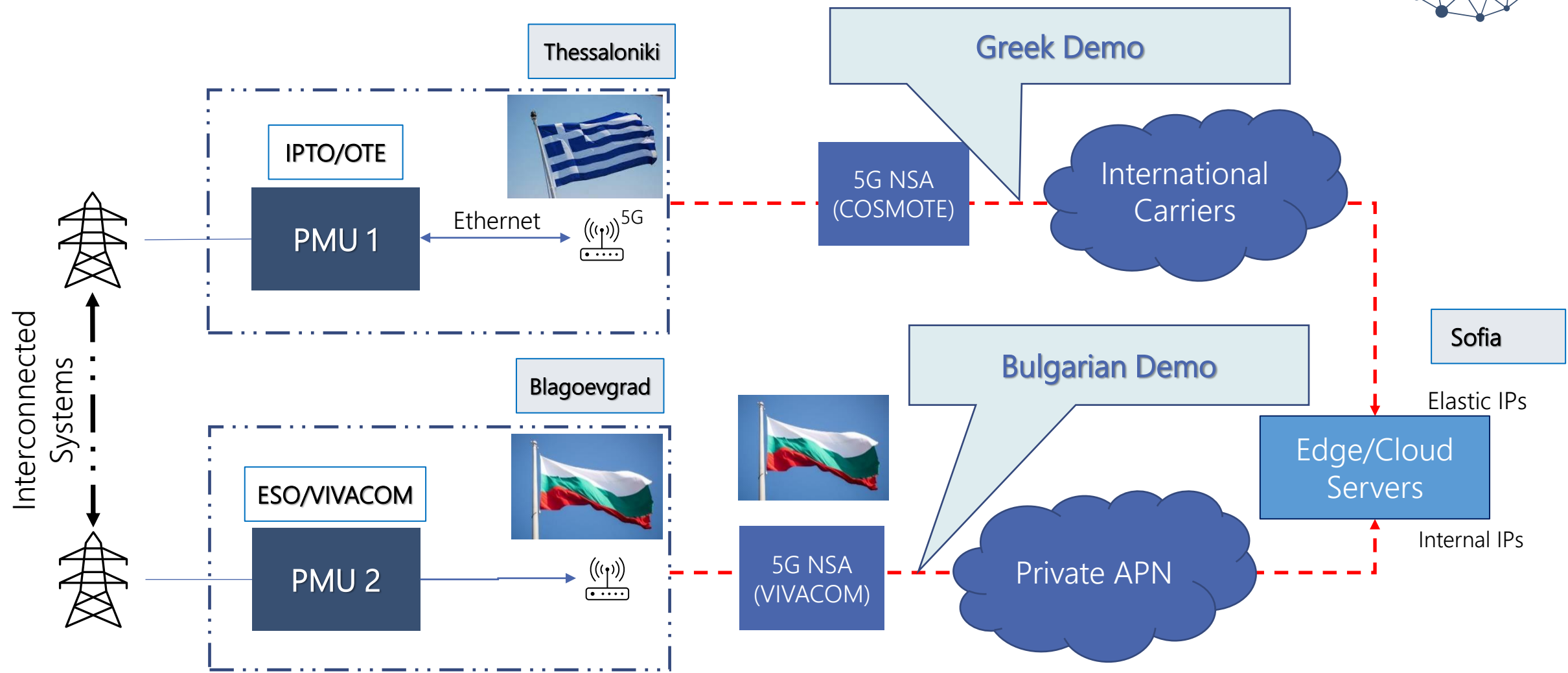


- ❑ Large and interconnected power systems are seen as the “backbone” of the critical infrastructures in our society.
 - *So far telecom providers played little or no role in the communication infrastructure.*
 - *This status quo is expected to change drastically in the smart grid era!*

- ❑ The *Smart Grid concept* and its deployment environments are aiming to increase efficiency, resilience, reliability and security of the evolved and greener power grids, *by means of increased digital automation and control.*

- ❑ The Fifth Generation (5G) of communication networks provides the features allowing the power grid to incorporate the service requirements of:
 - *Large bandwidth*
 - *End-to-end latency*
 - *High reliability*
 - *Massive connection type*

Real-Time Wide Area Monitoring – UC#4 – Greek/Bulgarian Pilot – Call Flow Paths



Real-Time Wide Area Monitoring – UC#4 – Greek/Bulgarian pilot - *Major Challenge*

Change of Lagkadas IPTO' Substation to Thessaloniki
early in the project,
due to insufficient 5G Network Coverage by public network.



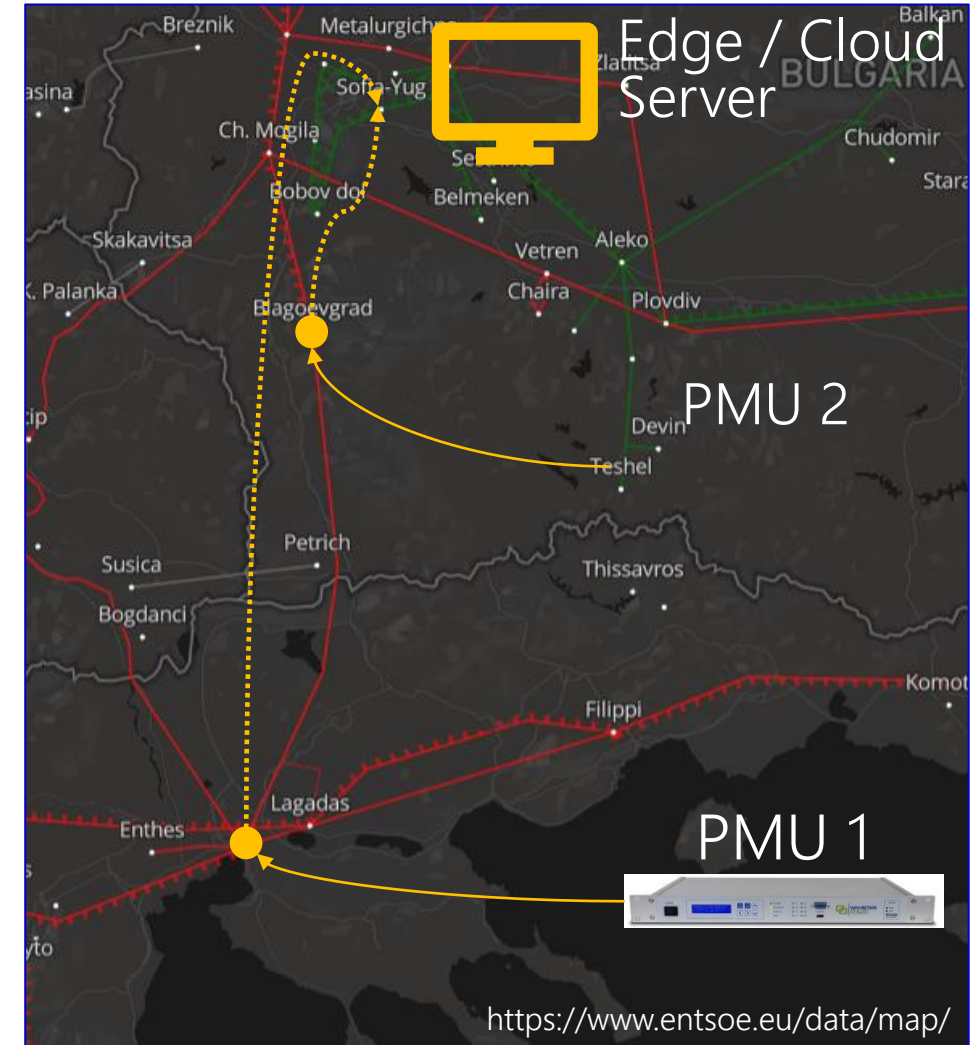
virtual Phasor Data Concentrator
(vPDC)



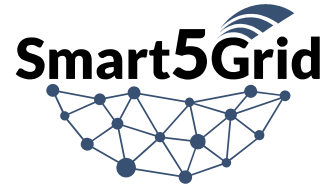
Phasor Measurement Units
(PMUs)



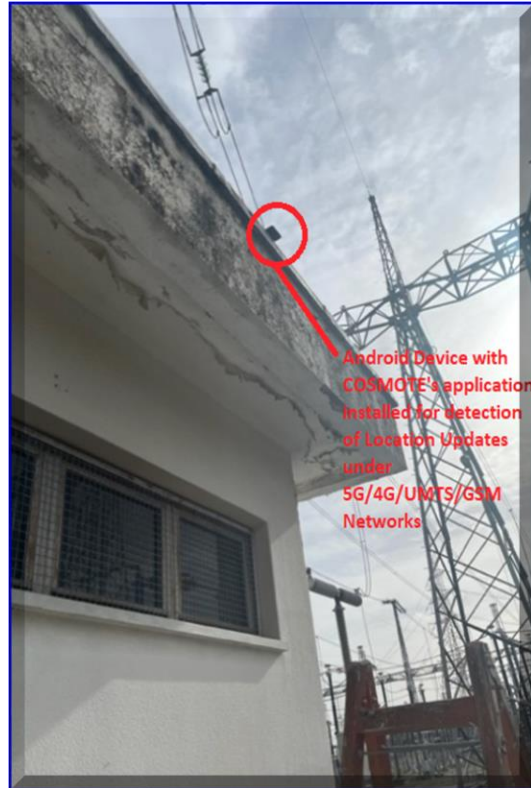
5G communication network



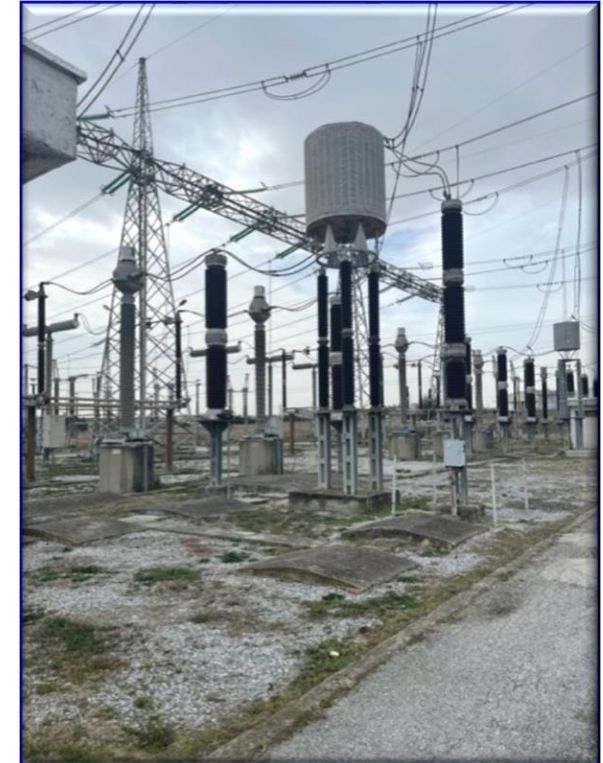
Real-Time Wide Area Monitoring – UC#4 – Greek Demo - **Site Survey**



- Use of R&D labs COSMOTOOLS application to investigate possible Location Updates (LUs) under 5G Networks



- IPTO's Substation - Direction towards COSMOTE's 5G Network Coverage



Real-Time Wide Area Monitoring – UC#4 – Greek Demo- **Installed Network Components**

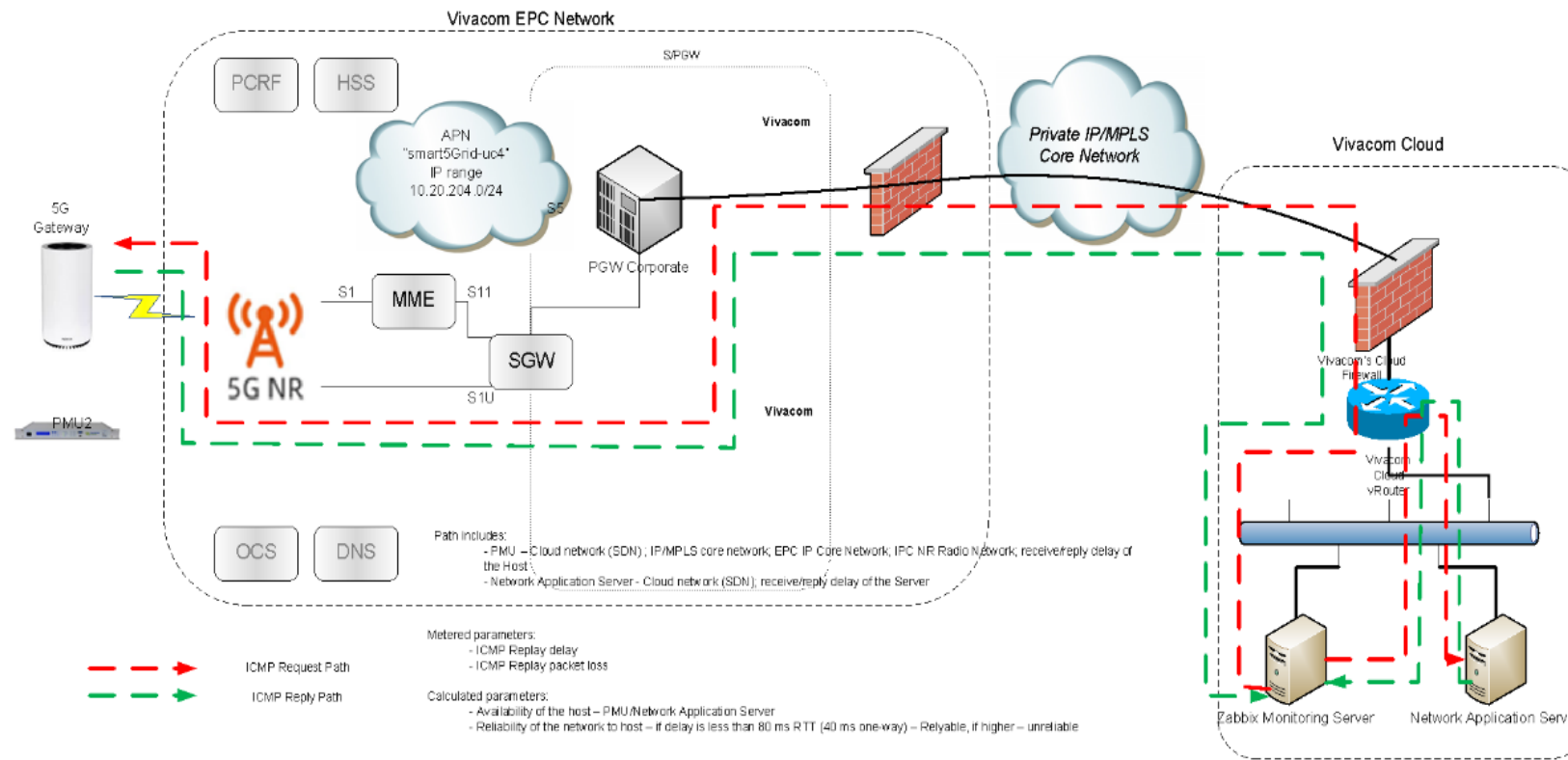


Testing Plan – “Local” Connection



Testing Plan with Zabbix Servers at “edge/cloud” server

Bulgarian Side

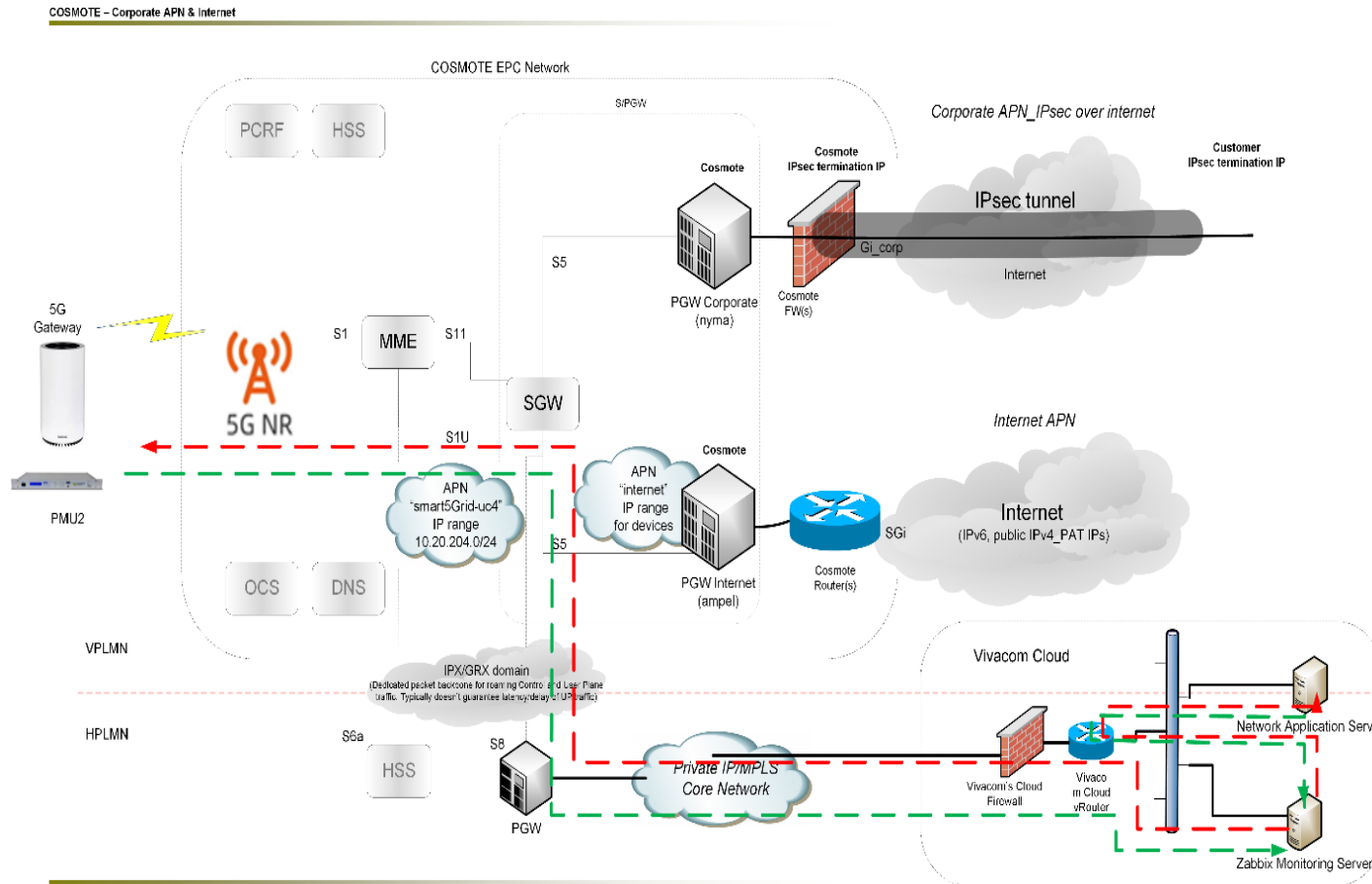


- **5G NSA Network of VIVACOM is exploited for the realization of this Scenario – displayed as EPC Network**
- **APN 'smart5grid-uc4' is created for forwarding the traffic in VIVACOM**
- **Private IP/MPLS Core Network of VIVACOM handles the *User Plane Data***
- **Corporate P/GW is exploited**

Testing Plan- Interconnection scenario "Roaming"

Testing Plan with Zabbix Servers at "edge/cloud" server

Greek Side

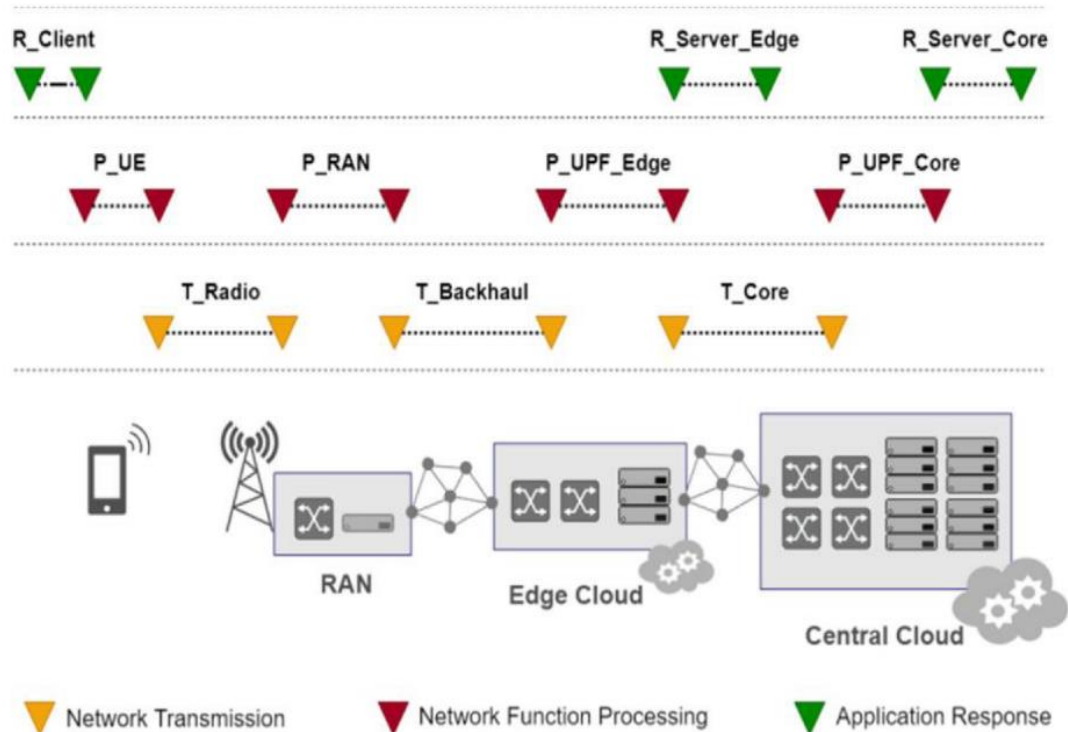


- **5G Commercial Roaming activated** between COSMOTE and VIVACOM, thus making this scenario feasible
- **Considered as Optimal Routing for Interconnection** between IPTO site and EDGE/CLOUD server since all data are kept 'locally'
- **Involvement of International Carriers** for the Interconnection path
- **IPX/GRX Dedicated Packet Backbone for Roaming Control** and User Plane Traffic responsible

UC#4 - FPVMs as a set of combined C-KPIs (Core Network KPIs) and A-KPIs (Application KPIs)



The methodology used to form the FPVMs is illustrated in the graph below, showing the decomposition of End-to-End Latency into 3 discrete segments



The End-to-End Latency here is considered to be composed of three types of delay, that is:

- **network transmission time** (depicted as **T**);
- **network function processing time** (depicted as **P**), and;
- **application response time** (depicted as **R**).

Two important factors considered for the Design of FPVMs



- ❖ The newly created FPVMs must satisfy the **user requirements**.
 The user requirements formation is the “output” of extensive works during previous deliverables – *particularly Smart5Grid's D2.1 in our case*.
 “Users” of the pilots have to **define clearly the performance** that the “networks” as servants must satisfy.
*For the case of Real-Time Wide Area Monitoring such a Metric is the **absolute wait (40msec)** time till the **vPDC** receives the measurements.*
- ❖ The **availability of resources** to measure the metrics on field.
 The latter is a particularly crucial factor, *since **pilots are actualised in the real-world sites leveraging the energy devices and 5G commercial networks.***



UC#4 – Final List of FPVMs and the associated Targeted Values



Metric code	Metric Name	Description	Unit	Expected Value
UC#4-FPVM-01	Network Latency	Latency is the time it takes for data packet to pass from source to destination. Network Latency the time needed by the network to pass the traffic from ingress point (first network device – 5G router) to egress point (last network device – Network interface of VM). Network latency is measured by sending and receiving ICMP echo request/response probes from Zabbix monitoring server to last 5G gateway/modem providing mobile service to end-user device.	msec	<40ms
UC#4-FPVMP-02	PMU- <u>vPDC</u> scheme Latency	Total time required for the PMU measurements to reach the Network Application, after the timestamping procedure. The upper limit for this KPI is the “absolute waiting time” value (40ms) defined in D2.1.	msec	<40ms
UC#4-FPVM-03	Application (<u>vPDC</u>) Packet Loss	Application Packet Loss refers to packets not reaching their destination after being discarded by the <u>vPDC</u> component.	%	To be defined later during the works of T6.4
UC#4-FPVM-04	Communication Network Availability	<p>Network Availability is measured as the total time the network is accessible and it is delivering data traffic between communication devices compared to the total monitored period.</p> $Availability = \frac{T_{Available}}{T_{total}} * 100, \%$	%	99,999
UC#4-FPVM-05	Communication Network Reliability	<p>Reliability is measured as the total time the network is delivering data packets with latency below 40ms compared to the total monitored period.</p> $Reliability = \frac{T_{Reliable}}{T_{total}} * 100, \%$	%	99,999

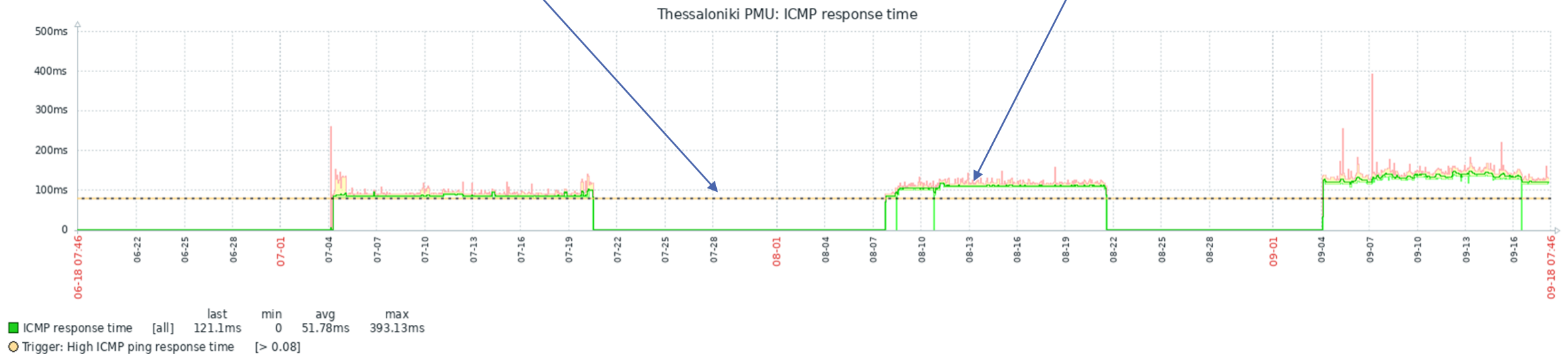
Real-Time Wide Area Monitoring –UC#4 – Greek Demo – *Results obtained for Interconnection scenario “Roaming”*



Readings Obtained at Zabbix server regarding the *icmp ping response time*
(round trip time for server to the Gateway Router and back)

Absence of readings is caused by **human intervention/error locally** at the Substation

Latency exceeds criterion due to delay at the **GRX Interconnection Network**



UC#4 - Cooperation with COSMOTE's internal Business Units – **Lessons learned**

- **Constructions Section** *(at the initial plan to implement our own 5G SA infrastructure, although this plan wasn't followed at the end)*
- **Packet Core Implementation Network Section** *(creation of 'i-trial-Smart5Grid' APN and IPSec tunnel for primary Interconnection Scenario with VIVACOM)*
- **Provisioning Section** *(to provide the testing SIM cards for the trial APNs)*
- **Radio Access Planning & Support Department** *(to speed up the rollout of 5G to the substation area within the project's deadlines and during the Site Surveys to configure the settings of the Zyxel Gateway Router)*

Thank you

For your attention!

For more information also see the project website:
<https://smart5grid.eu/>