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RED ELÉCTRICA

Enabling the Virtual Digital Substation through **Edge Computing**

Challenges

The **usual** technology that is deployed in **Power Grid substations to run and control critical service operations is frequently based on single-purpose appliances built and installed by vendors. This scheme** implies **some form of** subjugation, **and** the following issues are **on many occasions** generated:

01 VENDOR LOCK-IN

This **equipment's IP** is hold by each vendor and **cannot be interconnected**, resulting in low efficiency and *"vendor lock-in"* situations.

02 HIGHER COSTS

As a result of their reduced bargaining capacity, TSOs and DSOs tend to pay higher CAPEX and OPEX to enable the Power Grid operation and control.

03 REDUCED VISIBILITY

Although certified, **the** substation equipment is **normally delivered** as black boxes, exposing limited operational or error metrics **and with no potential tailored extension of their functionality.**

04 LOW SCALABILITY

Operations (set-up, deployment, maintenance...) cannot be done in parallel to multiple nodes, many times not even remotely. **New technology deployments of technology need to be done sequentially and may last up to years.**

05 LONG INNOVATION CYCLES

To amortize the **CAPEX** and because of the very long innovation cycle, Power Grid operators plan for decades-long life cycles. **This may potentially lead to miss out innovation opportunities enabling relevant benefits** that cannot be leveraged until years later than available.

Edge Computing overcomes all the above limitations. **By decoupling the SW from the HW**, all services and functions become a virtual yet fully performant asset. These SW elements can be instantly deployed on top of small edge computing general-purpose HW platforms located at every substation and connected to a central automation platform.

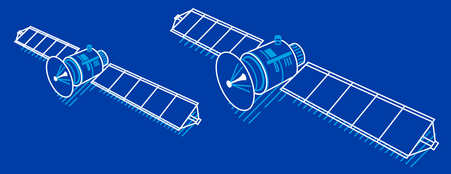
Solution architecture

Assets

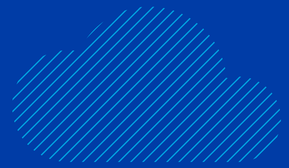
- 5G Spectrum (if available)
- Satellite Constellation
- Transport Network (Fiber)
- Inspection Devices
- Employees hand devices
- ARVR Goggles

Edge & Orchestration

- Massively distributed infrastructure
- Ad-hoc communications
- Macro and Micro – orchestration
- Multi-tenancy
- Use-case enablement – edge computing



Hispasat satellite constellation

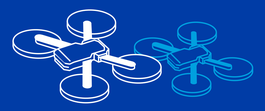


Tranport Network

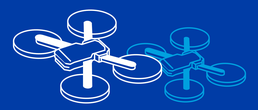
Safety Cameras

Inspection Cameras

5G Macro



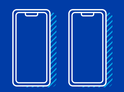
Substation / Plant Inspection Drones



Line Inspection Drones

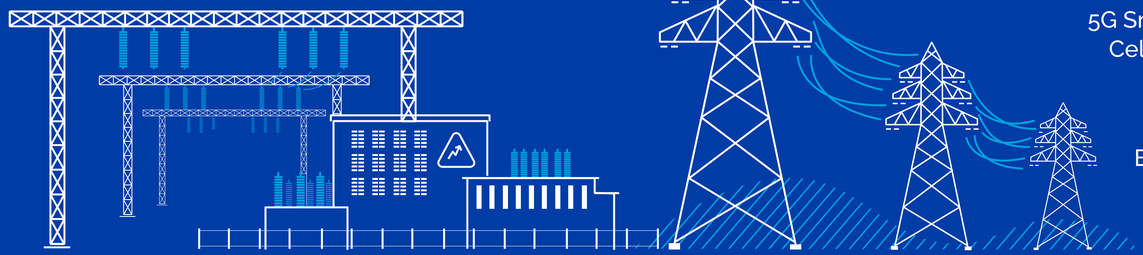
Edge Services

Inspection Vehicles



Employees PTT

AR for Remote Assistance



Power Plants / Substations / Construction

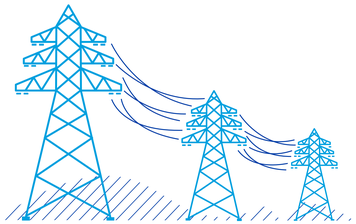
5G Small Cells

Satellite Backhauling

Edge Services

Rural Sites / Remote Locations

Use cases implemented



1

POWER GRID

+ **Automatic power grid fault detection:** monitor the power grid remotely and detect failure locations along lines reducing operation costs.
+ **Monitor and secure substations through** high resolution 3D sensors combined with AI support workers during maintenance, avoiding to reach live parts of the power grid.

3

VIRTUALIZING THE PROTECTION AND CONTROL FUNCTION

+ A SW app has been developed to read data from powerline sensors, apply a decision algorithm and produce a signal to execute a physical circuit break if needed. **Orchestration is responsible for securing that low-level compute resources (CPU threads, cache memory, NIC bandwitdth)** will always be available to secure the response takes place in less than 2ms.

2

CENTRALIZED MANAGEMENT

+ Edge Computing brings the possibility to virtualize the **"Protection and Control function"** and make it a SW that is installed on top of regular servers, instead of being delivered through an appliance. Edge Computing systems can have a centralized management from a central location.

4

LIFECYCLE MANAGEMENT

+ Orchestration is also **responsible for the deployment and lifecycle management of the SW solution** across the hundreds of substations in the country.
+ This example paves the way for **the extension to other services that are currently executed through function-specific appliances**, to implement the "virtual substation".

REMOTE ASSISTANCE

+ Edge Computing brings the possibility to virtualize the "Protection and Control function" and make it a SW that is installed on top of regular servers, instead of being delivered through an appliance. **Edge Computing systems can have a centralized management from a central location.**
+ Real-time wide area monitoring: **Aggregate and control data of 1000s of Medium and High Voltage decentralized Renewable Energy Sources** and their inverters.
+ **Regional Security Coordination:** From Distributed Energy Resources at Medium Voltage level operated by DSOs, to High Voltage level operated by TSOs.

REMOTE INSPECTION

+ Edge-To-Cloud AI analytics
+ Mission-Critical Comms

Use cases driven

1

PROTECTION & CONTROL VIRTUAL SWITCH

+ Edge Computing brings the possibility to virtualize the "Protection and Control function" by making it a SW piece installed on top of regular servers, instead of being delivered through an appliance as in legacy systems.
+ The SW application reads incoming data from powerline sensors and applies a permanent decision algorithm, producing a signal to execute a physical circuit break if needed.
+ Low-level resource orchestration is responsible for securing that low-level compute resources (CPU threads, cache memory, NIC bandwitdth) will always be available to enforce a response in less than 2ms with full guarantee and other operation norms.
+ Replacing appliances by a pure-SW solution running on top of general-purpose servers triggers critical economic and operational benefits. This SW can coexist with other apps without compromising its performance.

2

CENTRALIZED OBSERVATION AND LIFECYCLE MANAGEMENT

+ The remote orchestration agents report constantly to a central console on the status of the servers and on the operations' data, to predict potential service degrading or events.
+ SW maintenance (upgrades, updates) is automated for a fast or programmed delivery across hundreds of substations in hours.
+ The ability to distribute SW efficiently improves dramatically the capacity of the Power Grid to absorb available innovative features.

3

LOCAL WIRELESS NETWORKS (4G/5G) MANAGEMENT

+ Deploying sensors or cameras in a substation requires a reliable wireless network.
+ Orchestration facilitates the deployment, configuration and observation/maintenance of network radio and core functions, statically or dynamically, so networks can operate in unattended facilities with a low OPEX.

4

Edge AI functions

+ Incoming data from sensors can be processed locally by AI algorithms at high speed to spare compute power and storage at the Cloud level.

REMOTE WORKER ASSISTANCE

+ A key application for maintenance workers is Augmented Reality, which can in one hand deliver info of the existing power grid infra in real time, as well as facilitate the interaction from the field with expert supervisors sitting at their office desk.
+ Augmented or Virtual reality apps must sit at the Edge Computing as they require low-latency, high bandwidth and low jitter.

VIDEO ANALYTICS INSPECTION

+ Several types of video analytics have been defined
  - Visual Inspection of power lines
  - Partial Discharges
  - Perimetral security
  - Safety procedures' compliance
+ Cameras may be placed on poles or on Automatic Guided Vehicles or Drones.
+ All of these applications can sit at the substation Edge Computing server. Orchestration will enforce their running conditions.

VALUE-ADDED solution

Outcomes

Avoids vendor lock-in

Increased flexibility and reliability through a multi-vendor open solution that avoids vendor lock-in, enabling a larger number of HW and SW vendors **to be part of the ecosystem, thus improving competition and increasing the quality-for-price.**

Inherent Observability

The Edge Platform provides telemetry on a normalized format to be directly injected into the maintenance and support systems

Reliable low latency

Reliable low latency performance even in shared compute environments thanks to Custom Provisioning Profiles that Create provisioning profiles tailored for each specific use case.

Lower CAPEX, Lower OPEX

Costs naturally decrease when using conventional HW and edge computing SW solutions.

Breaking down data silos

the Power Grid operator gets not only a common deployment model but enables a global data space to ensure reliable and secured planning, operation, and protection of the power grid.

+ **This is the only right architecture to deploy AI at the Edge.**
+ **Accelerating** the innovation cycle.