Virtual Protection and Relay

VMware Validated Solution

Solution benefits

- Ensure compatibility and interoperability between infrastructure software and VPR applications
- Enhance manageability, reliability, safety, and security
- Connect control center(s) to edge substations, switchyards, and generation facilities and manage them with a common set of tools
- Reduce CAPEX due to smaller hardware footprint with hardware consolidation, and reduce OPEX due to labor reductions and lower maintenance overhead
- Simplify installation, maintenance, and future upgrading of utility workloads while making work environments safer by minimizing the number of dangerous touchpoints
- Streamline NERC-CIP compliance with increased access to data and smaller physical networks

Current substation architecture is outdated and inflexible. Virtualization technology is a step toward a modern, data-driven power grid that will be more nimble and resilient in the face of rising outages.

Extreme weather events such as prolonged heatwaves and winter storms are increasingly impacting electrical grids in their present state. Over the past 20 years, there has been a 67% increase in power outages from weather-related events, according to analysis by Climate Central[1]. The aging grid, mostly built in the 1950s, is a major contributor to these outages.

Distributed Energy Resources (DERs), which could make the grid more resilient to these impacts, cannot be orchestrated using existing technology. The vast amounts of data that can be generated by the grid is not easily collected and shared across the landscape This limits centralized management systems and makes it challenging for operators to accurately estimate and react to the changes in electricity demand as well as to minimize disruption during extreme weather events.

Legacy substation technology is built on thousands of fixed-function devices that cannot easily protect and control two-way flows of electricity within substations. They also will not provide value for future grid solutions such as blockchain transacted energy and packetized energy management. Installing, servicing, and upgrading these fixed-function devices is very expensive and time consuming. And meeting North American Electric Reliability Corporation Critical Infrastructure Protection (NERC CIP) compliance standards is still a painstaking and error-prone manual process.

Substation virtualization will make the grid more resilient

Utilities have taken a step toward a smarter grid by virtualizing critical grid management applications within the control center, using VMware Cloud Foundation and NERC CIP-compliant VMware Validated Designs. It has never been a better time to extend that capability into modernizing substations with

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[1] https://www.climatecentral.org/gallery/graphics/power-outages

vmware®

Solution capabilities

- Standardized hardware and software platform
    - o Precision Time Protocol (PTP) integration
    - o Realtime monitoring of GOOSE and sample value feeds
    - o Combining network technologies such as HSR/PRP
- Innovative new algorithms incorporating the combined pool of data (e.g.AI/ML)

the availability of IEC-61850-3 certified servers built for substations and VMware vSphere supporting latency-sensitive workloads in the substation.

Modern substations require standardized, flexible, scalable, and secure systems to build a data-driven power grid to improve the local decisions being made in real time (RT) and manage instabilities caused by fluctuating demand and generation imbalances over a wide area—all while remaining secure, resilient, and easy to manage. Modernizing the legacy command-and-control infrastructure within power substations, switchyards, and generations facilities today is a massive undertaking. But virtualization can initially reduce labor and downtime while building a platform with enormous return-on-investment potential.
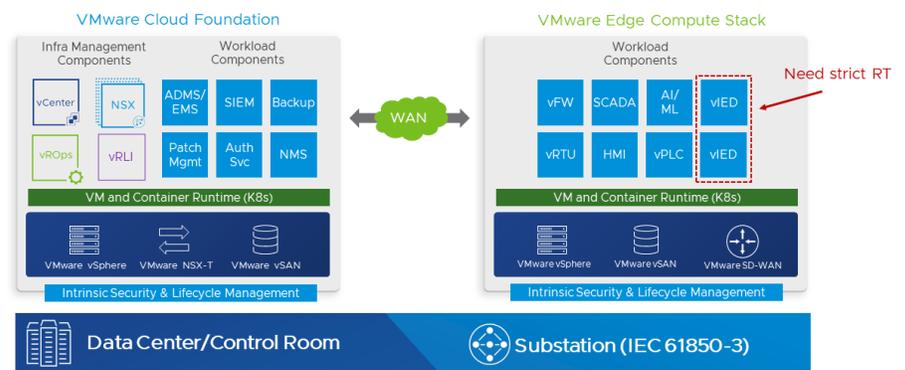

Figure 1. Virtualization platform for the utility grid, with consistent management and operation from the data center/control room to the substation

Utilities are beginning to recognize the need for optimizing and modernizing substations by building more intelligence at the edge. As more data is being generated by an increased number of sensors, the key needed to unlock the ability to continually analyze and act upon this overwhelming volume of information with minimal latency is higher processing power at the edge (substation). The journey to modern substation architecture starts with leveraging standardized, commercial, IEC-61850-3 certified commercial-off-the-shelf (COTS) ruggedized server hardware for the substations, and implementing software-defined automation and control systems. Multiple substation workloads can be virtualized and consolidated onto a single platform, making management of these workloads easier.

VMware, the trusted digital foundation to accelerate innovation, provides a purpose-built platform that meets the security, performance, and manageability requirements for running substation workloads. The VMware Edge Compute Stack (ECS) offers a single platform for running VM and container-based workloads and supports real-time workloads (such as protection relays or other critical components).

What is Virtual Protection and Relay?

Virtual Protection and Relay (VPR) is one of the essential building blocks for grid modernization. Converting the protection and control functions traditionally served by analog, electromechanical, solid-state, or microprocessor devices (also referred to as IEDs) into software applications running on a COTS ruggedized server with VMware virtualization infrastructure, forms the basis of a VPR system. Because all the components of VPR are in software, utilities can greatly simplify the commissioning of a new VPR system and its ongoing operation.

VPR can leverage the faster and more recent CPU architecture found in modern server technology. The hypervisor layer, with its real-time capabilities, delivers the deterministic, low-latency execution environment for VPR to allow it to deliver its functionality. Other VPR benefits include reduced hardware footprint, simplified life cycle management, and much-needed flexibility.

VMware-validated VPR solution

Intel and VMware are jointly working on validating VPR applications on COTS ruggedized servers that are certified to IEC 61850-3/IEEE 1613, making them suitable for the harsh environment of substations. These servers run VMware Edge Compute Stack, which consists of:

• **VMware vSphere** is the industry-leading type-1 hypervisor. It is now capable of being a real-time hypervisor to support strict, low-latency execution of real-time workloads as required by VPR applications.

• **VMware Tanzu Kubernetes Grid** is VMware's multi-cloud Kubernetes (K8s) distribution for running modern applications, micro-services. TKG delivers full lifecycle management of K8s clusters and is integrated with vSphere.

• **VMware vSAN** software defined storage delivers hyperconverged infrastructure (HCI) at the edge. HCI enables multiple servers to pool their storage resources and make them available to all the workloads running on those servers.

Learn more

- *Power of Infrastructure Modernization eBook* (provided by Intel)

- *Dell Technologies Grid Management Platform Common Design Architecture*
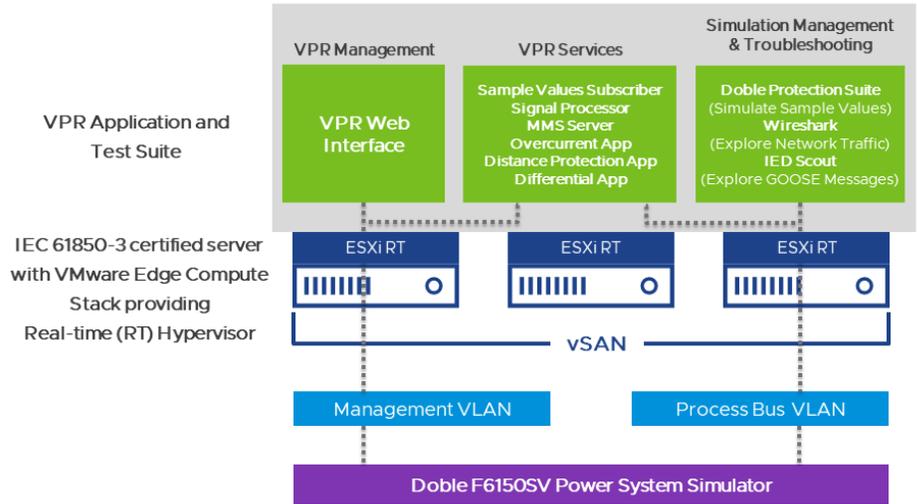
- *VMware Edge Compute Stack*

Figure 2. VPR solution testbed

In addition to infrastructure, VMware is validating protection and control applications built by OEMs to ensure interoperability, system scaling, resiliency, and that all performance requirements are met in order to optimize designs for specific VPR applications as they are architected. A sampled value streams generator is used to simulate IEC 61850 Sample Values (SVs) and GOOSE messages typically supplied by Merging Units (MUs) while observing how the VPR applications respond to these messages and measuring their response time.

The IEC 61850-3 certified servers are also equipped with adapters capable of supporting Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR), which will be validated as part of the overall solution.

Call to action

VMware is looking for utilities that are interested in beginning their journey towards a fully digitized substation. We are also looking to work with IED vendors as our co-innovation partners.

Contact us at gridmodernization@vmware.com.