Software-defined substation application architecture

VMware solution benefits

- Software-defined applications to consolidate the plethora of fixed-function hardware systems found in substations
- Simplify installation, maintenance, and future upgrades while making work environments safer by minimizing the number of dangerous physical connections
- Connect control center(s) to edge substations, switchyards, and generation facilities and manage them with a common set of tools
- Reduce CapEx and OpEx with smaller hardware footprint and lower maintenance overhead
- Streamline NERC-CIP compliance with increased access to data and the implementation of zero-trust cyber-secure networks

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Common challenges in today's power grids

Traditional substation application architecture is outdated and inflexible. Across the globe, power service providers are looking for ways to realize their sustainability goals without reducing grid resiliency. Renewable energy solutions, actively being commissioned to add capacity and displace existing fossil fuel generation, are changing the operating characteristics within their service territories. This is especially true for traditional, low-voltage delivery areas where distributed energy renewables (DERs) are being interconnected and represent an increasing percentage of local supply.

Centralized systems, such as Advanced Distribution Management System (ADMS), are delivering improvements in orchestrating sources and demands, outage response times, continuity, and overall power quality. Data quantity and quality is the key factor in their performance. As use cases are added, there is a growing requirement for high-speed, high-bandwidth connectivity and compute.

Legacy substation operation uses thousands of fixed-function devices that cannot easily protect and control two-way flows of electricity. Installing, servicing, and upgrading these fixed-function devices is expensive and time consuming. Manual data collection to comply with regulations such as North American Electric Reliability Corporation Critical Infrastructure Protection (NERC CIP) can be painful.

Virtualization making the grid more resilient through local data processing

Virtualization technology will enable modern, data-driven operations that will be more nimble and resilient. Utilities have taken a step toward a smarter grid by virtualizing critical grid management applications within the control center, using VMware Cloud Foundation. It has never been a better time to extend that capability into modernizing substations with the availability of certified rugged servers and VMware vSphere persistently supporting latency-sensitive critical workloads.

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. VMware Edge Compute Stack offers a single platform for running VM and container-based utility applications, simultaneously supporting real-time and non-real-time workloads.

Software-defined substation application architecture examples

- **Active Network Management (ANM)** can augment ADMS, ensuring that the real-time electricity being produced by DERs is prioritized and balanced, while remaining within the physical limitations of the existing grid infrastructure. Through state estimation, forecasting of power flow, and contingency analysis, ANM can maximize allowable throughput. When installed in edge substations, local ANM intelligence can ensure maximum feasible DER production, even during a communication outage that separates portions of the grid.
- **Adaptive Protection** increases in importance as DER usage rises. As another extension of ADMS, it can dynamically assess and adapt system protection settings for a wide area. This optimization is further influenced by local regulatory and business rules input by the service provider, as projected updates are validated against device capabilities before being applied. AI then assesses past response performance, present operating conditions, and future settings forecasting to present to operators.
- **Virtualized Protection, Automation, and Control (vPAC)** is needed at each substation. The protection algorithms, custom logical controls, and automation of high voltage apparatus, previously performed by a large grouping of traditional microprocessor devices, is now delivered by vPAC (Fig. 1). High speed (real-time) and deterministic performance is still available, even after a drastic consolidation onto the same small set of rugged computing hardware that is already hosting other, less sensitive workloads. The portability and scalability of this software-defined system offers significant advantages in terms of standardization of deployment and flexibility in operation.
- **Asset Management** tools (AMT) store an entire station's critical vendor-specific information about all hardware and software assets and performs management and administrative functions. This virtual gateway can also facilitate multiple communications protocols, allowing automatic collection of configurations, device versions, events and commissioning reports, etc.

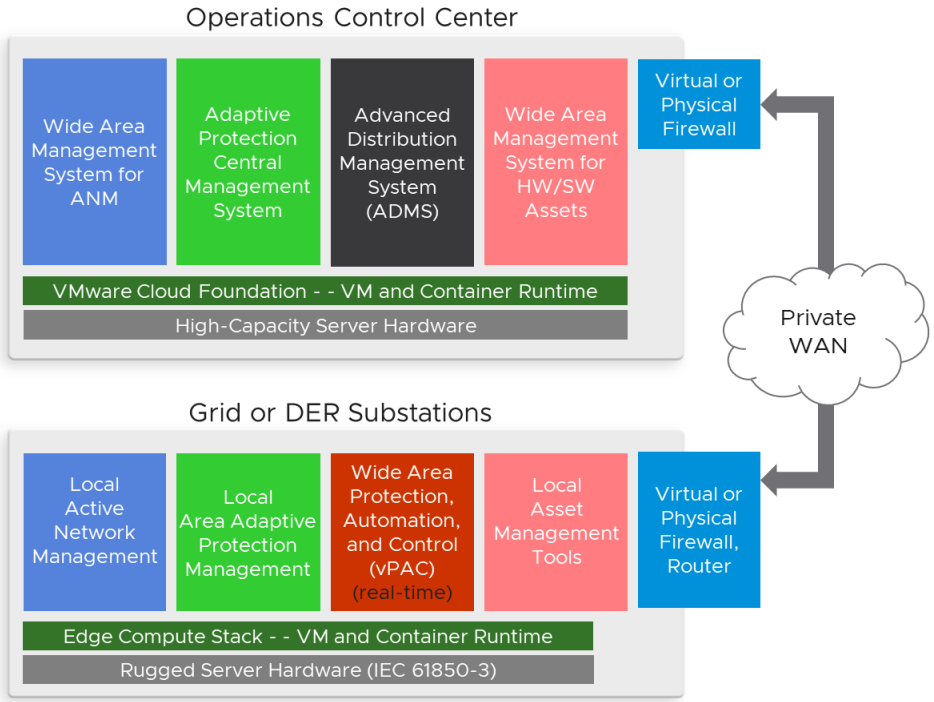

Figure 1: Virtualization platform with consistent management of the grid from the data center/control room to the substation