GridWise Alliance Technology Council Meeting Agenda

Adaptive Protection and other Resilience Enhancing Technologies

July 26, 2023 @ 3:00 PM ET

I.	Welcome & Antitrust Guidelines	**Josh Steinhardt**, Operations Director
II.	Presentations on Adaptive Protection and other Resilience Enhancing Technologies	**Montie Smith**, Energy Solutions Advisor, Dell Technologies **Paul Myrda**, Sr. Technical Executive, Electric Power Research Institute (EPRI) **Sergey Kynev**, Lead Engineer, Siemens Energy
III.	Questions and Discussion	**All**

GridWise Alliance
Antitrust Compliance Program Guidelines

It is the policy of the GridWise Alliance to comply fully with the antitrust laws. The Sherman Act and other applicable antitrust laws are intended to promote vigorous and fair competition and to combat various restraints of trade.

Each person who participates in GridWise Alliance activities has a responsibility to his/her employers and to the GridWise Alliance to avoid any improper conduct from an antitrust standpoint. The following guidelines will assist in meeting this responsibility:

1. GridWise Alliance meetings and discussions generally cover topics related to the generation, transmission and distribution of electricity. Should related discussions ever have any potential for competitive impact, all due care shall be taken to avoid such discussion between competitors.

2. In view of antitrust considerations and to avoid any possible restraints on competition, the following legally sensitive subjects must be avoided during any discussion between competitors:

   (a) Future marketing plans of individual competitors should not be discussed between competitors;

   (b) Any complaints or business plans relating to specific customers, specific suppliers, specific geographic markets or specific products, should not be discussed between competitors;

   (c) Purchasing plans or bidding plans of companies in competition should not be discussed (except privately between two parties with a vertical commercial relationship such as supplier and customer); and

   (d) Current and future price information and pricing plans, bidding plans, refund or rebate plans, discount plans, credit plans, specific product costs, profit margin information and terms of sale should not be discussed between competitors. All of the above are elements of competition.

3. Any question regarding the legality of a discussion topic or business practice should be brought to the attention of the GridWise Alliance legal counsel or a company's individual legal counsel for advice.

Dell Technologies in Utilities

GridWise Alliance Technology Council Meeting:
Adaptive Protection Technologies

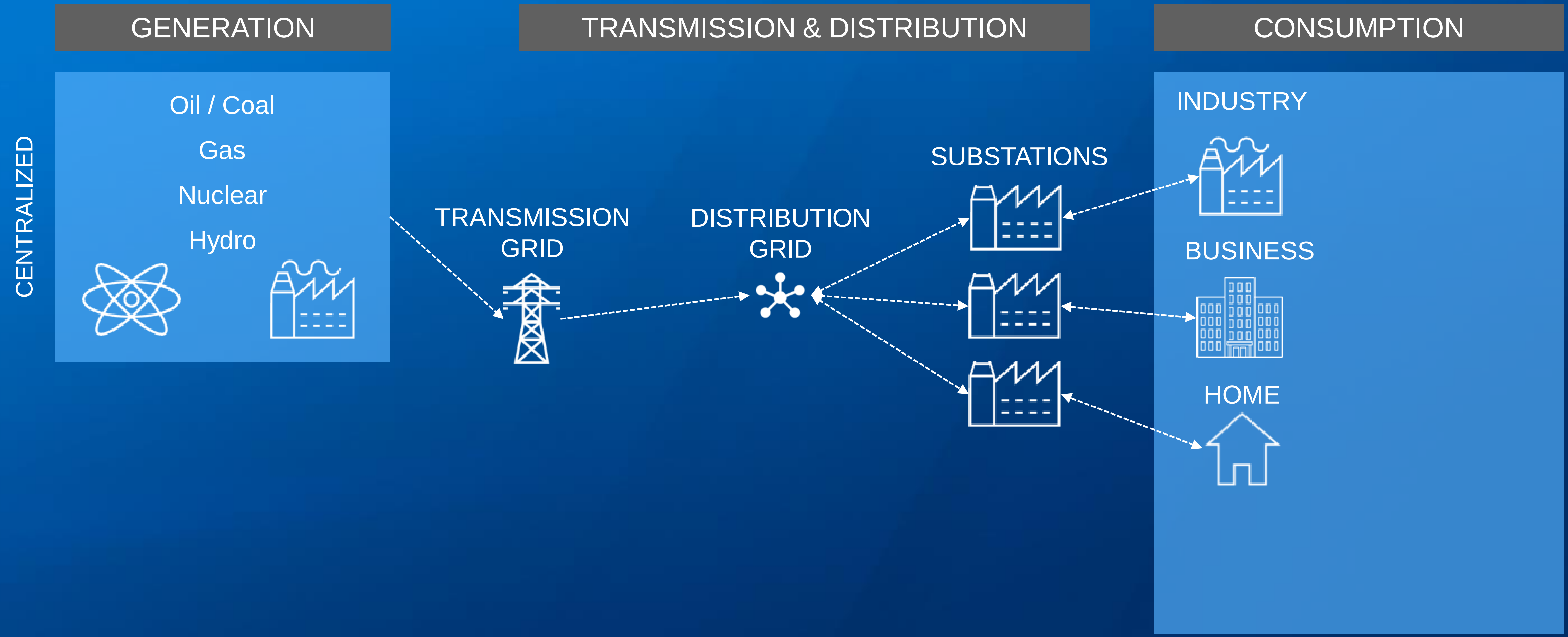
Montie Smith – Energy Solution Advisor

DELL Technologies

vPAC: Virtual Protection, Automation, and Control

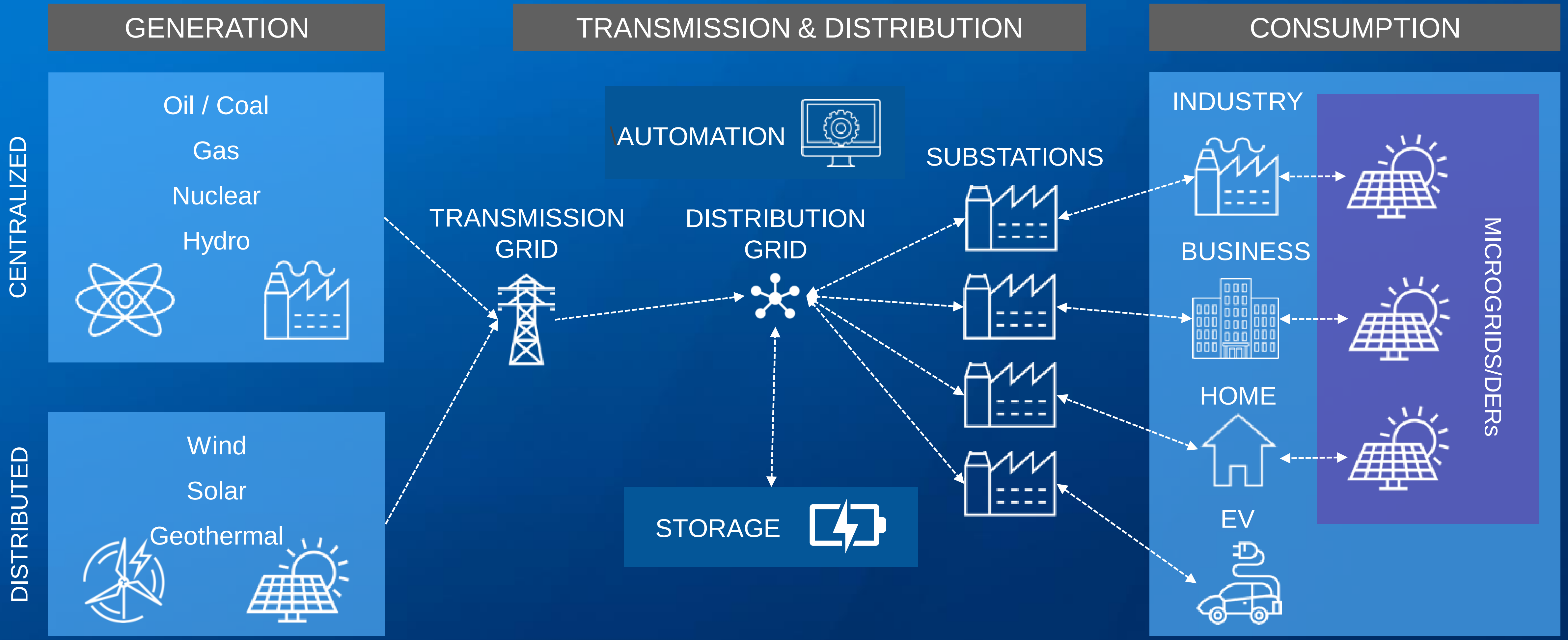
DELL Technologies

Driver of Change: Disrupted Electric Grid for the 21st Century



DELL Technologies

Driver of Change: Disrupted Electric Grid for the 21st Century



DELLTechnologies

Digitalize To Optimize

Software-Defined Automation & Control Systems

Enhance Reliability, Safety, Security, Manageability and Edge Analytics

Legacy Substation

- RTU
- Firewall
- Router
- Switch
- PMU
- SCADA
- Security
- IED’s

Rugged Server’s
(IEC – 61850 – 3 class 2 & ANSI 1613)

Future Substation

Partition	Isolation	Encapsulation	Hardware Independence

Standardize Hardware Platform	Improve Reliability, Safety and Security	Reduce Capital Investment	Reduce Operation and Maintenance Cost

Device Reduction	Decrease Operations & Maintenance Cost

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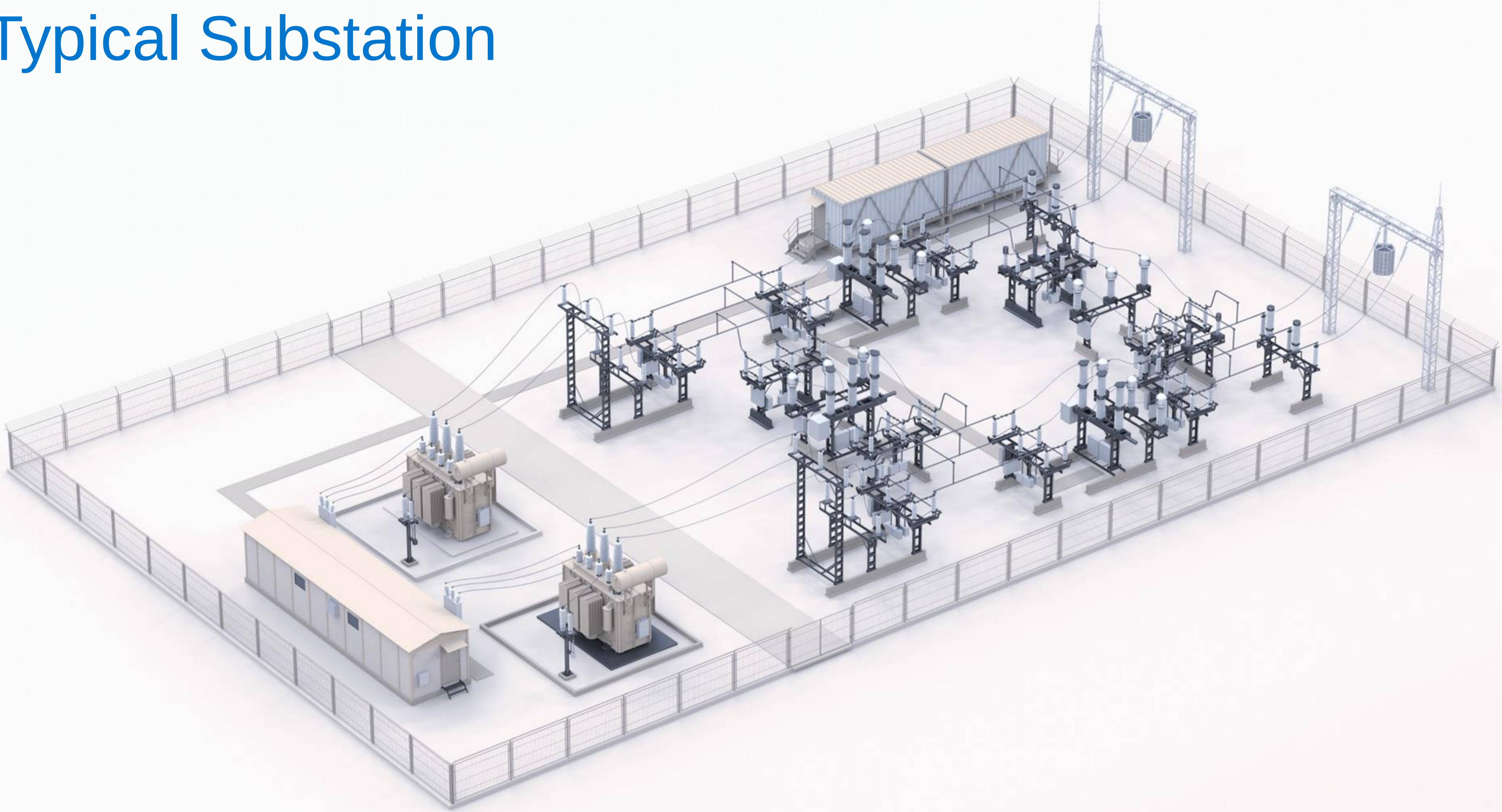
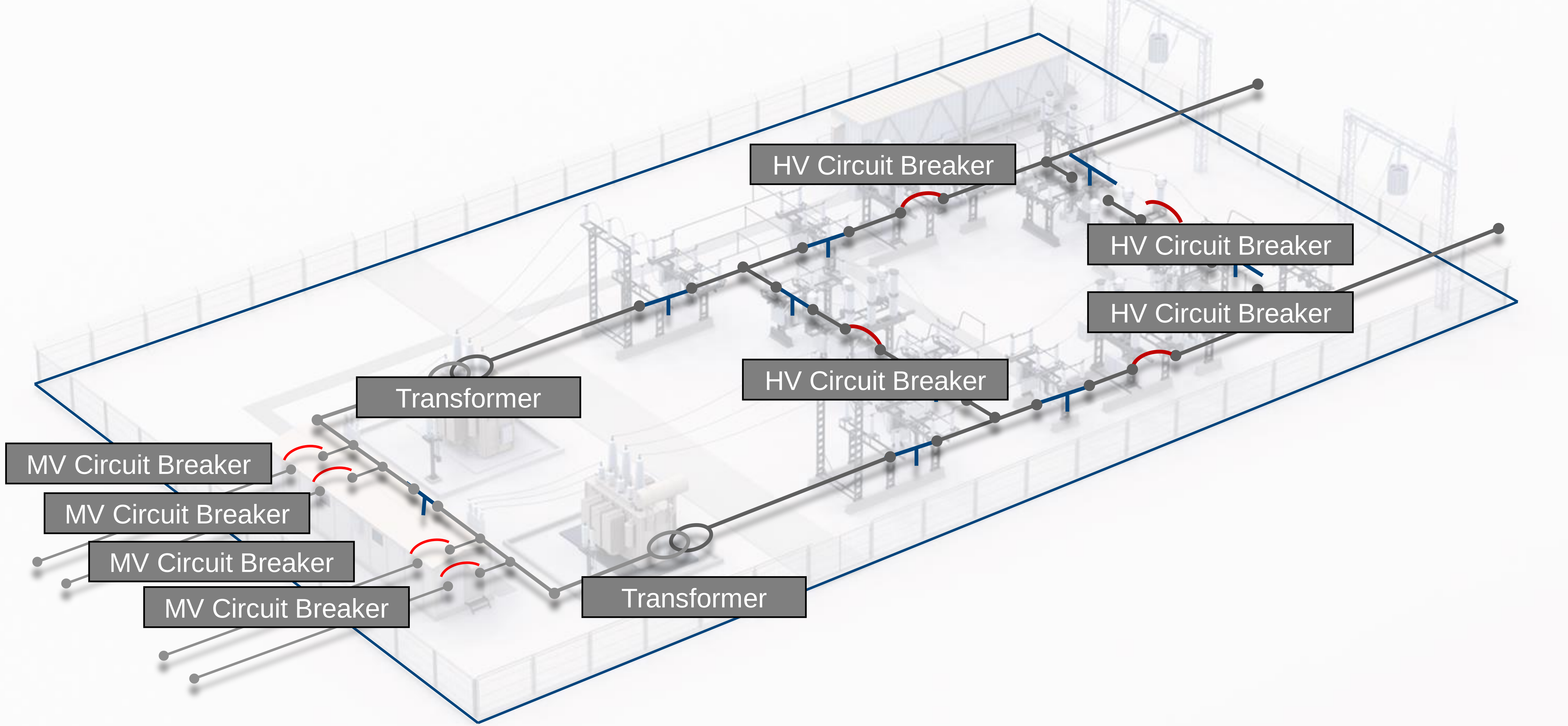
Typical Substation



Typical Substation Equipment



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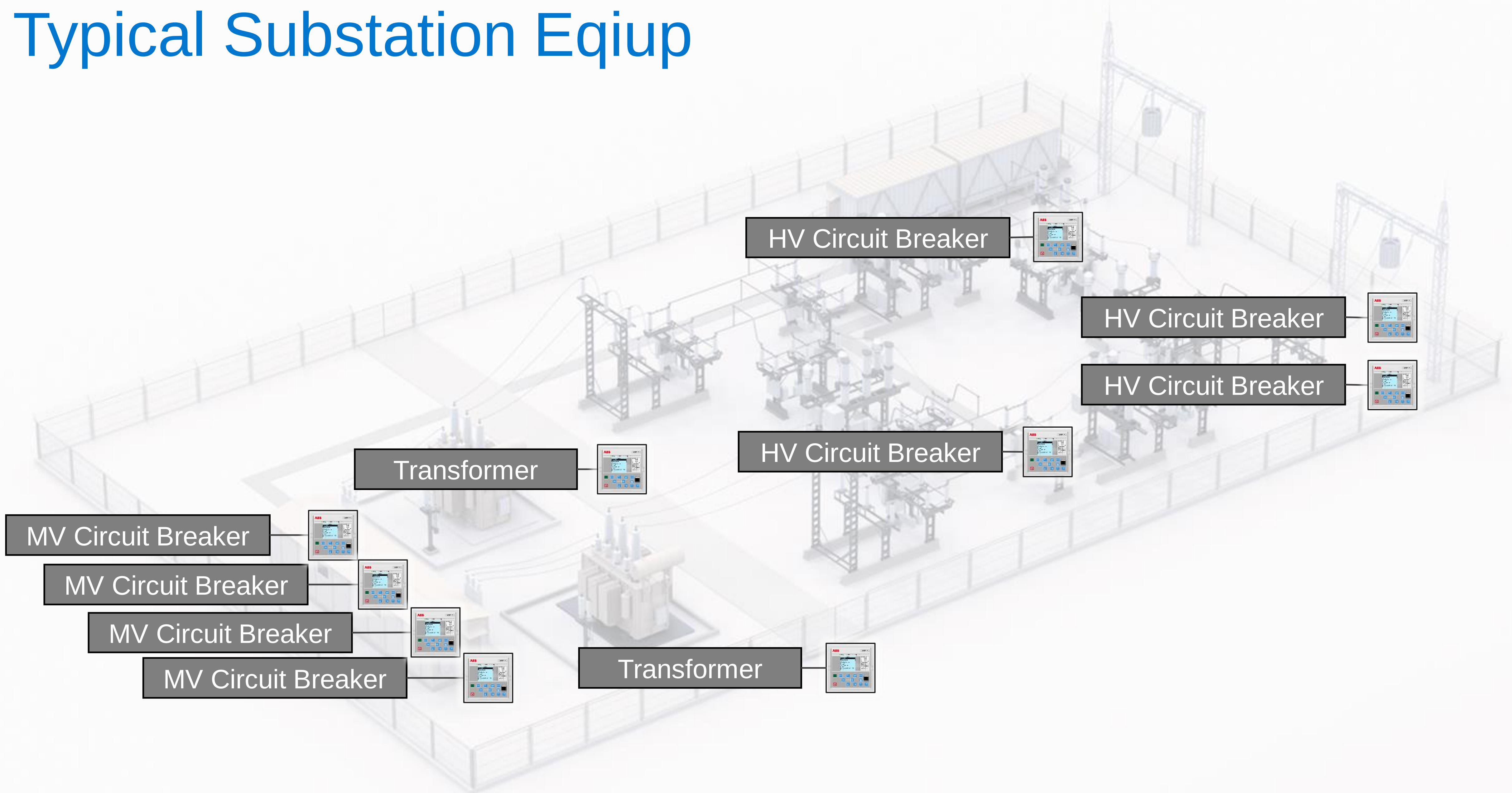
Typical Substation Eqiup



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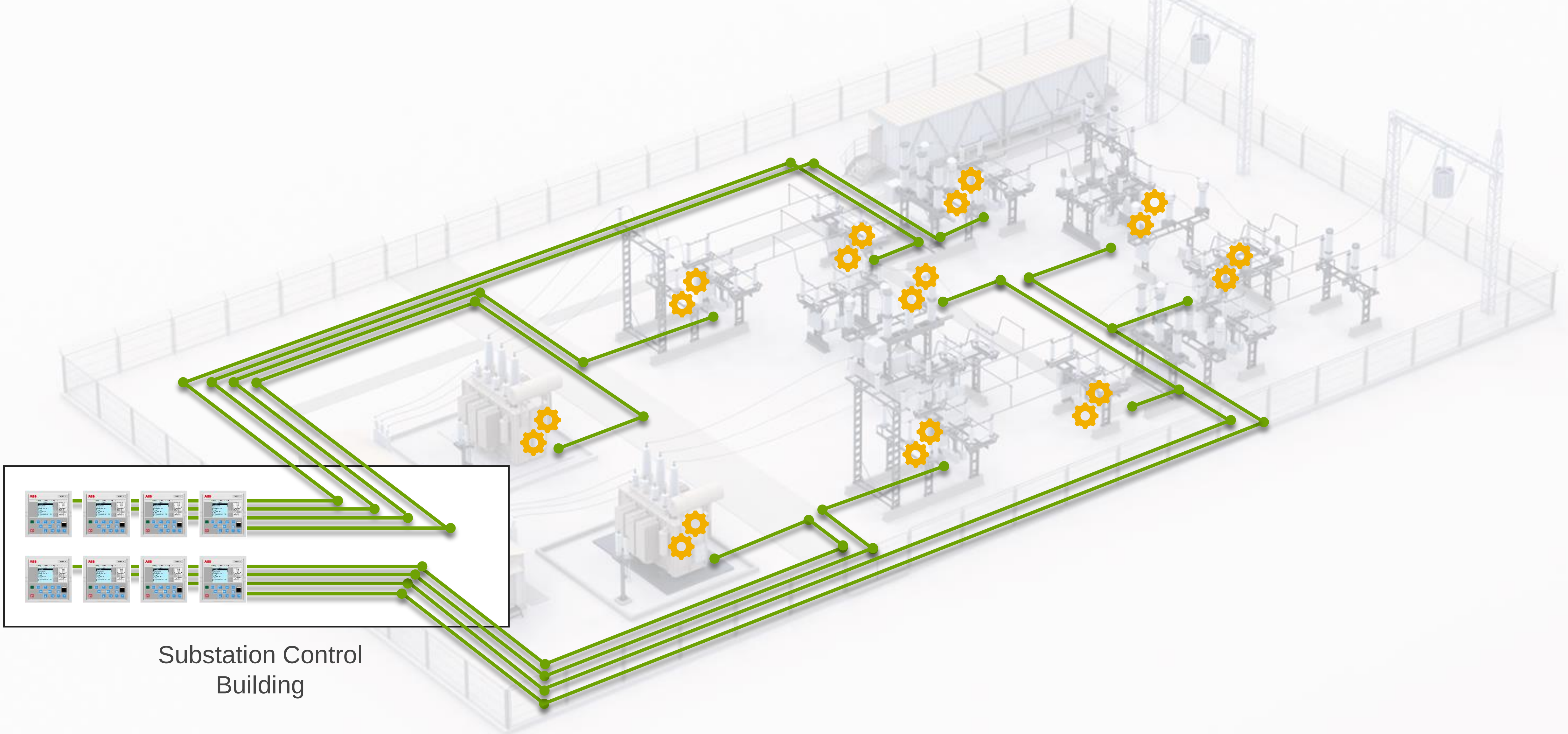
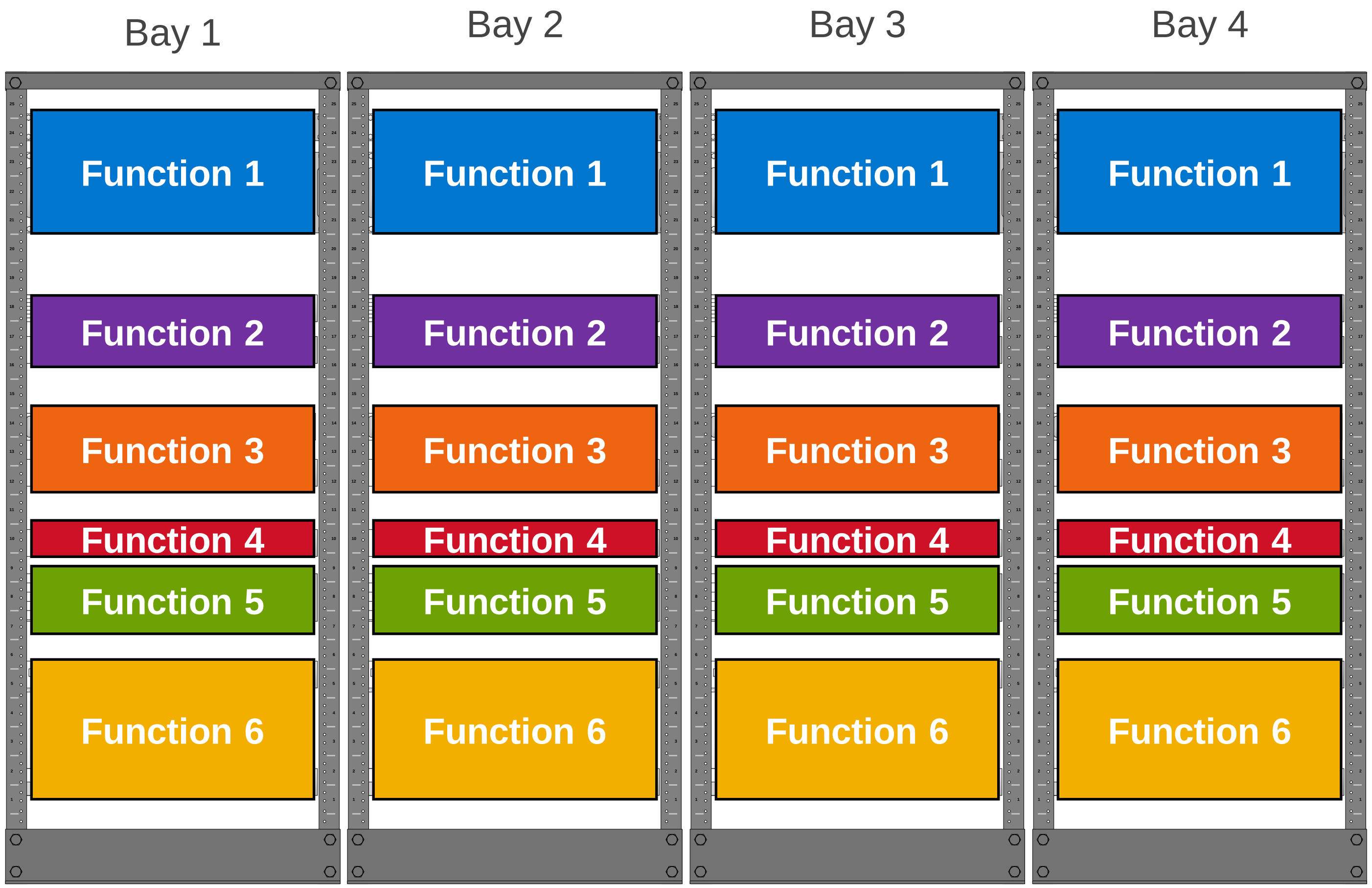
Centralized Protection Equipment



Substation Control Building

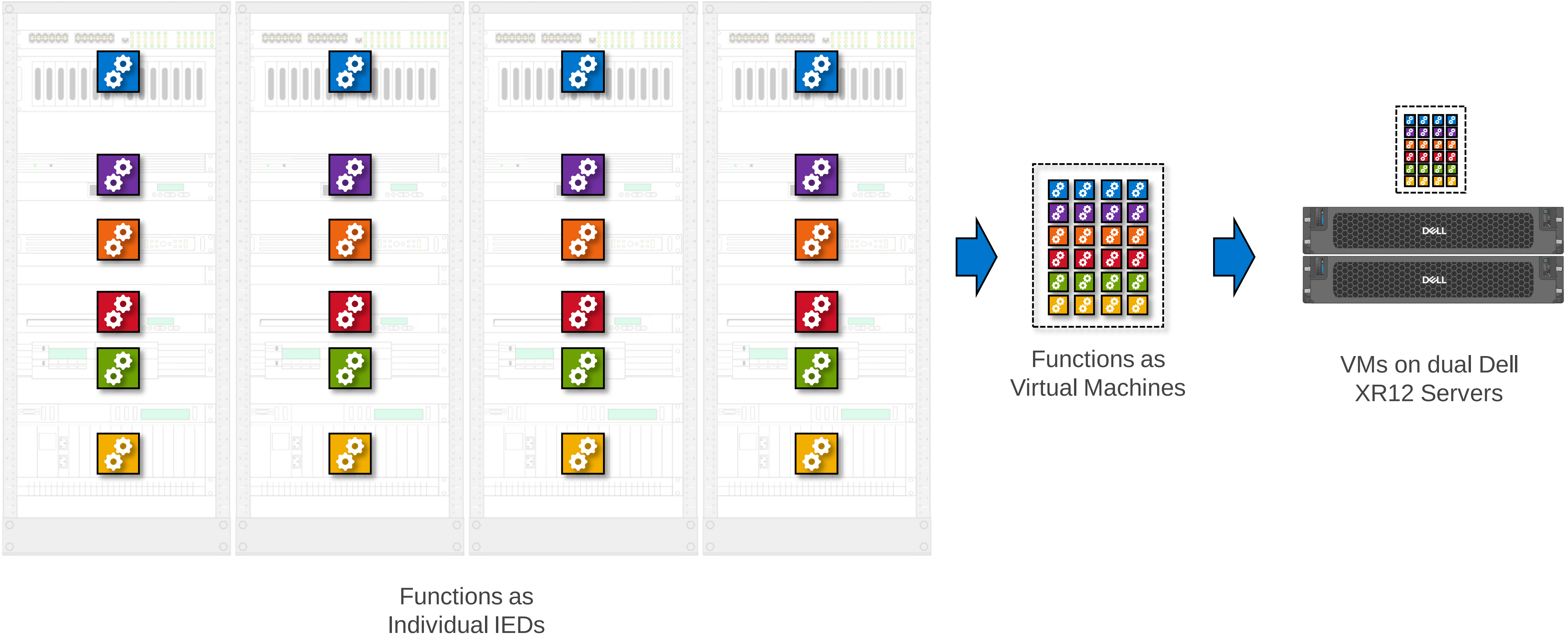
Microprocessor Based Substation Control



Current Substation Control Architecture

- Current substation control and monitoring architecture is limited. It consists of many single function intelligent electronic devices (IED) from multiple vendors each connected via complex copper cabling to substation equipment.
- This leads to an inefficient use of space and resources that is not easy to scale. This lack of scalability leads to increased O&M costs.
- Fundamental changes in substation architecture is needed to enable the energy transition and meet new distribution models.

Substation Functions as VMs



Innovation Through Virtualization

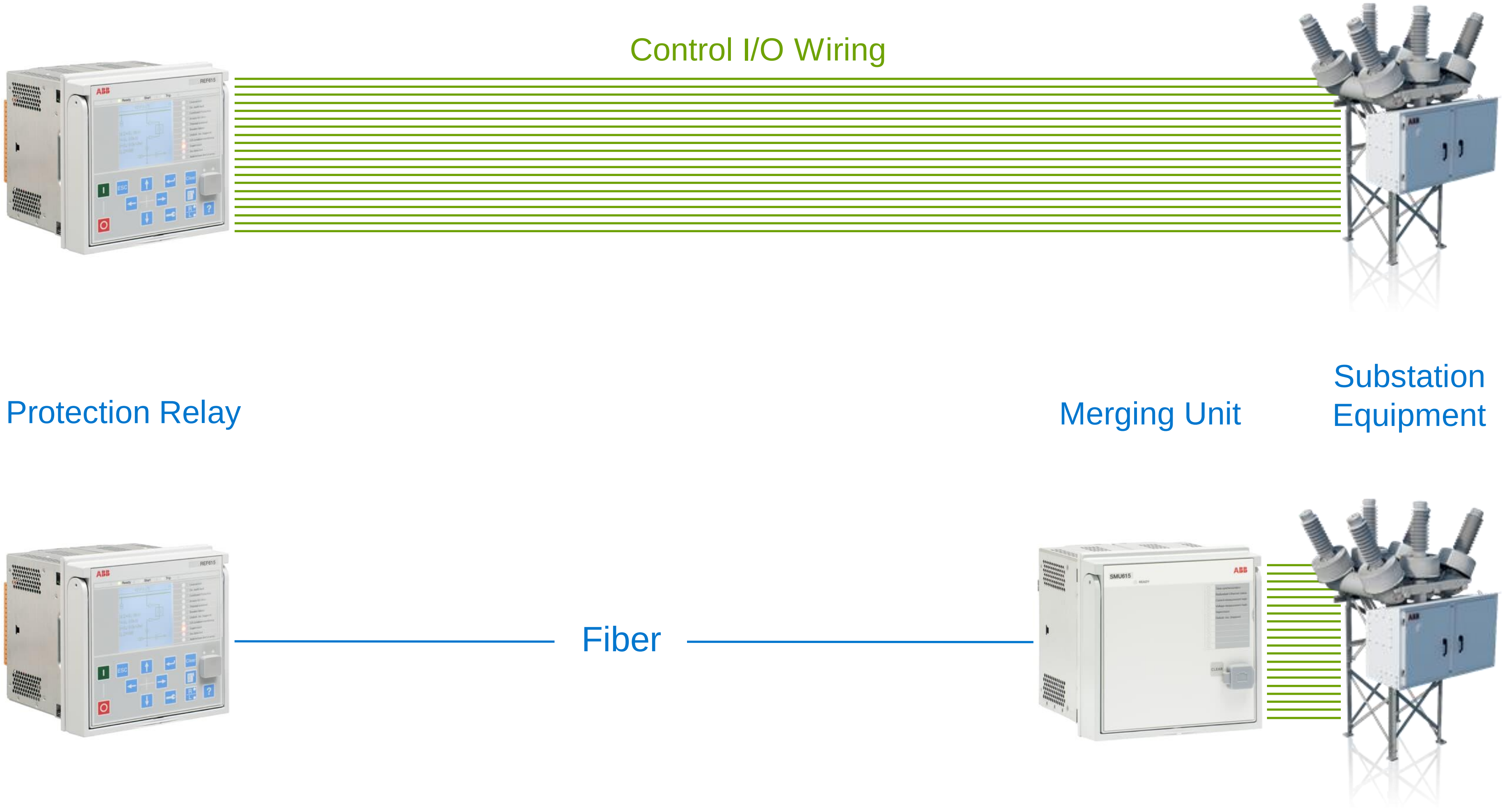
D&LL Technologies

Protection Relay vs Merging Unit vs VPR

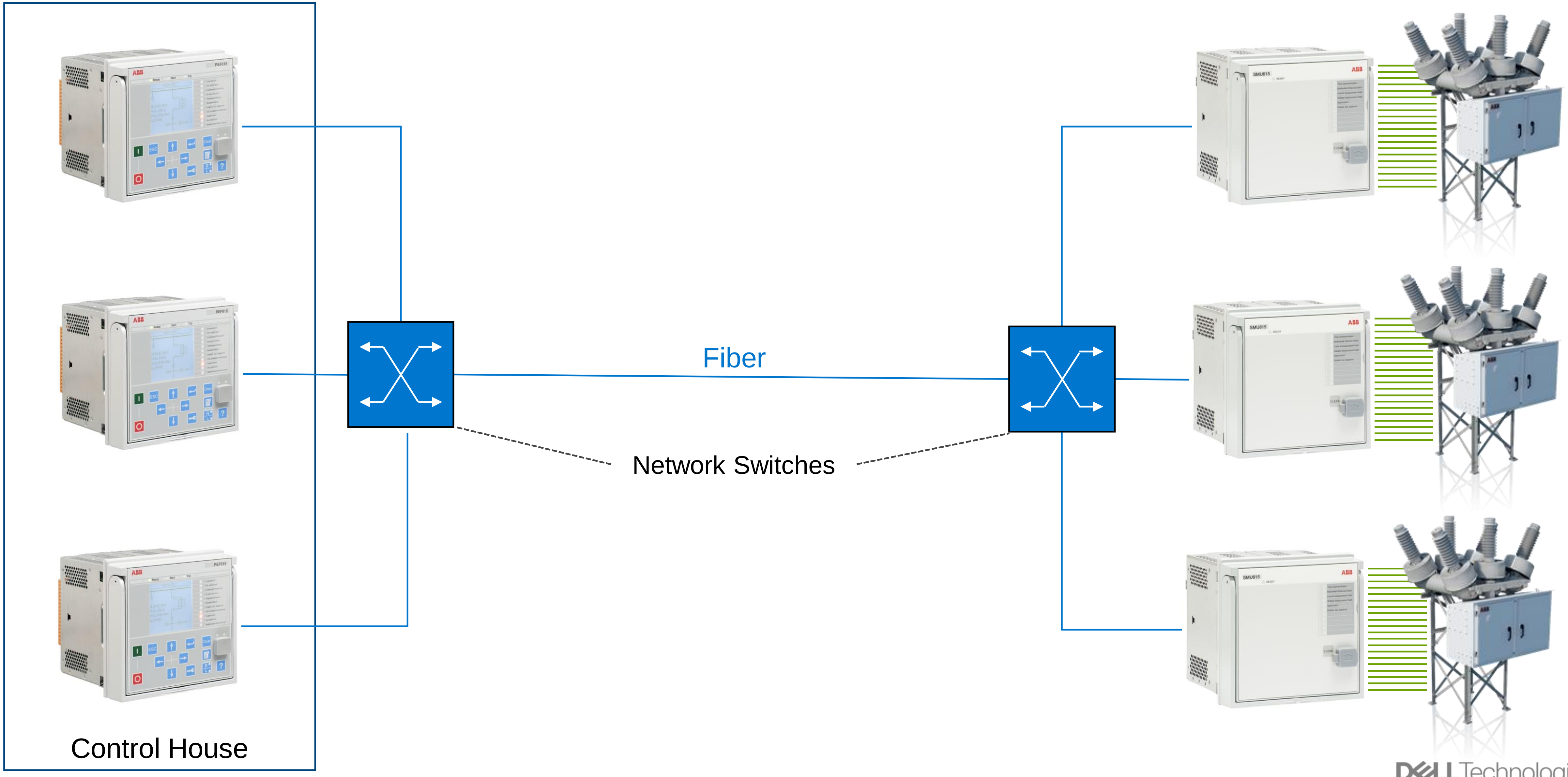
Protection Relay		Virtual Protection Relay		Merging Unit
	=	 VPR	+	
Protection Algorithms		Protection Algorithms		Protection Algorithms
Control Functions		Control Functions		Control Functions
Automation		Automation		Automation
Analog/Digital I/O		Analog/Digital I/O		Analog/Digital I/O

D&LLTechnologies

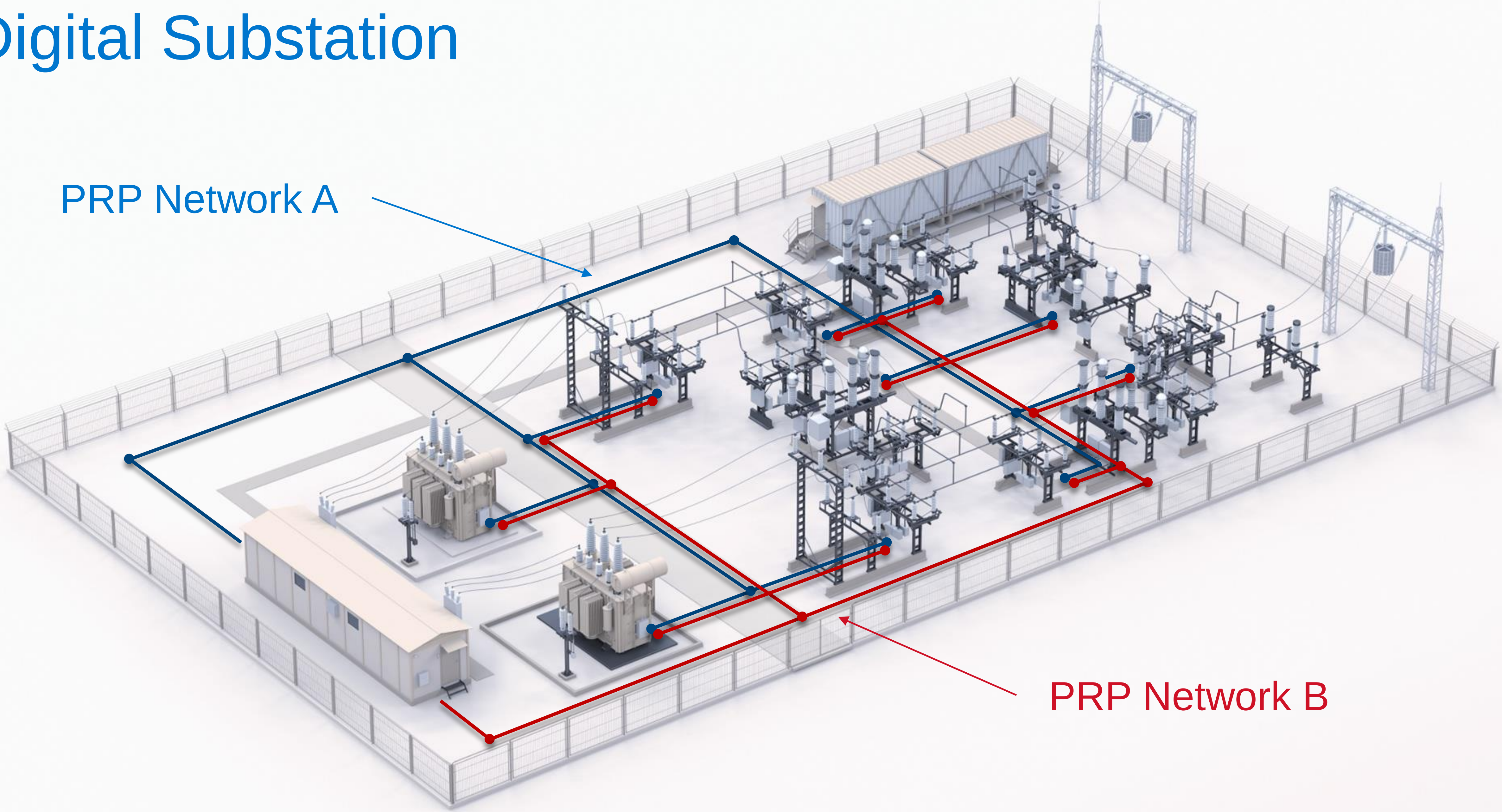
Protection Relay vs Merging Unit



Digital Substation Network



Digital Substation



PRP: Parallel Redundancy Protocol

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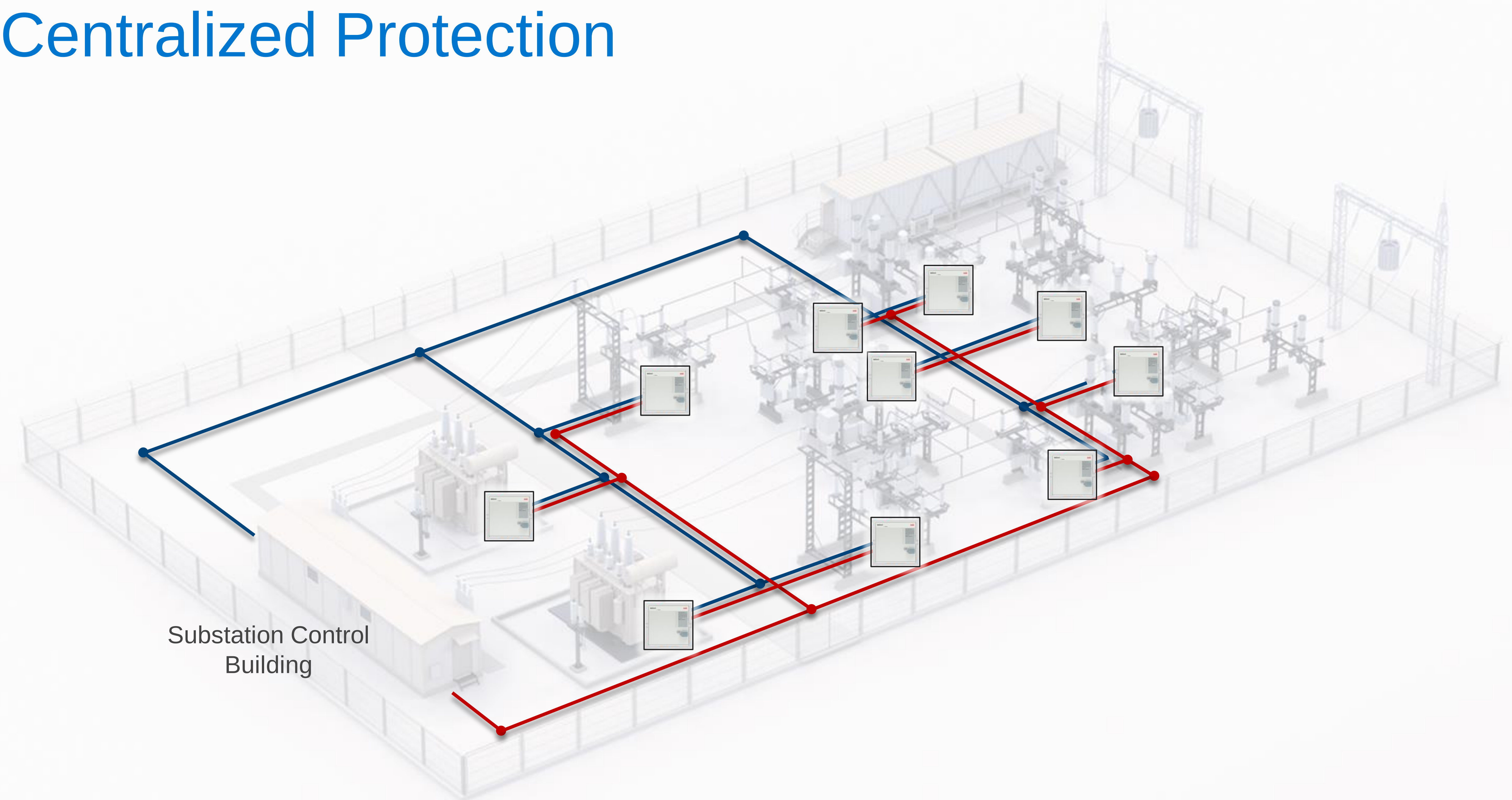
Centralized Protection



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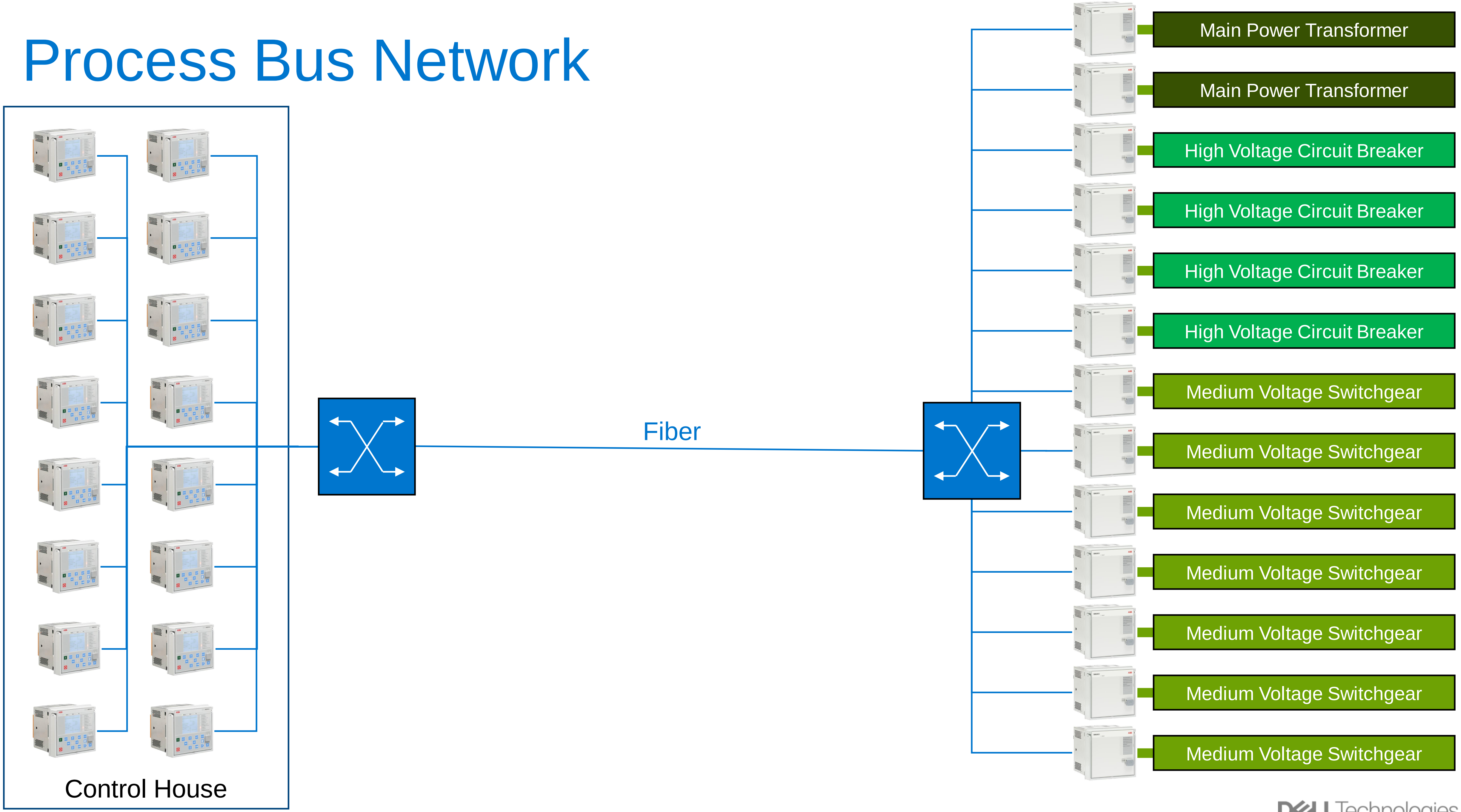
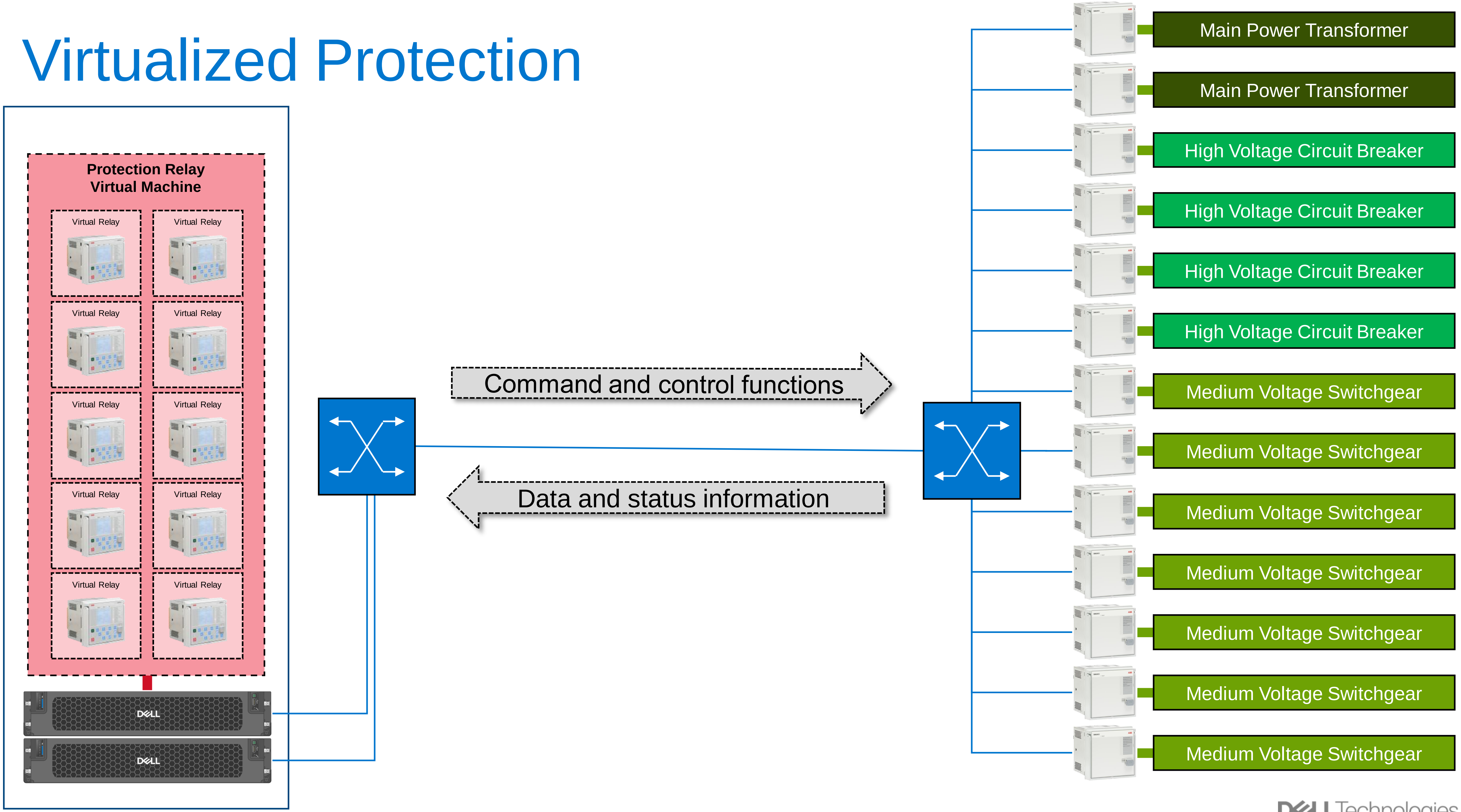
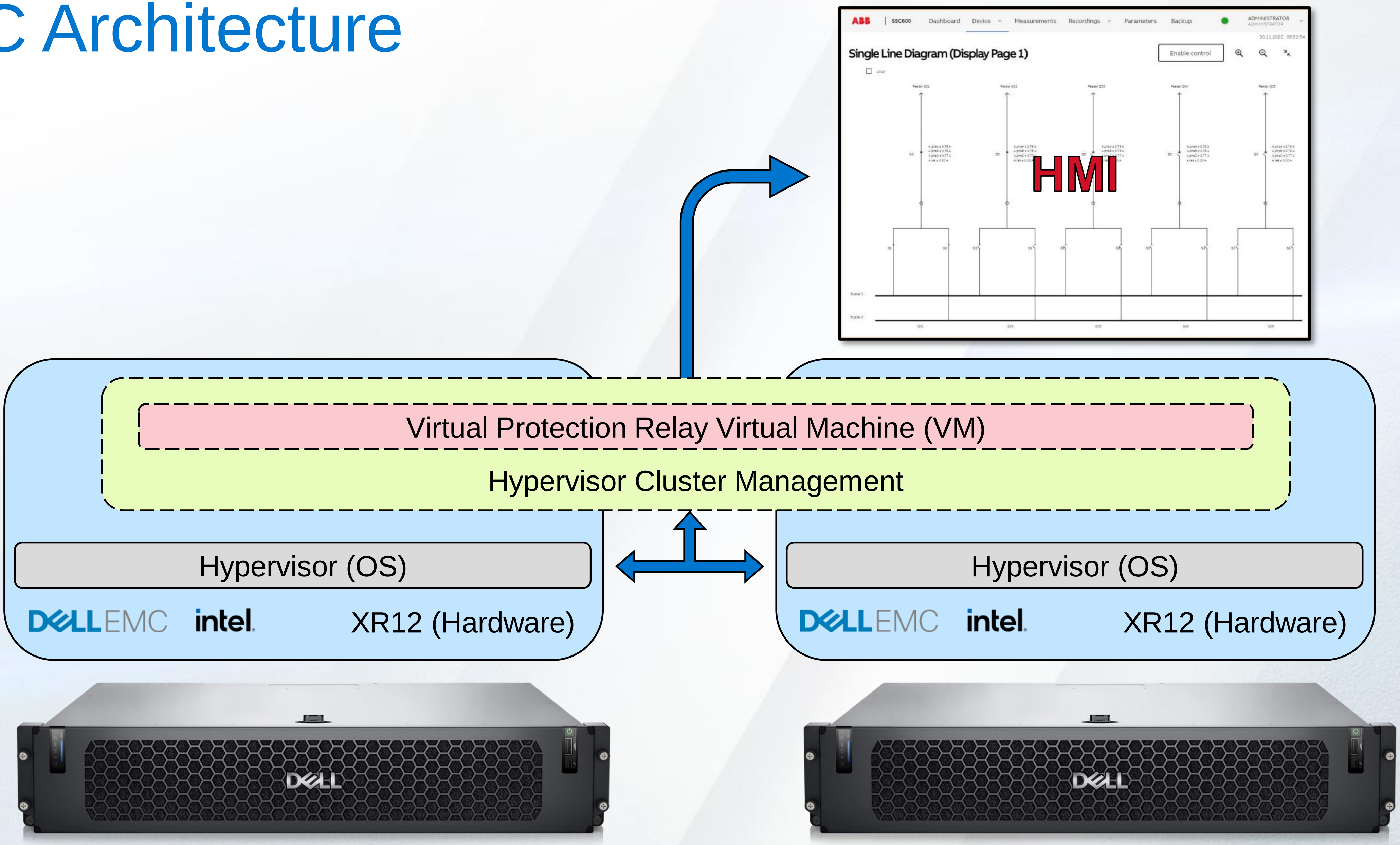
Process Bus Network



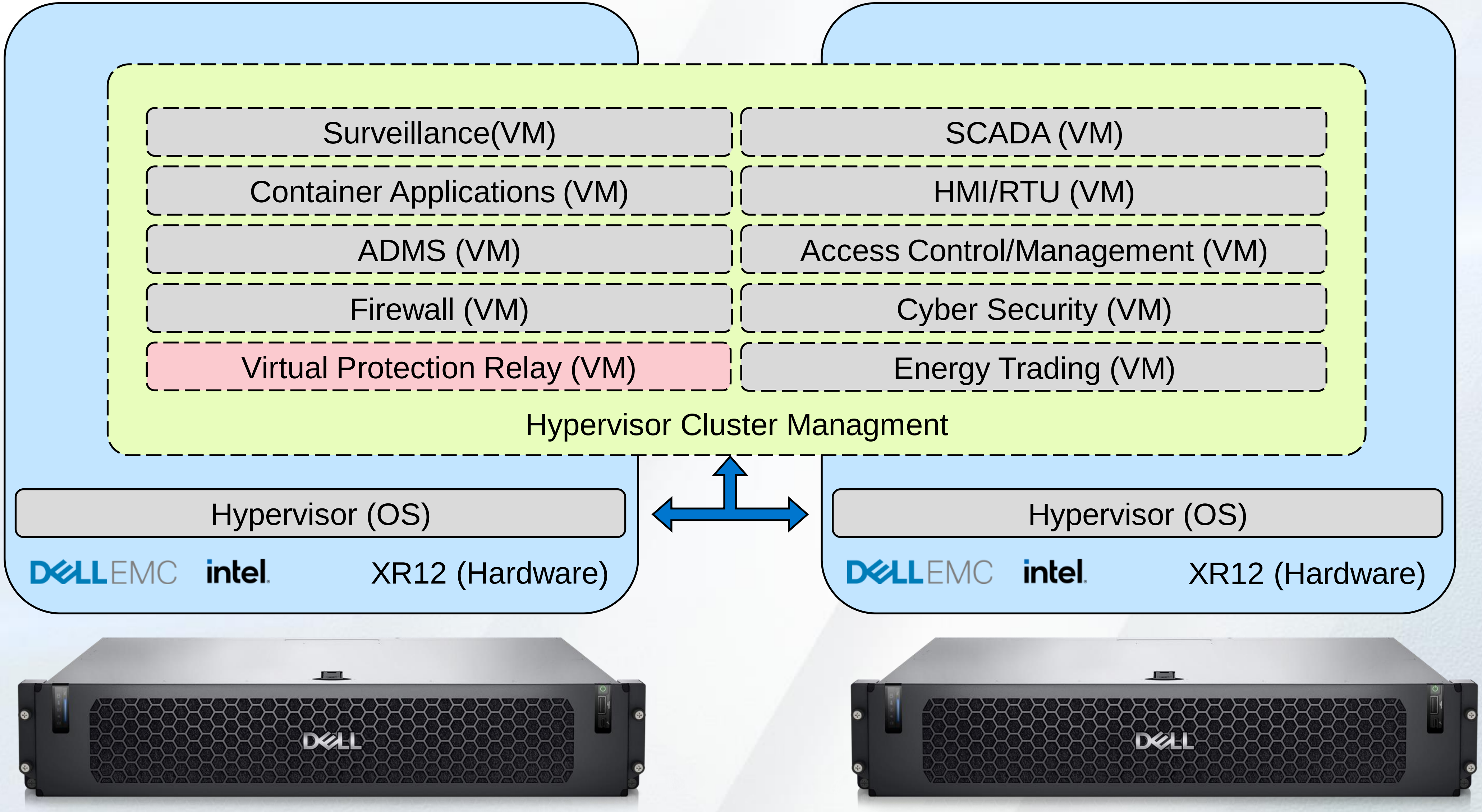
Virtualized Protection

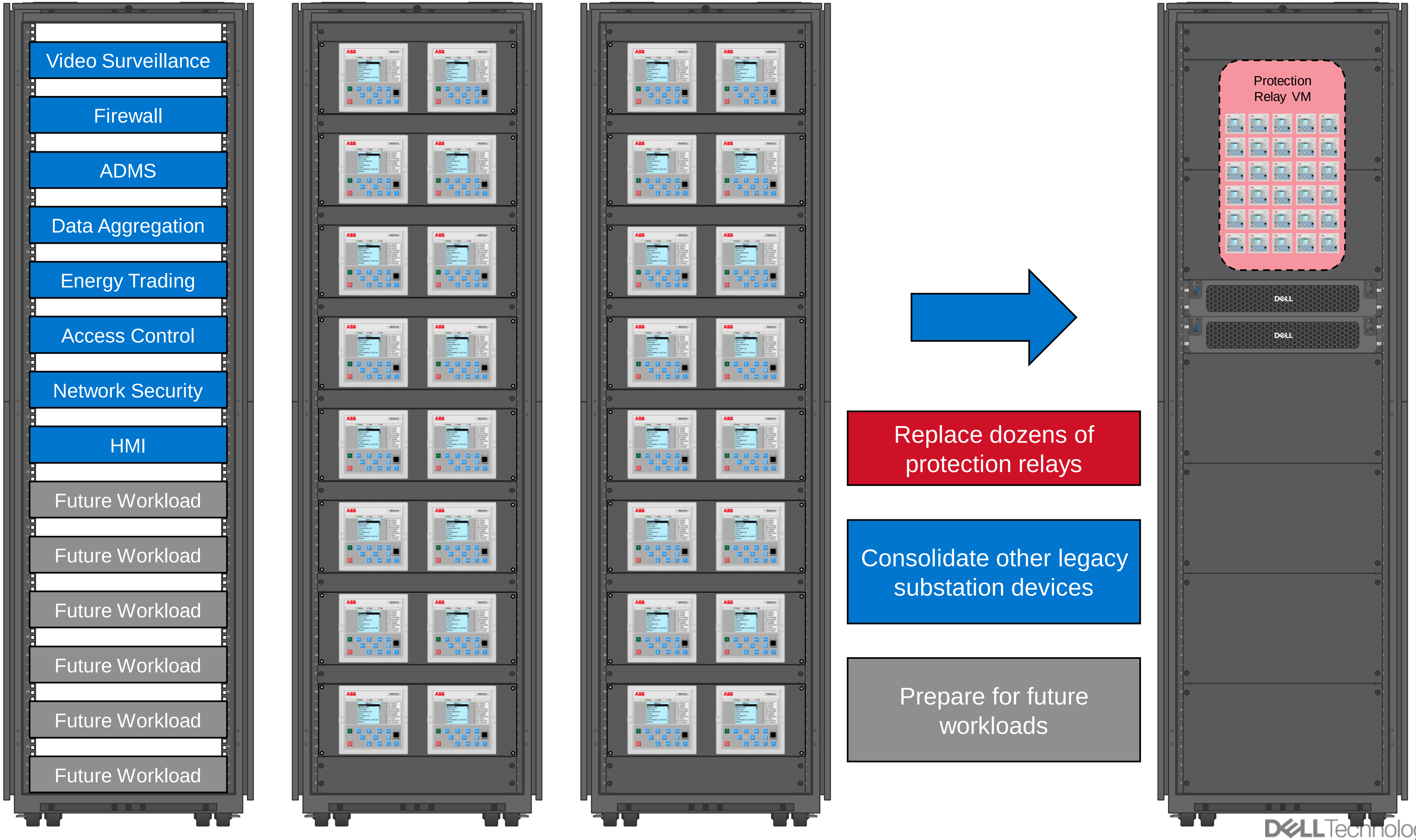


vPAC Architecture



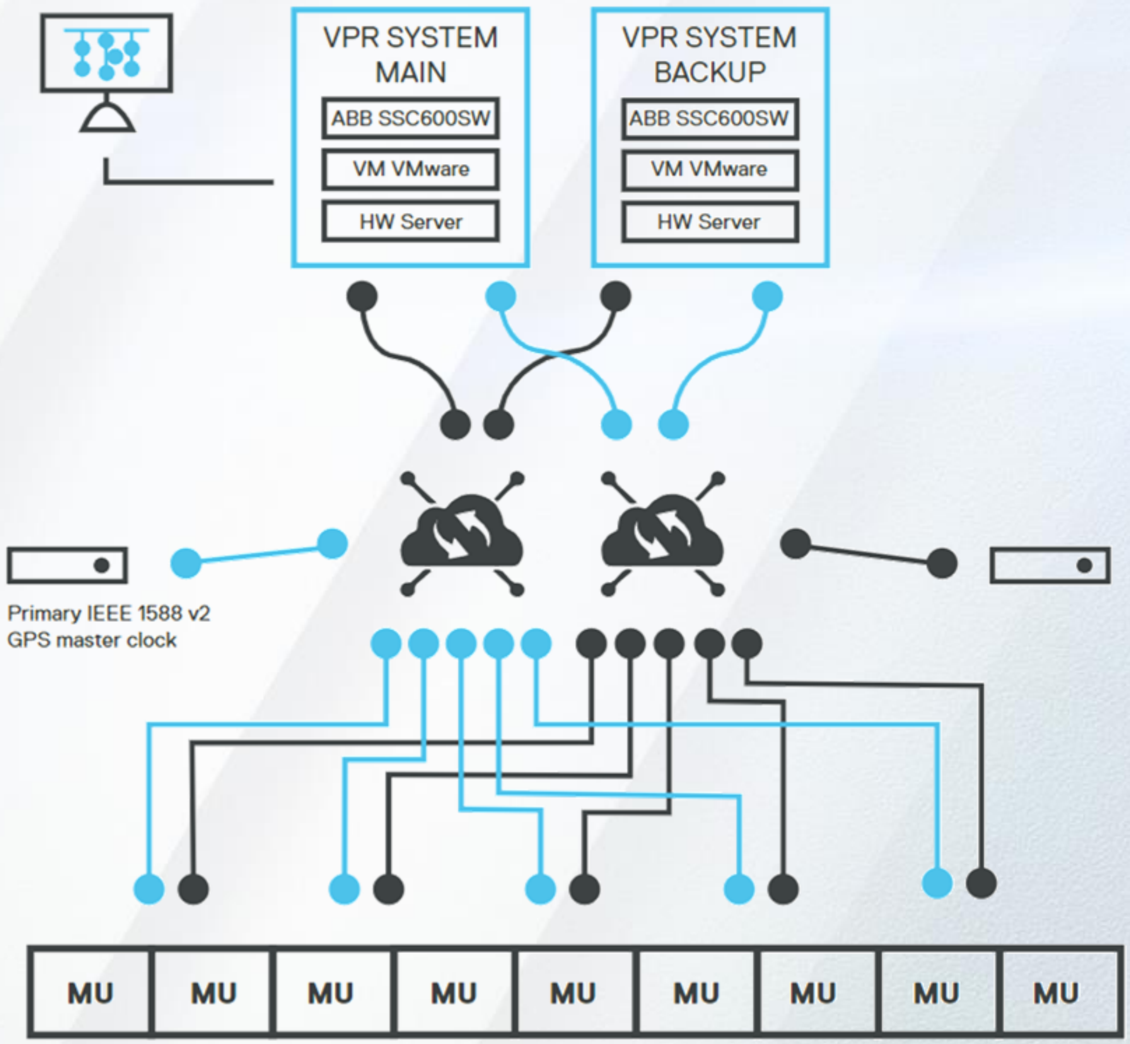
vPAC Future


Surveillance(VM)
SCADA (VM)
Container Applications (VM)
HMI/RTU (VM)
ADMS (VM)
Access Control/Management (VM)
Firewall (VM)
Cyber Security (VM)
Virtual Protection Relay (VM)
Energy Trading (VM)
Hypervisor Cluster Managment
Hypervisor (OS)
Hypervisor (OS)
XR12 (Hardware)
XR12 (Hardware)


Video Surveillance
Firewall
ADMS
Data Aggregation
Energy Trading
Access Control
Network Security
HMI
Future Workload
Future Workload
Future Workload
Future Workload
Future Workload
Future Workload
Protection Relay VM
Replace dozens of protection relays
Consolidate other legacy substation devices
Prepare for future workloads

vPAC: Virtual Protection, Automation, and Control

- Full scalability of hardware and software
- Multi-vendor integration on the same hardware platform
- Remote asset and apps management through VM centralized asset management tools
- Compatible with open-source commercial vendors for the VM layer
- Allow EPCs and utilities to utilize the same components worldwide and customize only the apps needed in the VMs/containers



Business Value Proposition

GLOBAL UTILITY TRENDS

- 60% of Utilities use advanced analytics for targeted customer engagement[1]
- 70% of all new energy generation capacity expected to come from renewables[2]
- 35% of operators that will deploy AI for grid management by 2023[1]
- 50% of Utilities will integrate IT and OT security to secure overall business risk by 2026[1]
- 84% of utilities are either implementing or planning to implement Edge enabled distribution automation[3]
- Clean Alternative Power global power capacity from renewables to double from ~30% in 2020 to 60% in 2030[3]

Graphic supplied by Capgemini SE

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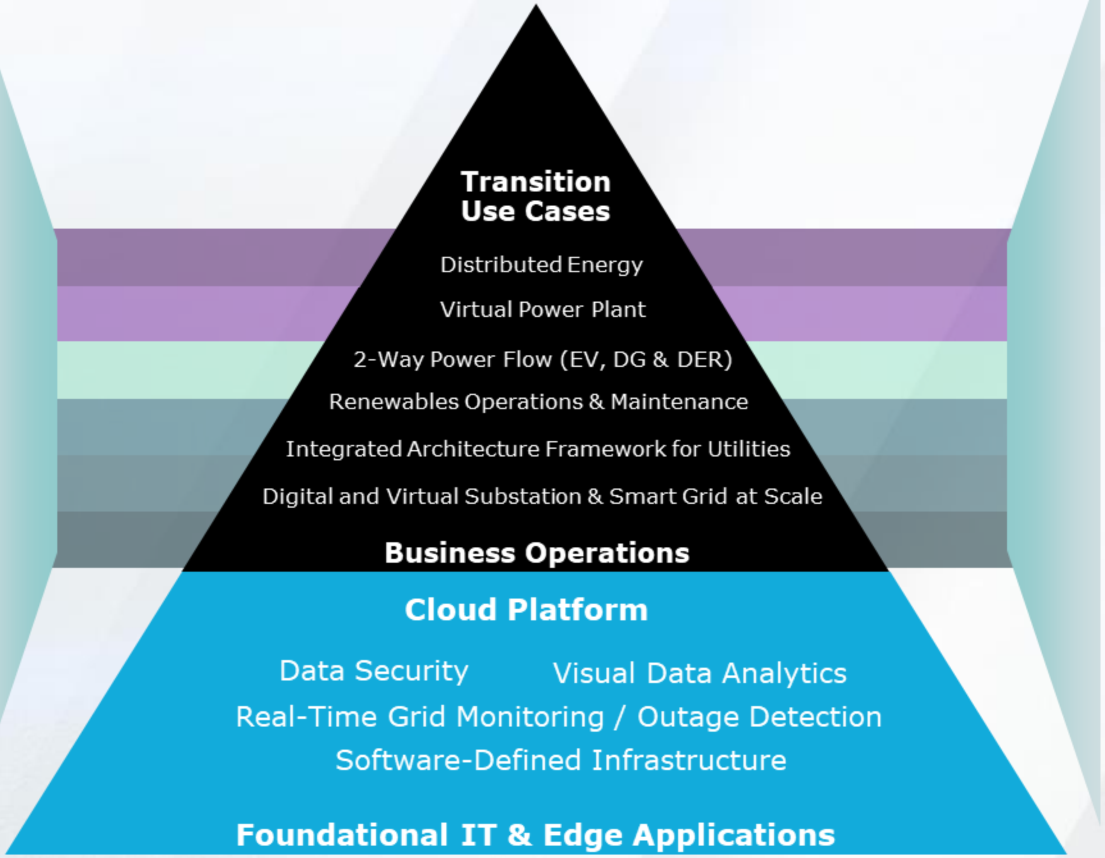
[1] IDC FutureScape 2021
[2] IEA Global Energy Review 2021
[3] Edge Computing is Fueling Energy's Smart Tech Revolution
[4] Salt River Project – vPAC POC



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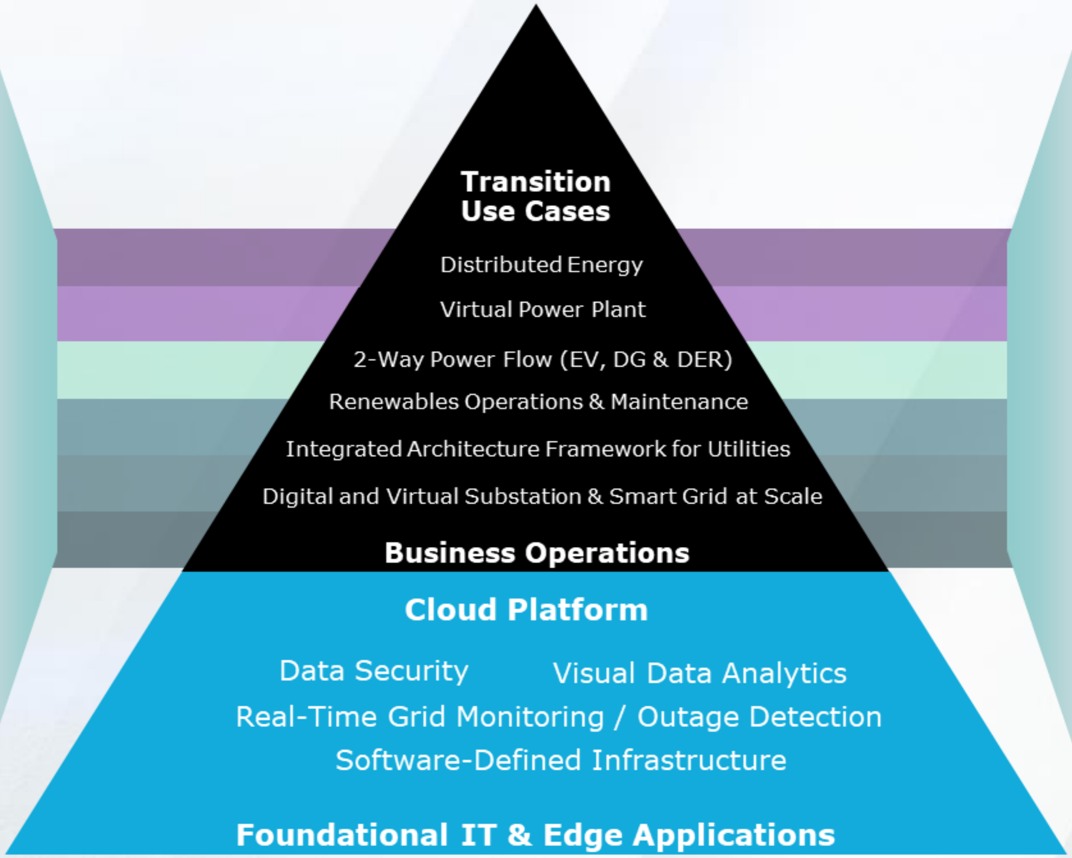


MEASURABLE BUSINESS RESULTS

- Reduced number of devices 50%[4]
- Reduced cost of O&M (OpEx Savings) 76%[4]
- Reduced hardware physical footprint 50%
- TCO reduction in installation and maintenance costs with vPAC (avg. 33%)
- 80% reduction in use of copper by switching to NCIT fiber-based technology
- Improved monitoring of harmonics introduced by 2-way energy flow and increase in induction motors
- Full IEC-61850 design compliance for interoperability and scalability
- NERC-CIP compliance for reduction in security breaches
- Improved computational capacity and data transfer speed via network

Graphic supplied by Capgemini SE

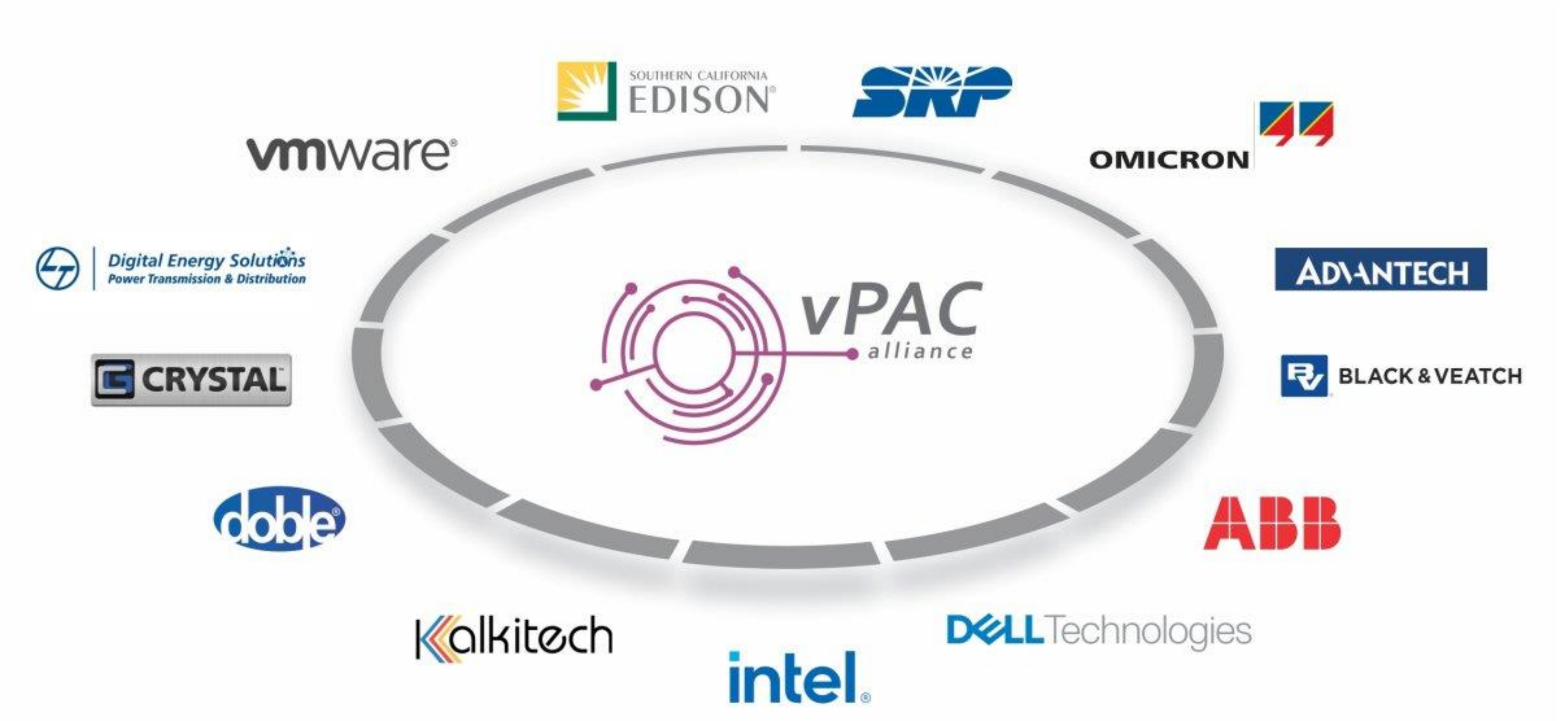
DELL Technologies

Active Partnerships and PoCs

vPAC Alliance

"The following member companies have come together to form the vPAC Alliance and have started to fulfill its mission to develop a standards-based, flexible, manageable, and interoperable platform for the next-generation smart grid."

vPAC Alliance



Internal Use - Confidential

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vPAC Demo

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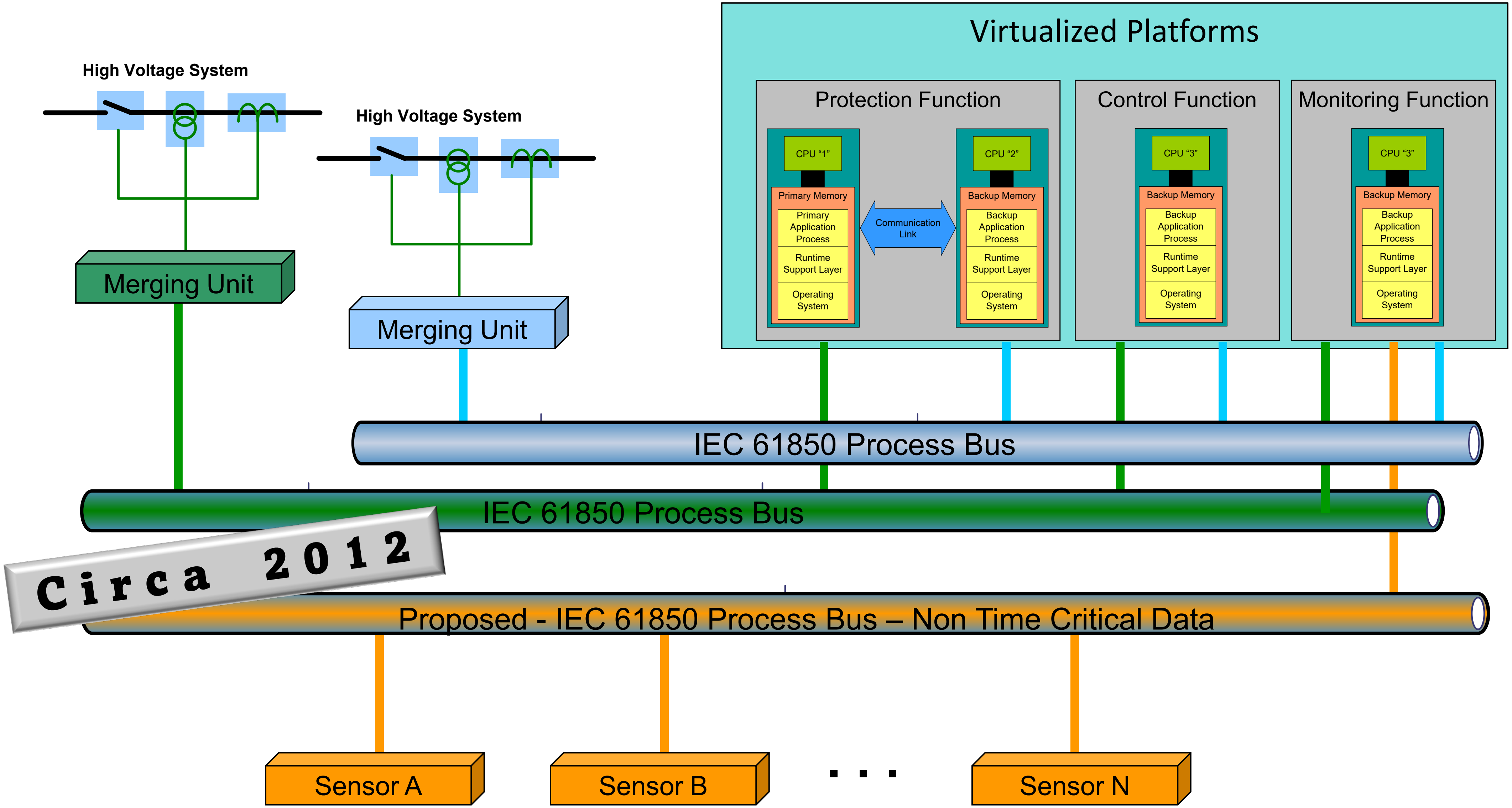
GridWise Alliance Technology Council Meeting

Virtualization of P&C and More

Paul Myrda
Sr. Technical Executive

July 26, 2023

Simplified Overview Protection, Control & Monitoring

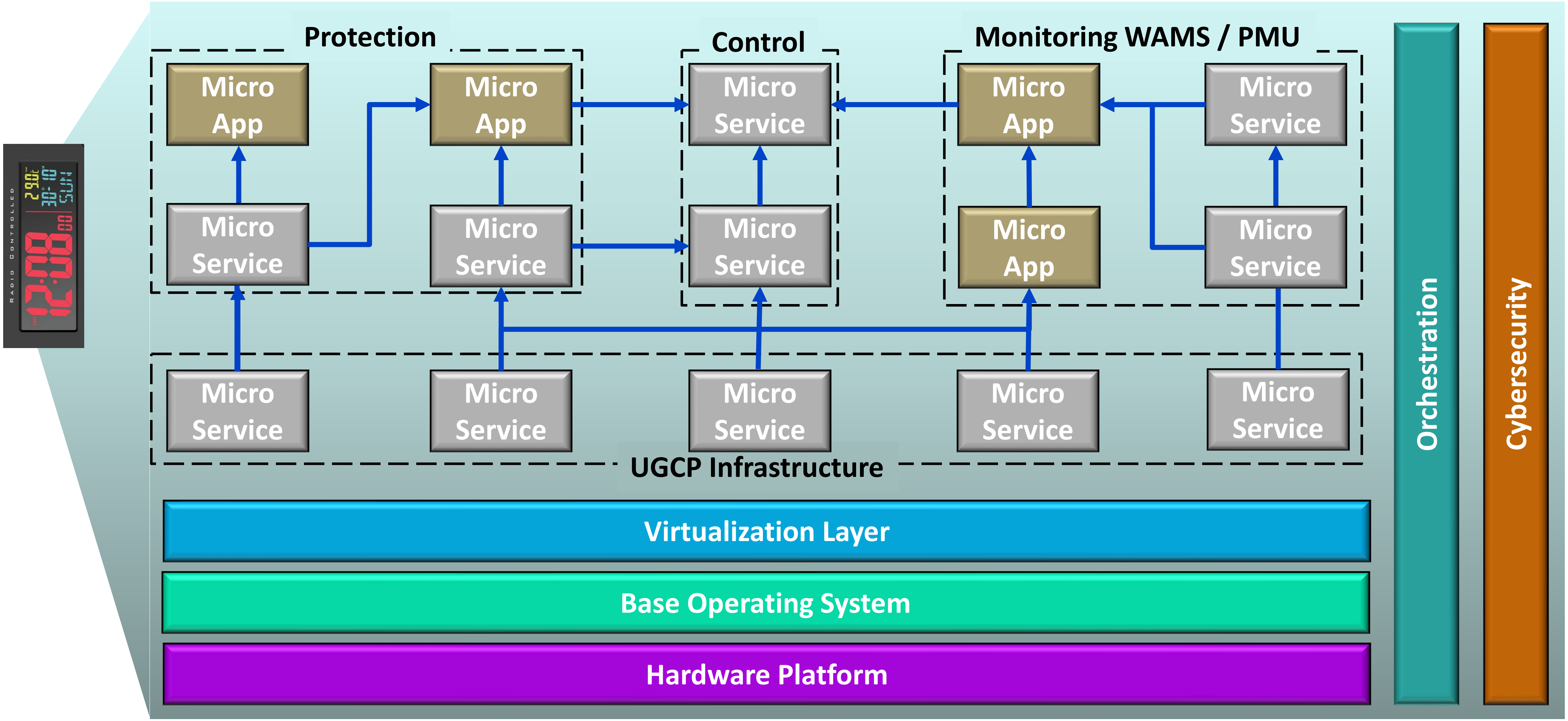


Why do we need a new PAC platform?

- Deploying more racks of defined-function IEDs is unsustainable – we already are challenged to keep up with the obsolescence treadmill.
- The industrial, business, and communications/IT worlds have moved to new wide-area flexible generic platforms and tools.
- Leading-edge developments we see in PAC give us methods and tools to adapt to the emerging grid.

The new Unified Grid Control Platform (UGCP) PAC architecture merges these developments

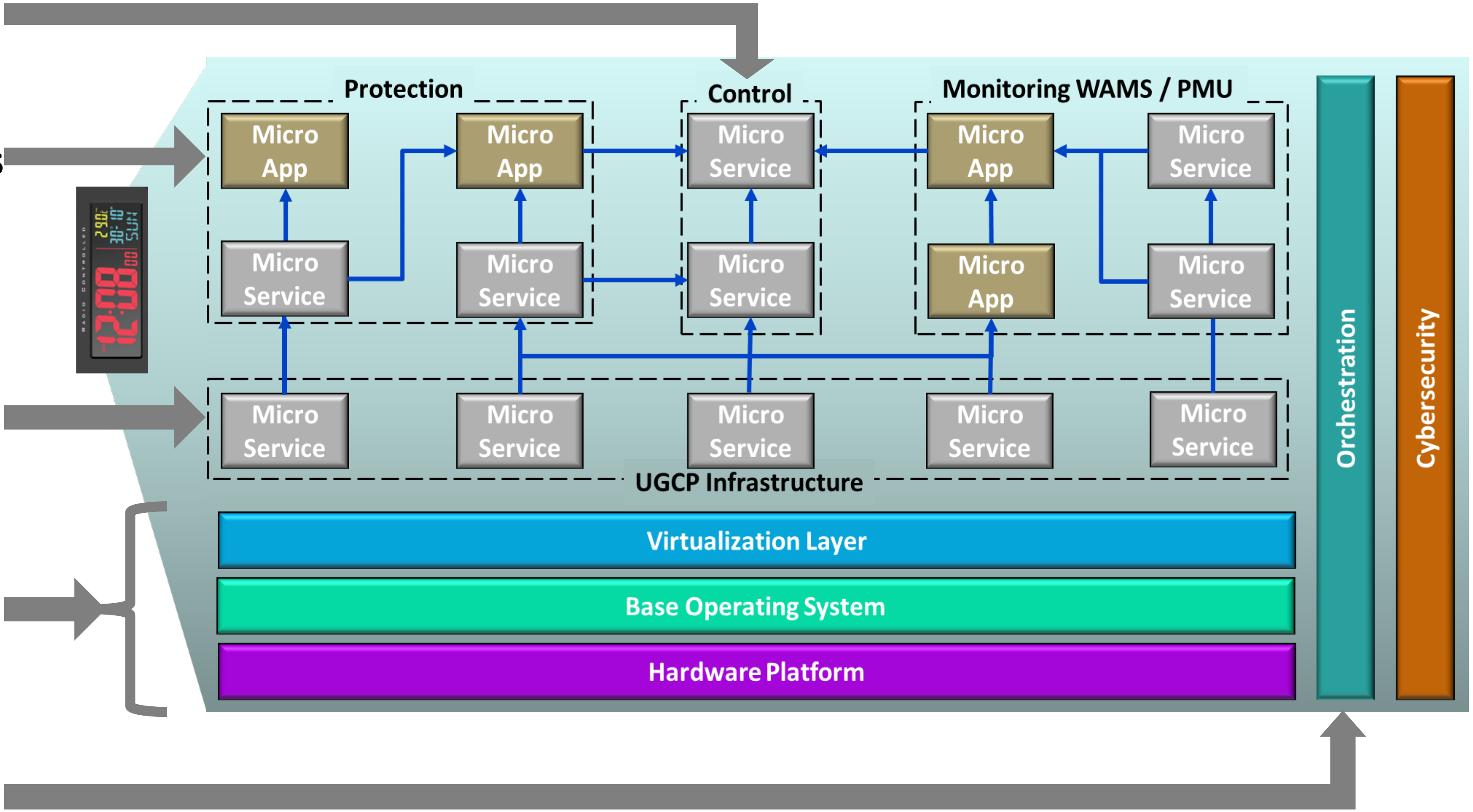
UGCP Architecture - Conceptual



EPRI

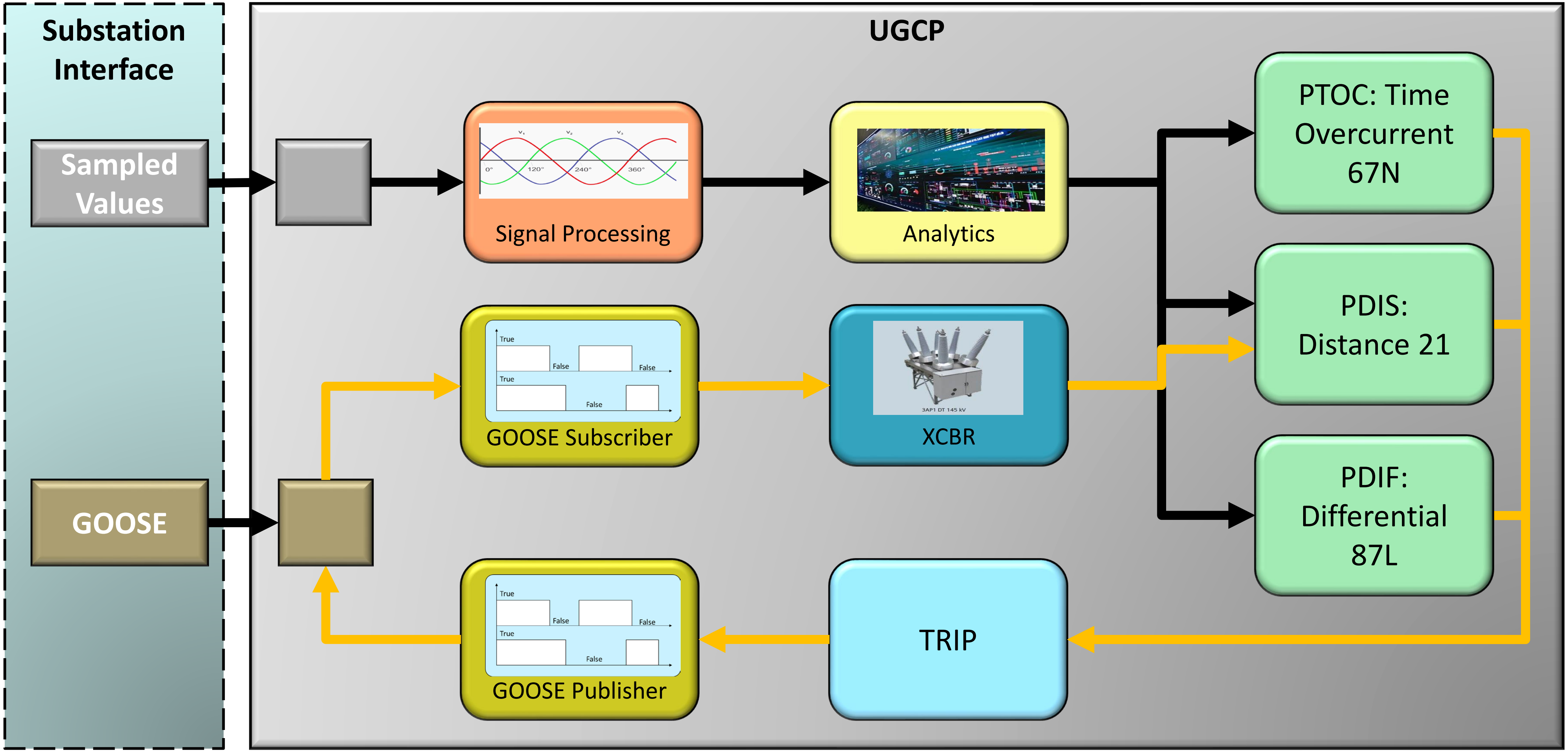
UGCP Architecture - Conceptual

- **Event Based Services**
  - Low latency
- **Protection Domain Services**
  - CPU Intensive
  - Millisecond time
- **Infrastructure Services**
  - Microsecond precision time
  - PTP Synchronization
  - GOOSE Interchange
- **Micro-Orchestration**
  - Core / Memory assignments
  - CPU time
- **Macro-Orchestration**
  - Clusters of nodes



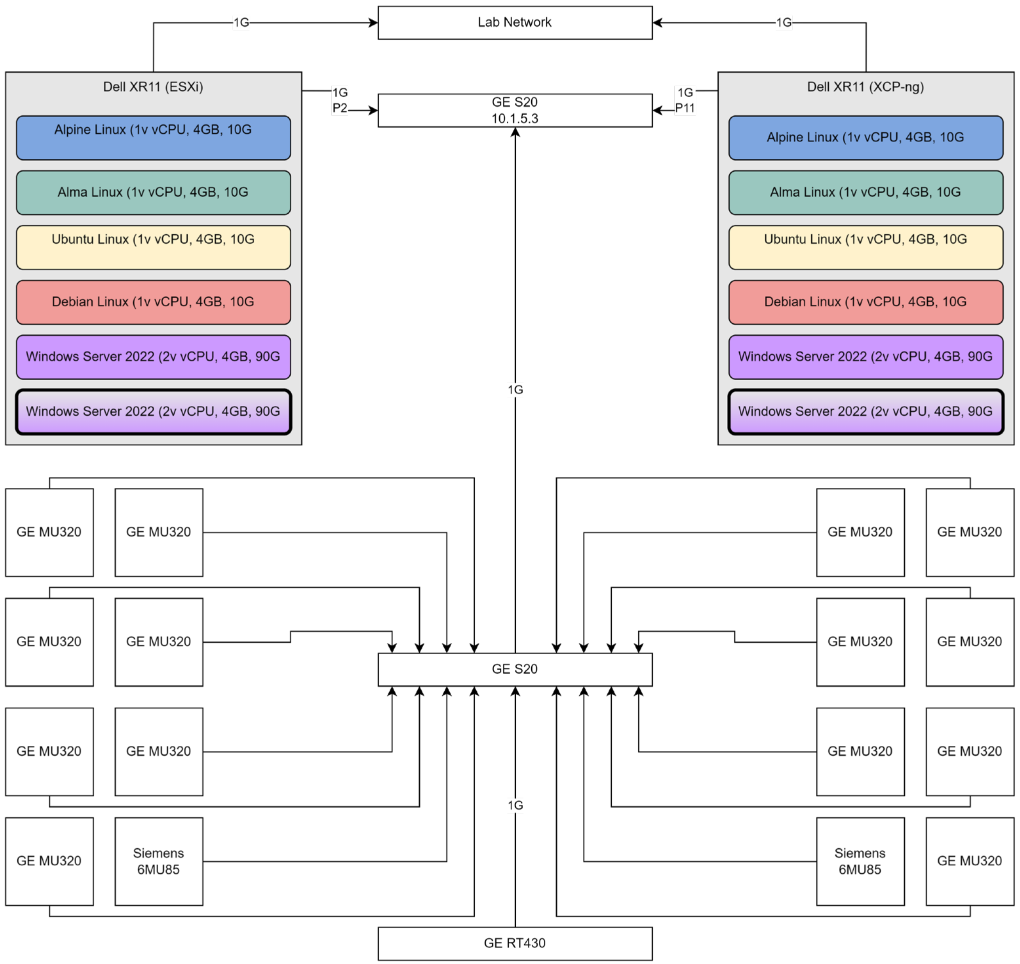
EPRI

Example Functional Architecture



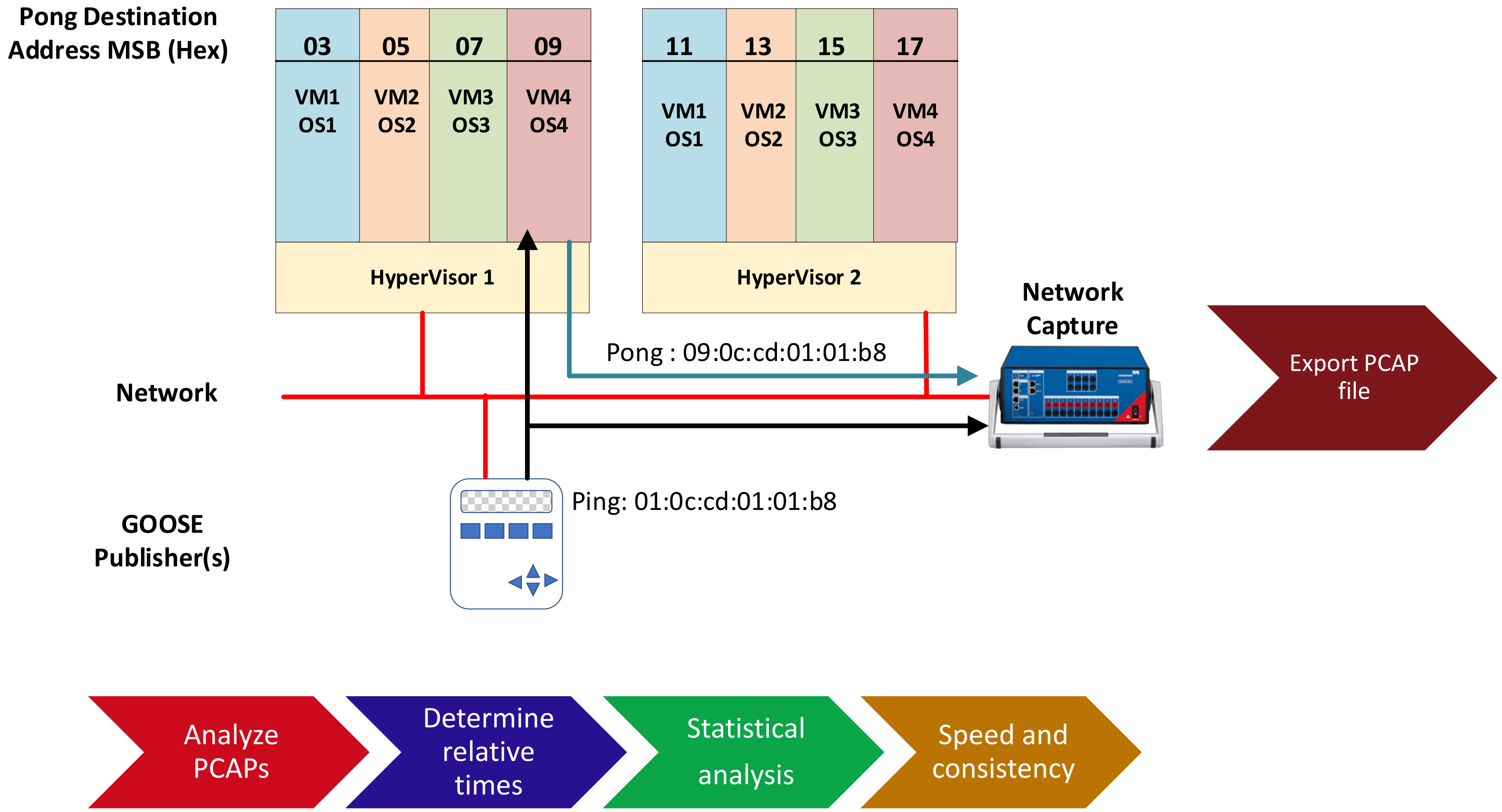
Utility Test Bed

- Duplicate Hardware Platforms
- 2 different virtualization products
- 6 different VM's
- Similar Lab at EPRI Knoxville



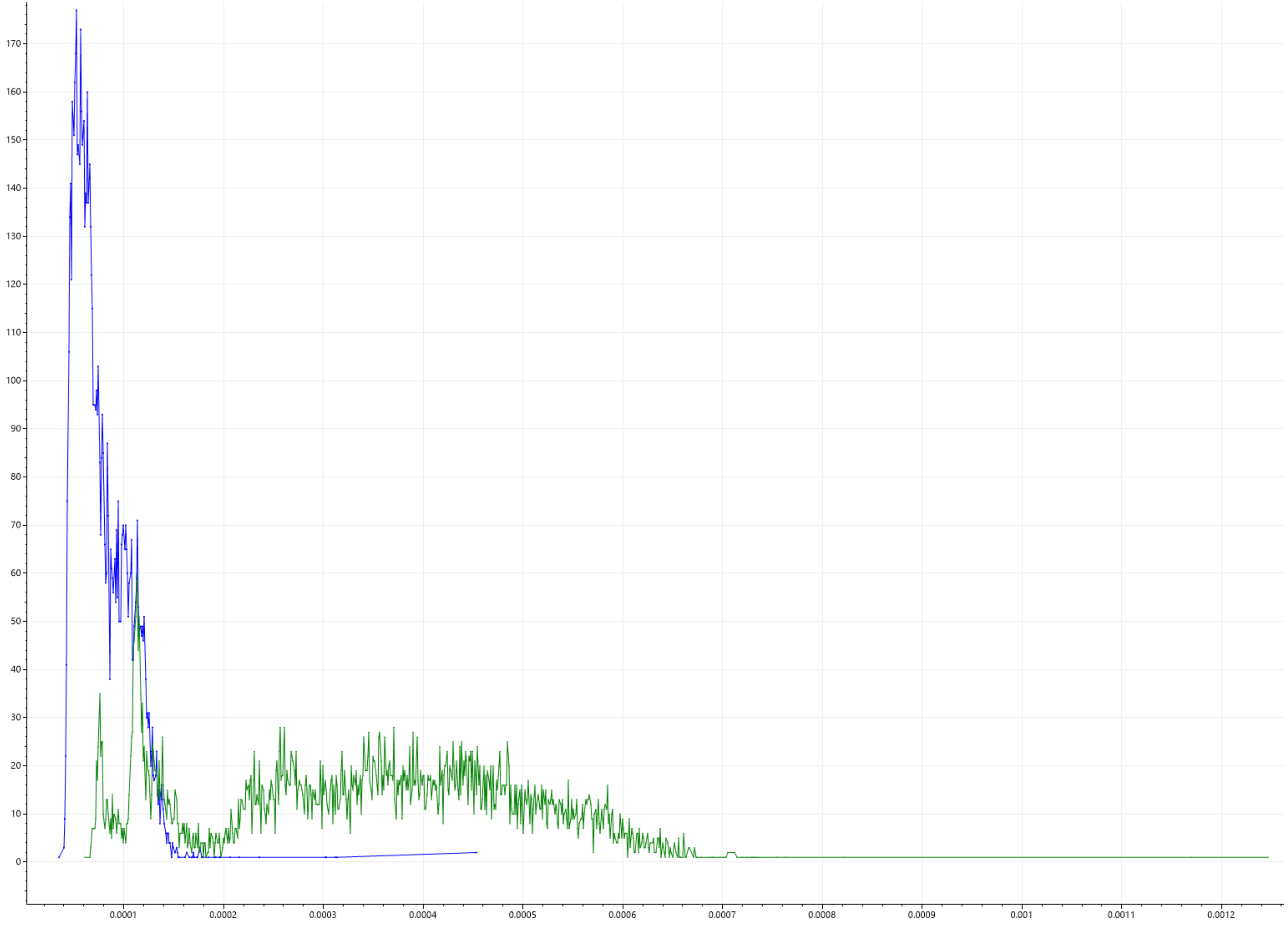
EPRI initial testing of GOOSE communications among platforms and containers

- Separate hardware platforms can be different.
- Hypervisor (Type 1 runs on HW) manages containers with virtual machines.
- Virtual machines are networked and can exchange GOOSE or any other PAC traffic



EPRI initial testing of GOOSE communications among platforms and containers

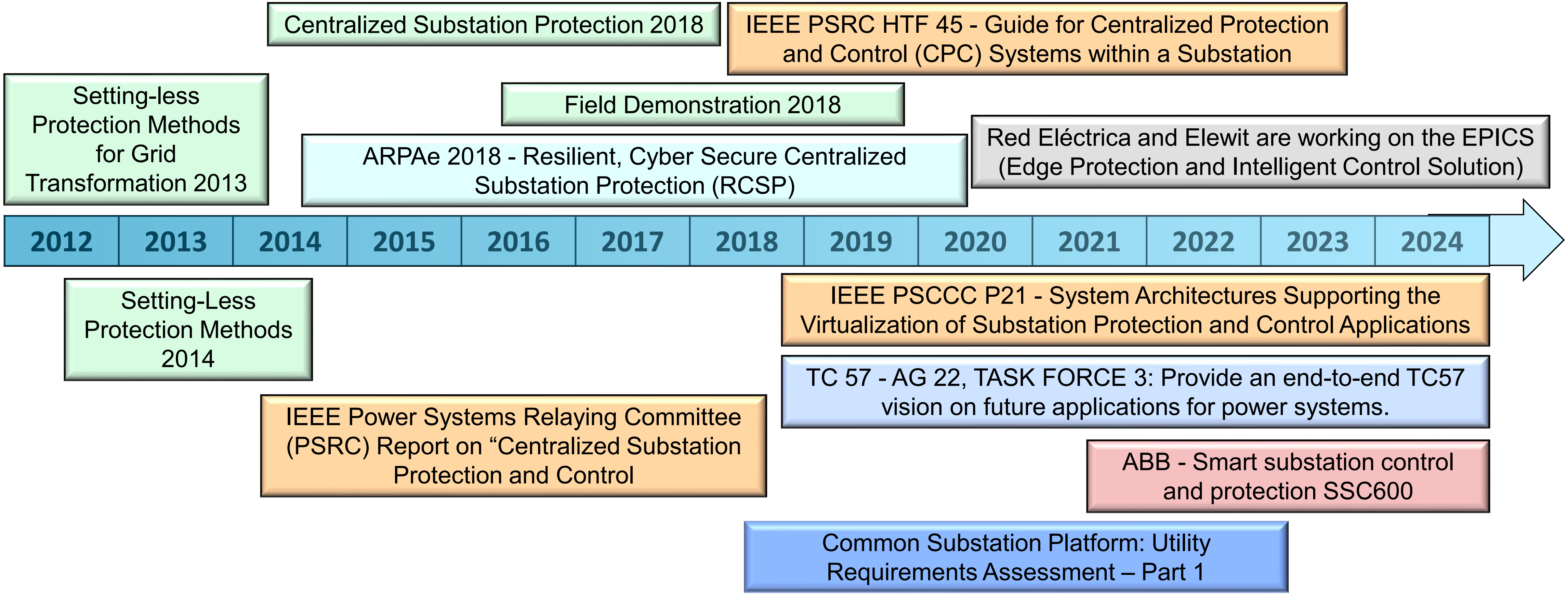
- Typical 100 ns inter-container GOOSE messaging response time depending on loading.
- Tests on today’s practical hardware showed plenty of capacity for full-substation PAC functions exchanging messages continuously.



Partial Test Scale Up Plan

Test	VM-1	VM-2	VM-3	VM-4
1	GOOSE test software executing	Not running	Not running	Not running
2	GOOSE test software executing	Running	Not running	Not running
3	GOOSE test software executing	Running	Running	Not running
4	GOOSE test software executing	Running	Running	Running
5	GOOSE test software executing	GOOSE test software executing	Not running	Not running
6	GOOSE test software executing	GOOSE test software executing	Running	Not running
7	GOOSE test software executing	GOOSE test software executing	Running	Running
8	GOOSE test software executing	Loading software running at 50%	Running	Running
9	GOOSE test software executing	Loading software running at 50%	Loading software running at 50%	Running
10	GOOSE test software executing	Loading software running at 50%	Loading software running at 50%	Loading software running at 50%
11	GOOSE test software executing	GOOSE test software executing Loading software running at 50%	Loading software running at 50%	Loading software running at 50%

Relevant Industry Grid Edge Activities



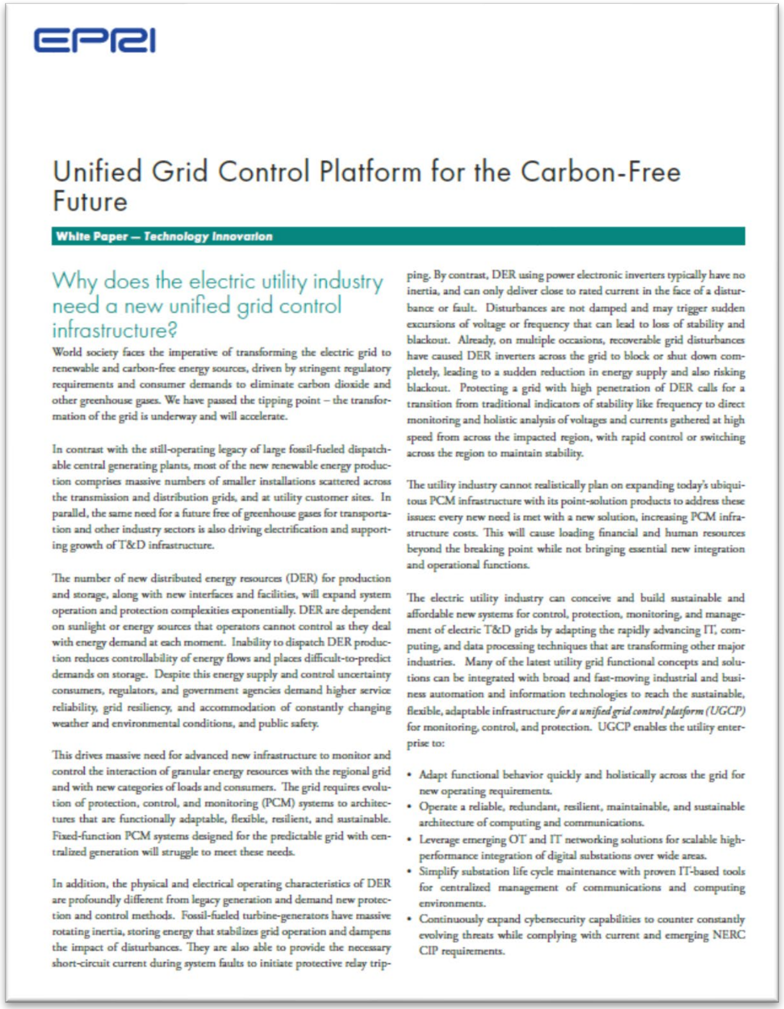
Recent Related Publications

Publication 3002023378

Common Substation Platform: Utility Requirements Assessment – Part 1

2022 TECHNICAL REPORT

Publication 3002021252



Unified Grid Control Platform for the Carbon-Free Future

White Paper — *Technology Innovation*

Why does the electric utility industry need a new unified grid control infrastructure?

World society faces the imperative of transforming the electric grid to renewable and carbon-free energy sources, driven by stringent regulatory requirements and consumer demands to eliminate carbon dioxide and other greenhouse gases. We have passed the tipping point – the transformation of the grid is underway and will accelerate.

In contrast with the still-operating legacy of large fossil-fueled dispatchable central generating plants, most of the new renewable energy production comprises massive numbers of smaller installations scattered across the transmission and distribution grids, and at utility customer sites. In parallel, the same need for a future free of greenhouse gases for transportation and other industry sectors is also driving electrification and supporting growth of T&D infrastructure.

The number of new distributed energy resources (DER) for production and storage, along with new interfaces and facilities, will expand system operation and protection complexities exponentially. DER are dependent on sunlight or energy sources that operators cannot control as they deal with energy demand at each moment. Inability to dispatch DER production reduces controllability of energy flows and places difficult-to-predict demands on storage. Despite this energy supply and control uncertainty consumers, regulators, and government agencies demand higher service reliability, grid resiliency, and accommodation of constantly changing weather and environmental conditions, and public safety.

This drives massive need for advanced new infrastructure to monitor and control the interaction of granular energy resources with the regional grid and with new categories of loads and consumers. The grid requires evolution of protection, control, and monitoring (PCM) systems to architectures that are functionally adaptable, flexible, resilient, and sustainable. Fixed-function PCM systems designed for the predictable grid with centralized generation will struggle to meet these needs.

In addition, the physical and electrical operating characteristics of DER are profoundly different from legacy generation and demand new protection and control methods. Fossil-fueled turbine-generators have massive rotating inertia, storing energy that stabilizes grid operation and dampens the impact of disturbances. They are also able to provide the necessary short-circuit current during system faults to initiate protective relay tripping. By contrast, DER using power electronic inverters typically have no inertia, and can only deliver close to rated current in the face of a disturbance or fault. Disturbances are not damped and may trigger sudden excursions of voltage or frequency that can lead to loss of stability and blackout. Already, on multiple occasions, recoverable grid disturbances have caused DER inverters across the grid to block or shut down completely, leading to a sudden reduction in energy supply and also risking blackout. Protecting a grid with high penetration of DER calls for a transition from traditional indicators of stability like frequency to direct monitoring and holistic analysis of voltages and currents gathered at high speed from across the impacted region, with rapid control or switching across the region to maintain stability.

The utility industry cannot realistically plan on expanding today's ubiquitous PCM infrastructure with its point-solution products to address these issues: every new need is met with a new solution, increasing PCM infrastructure costs. This will cause loading financial and human resources beyond the breaking point while not bringing essential new integration and operational functions.

The electric utility industry can conceive and build sustainable and affordable new systems for control, protection, monitoring, and management of electric T&D grids by adapting the rapidly advancing IT, computing, and data processing techniques that are transforming other major industries. Many of the latest utility grid functional concepts and solutions can be integrated with broad and fast-moving industrial and business automation and information technologies to reach the sustainable, flexible, adaptable infrastructure *for a unified grid control platform (UGCP)* for monitoring, control, and protection. UGCP enables the utility enterprise to:

- Adapt functional behavior quickly and holistically across the grid for new operating requirements.
- Operate a reliable, redundant, resilient, maintainable, and sustainable architecture of computing and communications.
- Leverage emerging OT and IT networking solutions for scalable high-performance integration of digital substations over wide areas.
- Simplify substation life cycle maintenance with proven IT-based tools for centralized management of communications and computing environments.
- Continuously expand cybersecurity capabilities to counter constantly evolving threats while complying with current and emerging NERC CIP requirements.

Together...Shaping the Future of Energy™

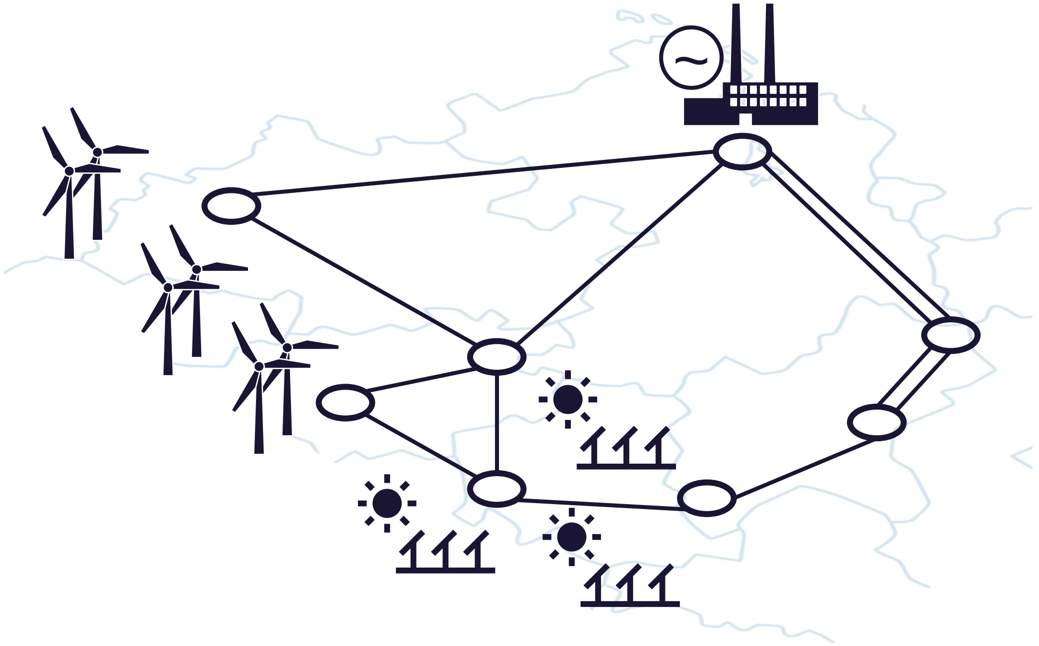
SVC PLUS FS Grid-Forming for Voltage & Frequency Support

 www.siemens-energy.com

Transition to inverter-dominated system

Shift from power systems dominated by synchronous machines to inverter-dominated systems

Some weak connected "pockets" are already 100% inverters



Need for Grid-Forming
Need for Inertia
Need for Fast Frequency Response

DER generation interruption

SIEMENS energy

- Significant amount of DER may block and delay recovery after a fault (e.g. Odessa disturbance).
- This leads to frequency drop and potentially load shedding
- Risk of frequency collapse in island or weakly connected grids

Need for GFM short-term storage

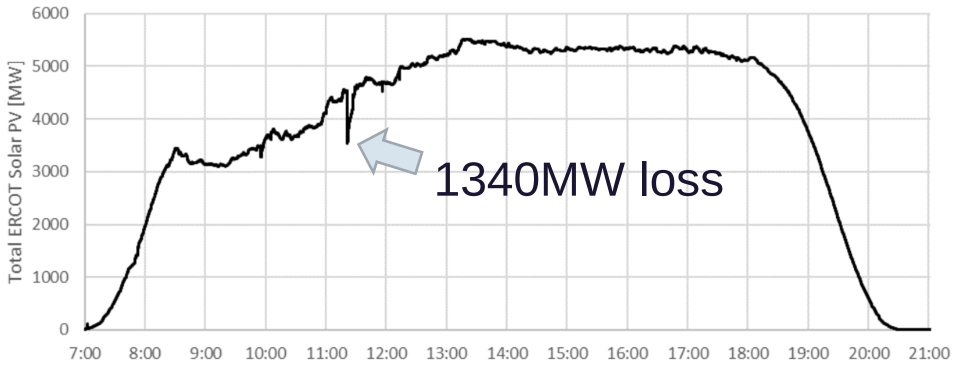
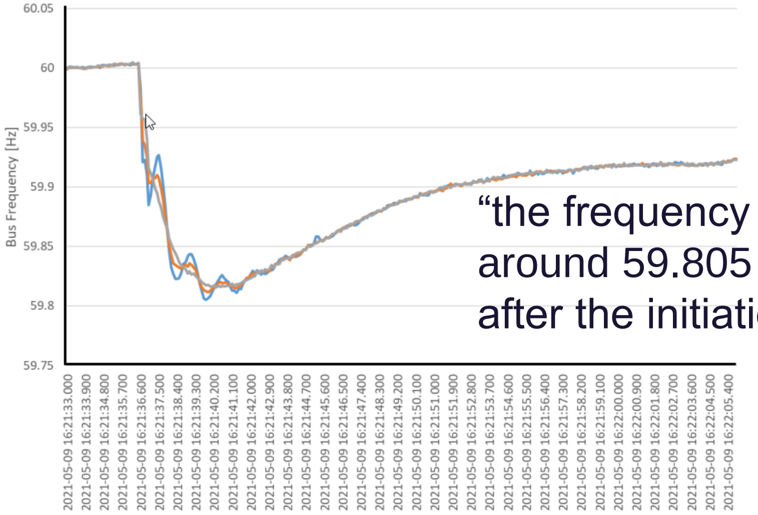


Figure I.1: ERCOT Solar PV Profile for May 9, 2021



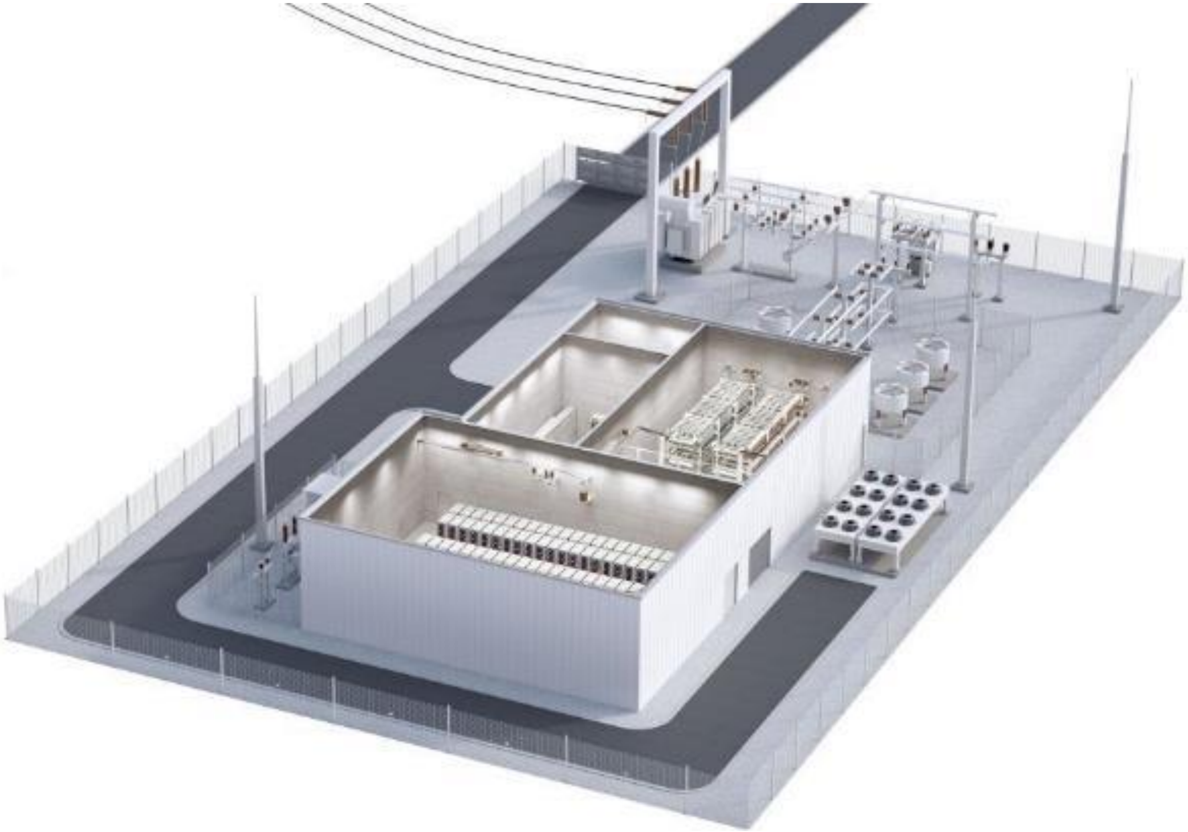
“the frequency nadir occurred at around 59.805 Hz at 3.3 seconds after the initiation of the event.”

Figure I.6: System Frequency during Event [Source: UTK/ORNL]

Source: Odessa Disturbance. Texas Events: May 9, 2021 and June 26, 2021. September 2021
https://www.nerc.com/pa/rrm/ea/Documents/Odessa_Disturbance_Report.pdf

World-first project is currently under execution
GFM SuperCap STATCOM

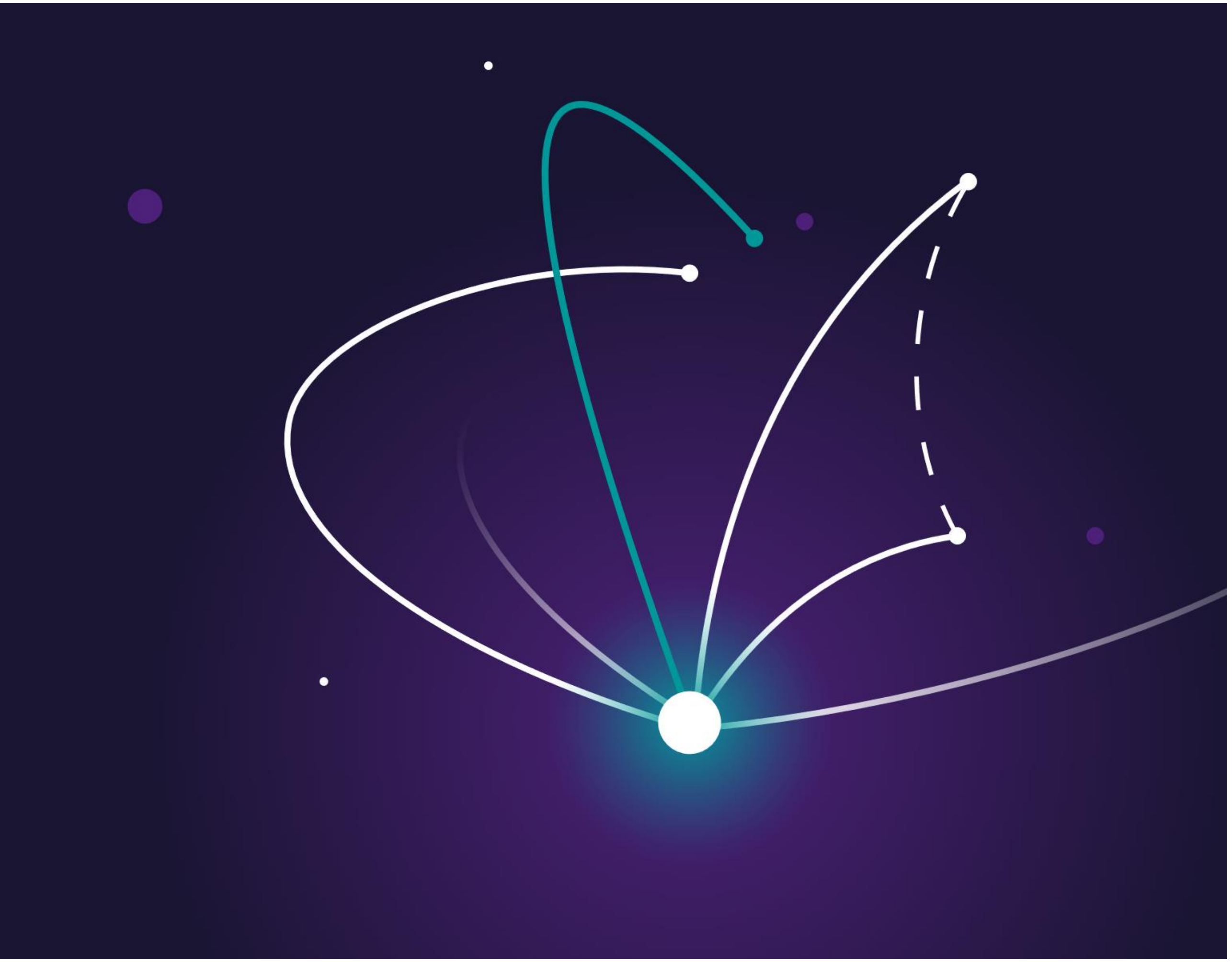
SIEMENS energy



Product	SVC PLUS FS (Siemens Energy)
Active power	+/-200MW
Energy	200MWs
Reactive Power	+/-300MVAR
System Voltage	380kV
Special Features	- GF Statcom with supercap energy storage - Virtual Synchronous Machine - Fast Frequency Response - Voltage control
In Service Date	est. 2025

IEEE Power & Energy Magazine - March/April 2023STATCOM Technology Evolution for Tomorrowâ€™s Grid (nxtbook.com)

Contact Details



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