

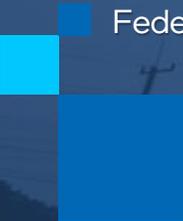
Future of the Utility Market - Utility 2.0

Automation & Control Digitalization in Power Sector

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Intel Corporation

Federal & Industrial Solutions Division(FIS)



intel®



Emergence of Bi-Directional Grid

Enhance Reliability, Safety, Security, Manageability and Edge Analytics

Energy Demand Quadruple's



Microgrid's



Data Center's



Rooftop & Parking lot Solar



Power Storage



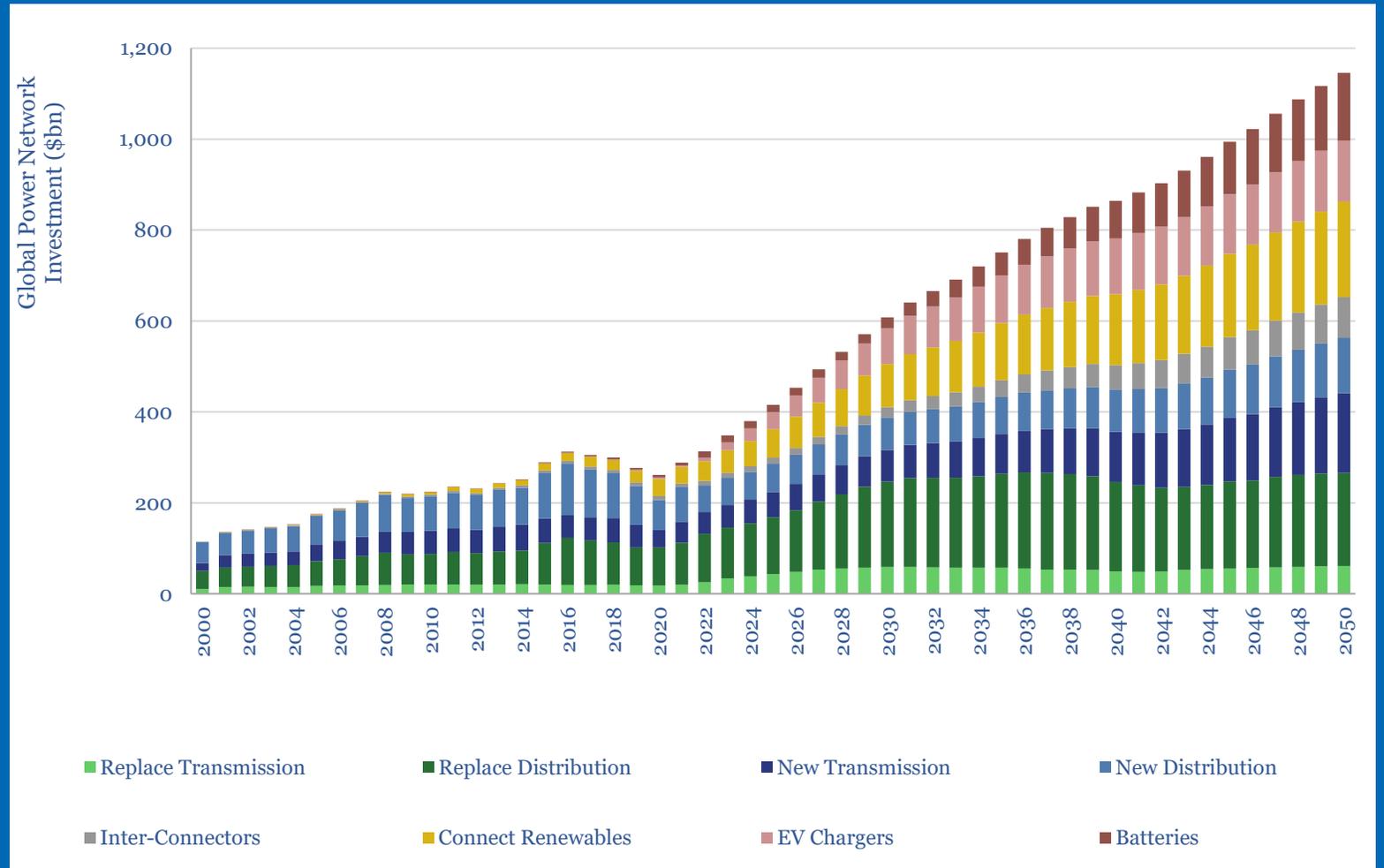
Electrification of Transportation Sector

Net Zero by 2050

Global Power Network Investment

Opportunities in Power Sector

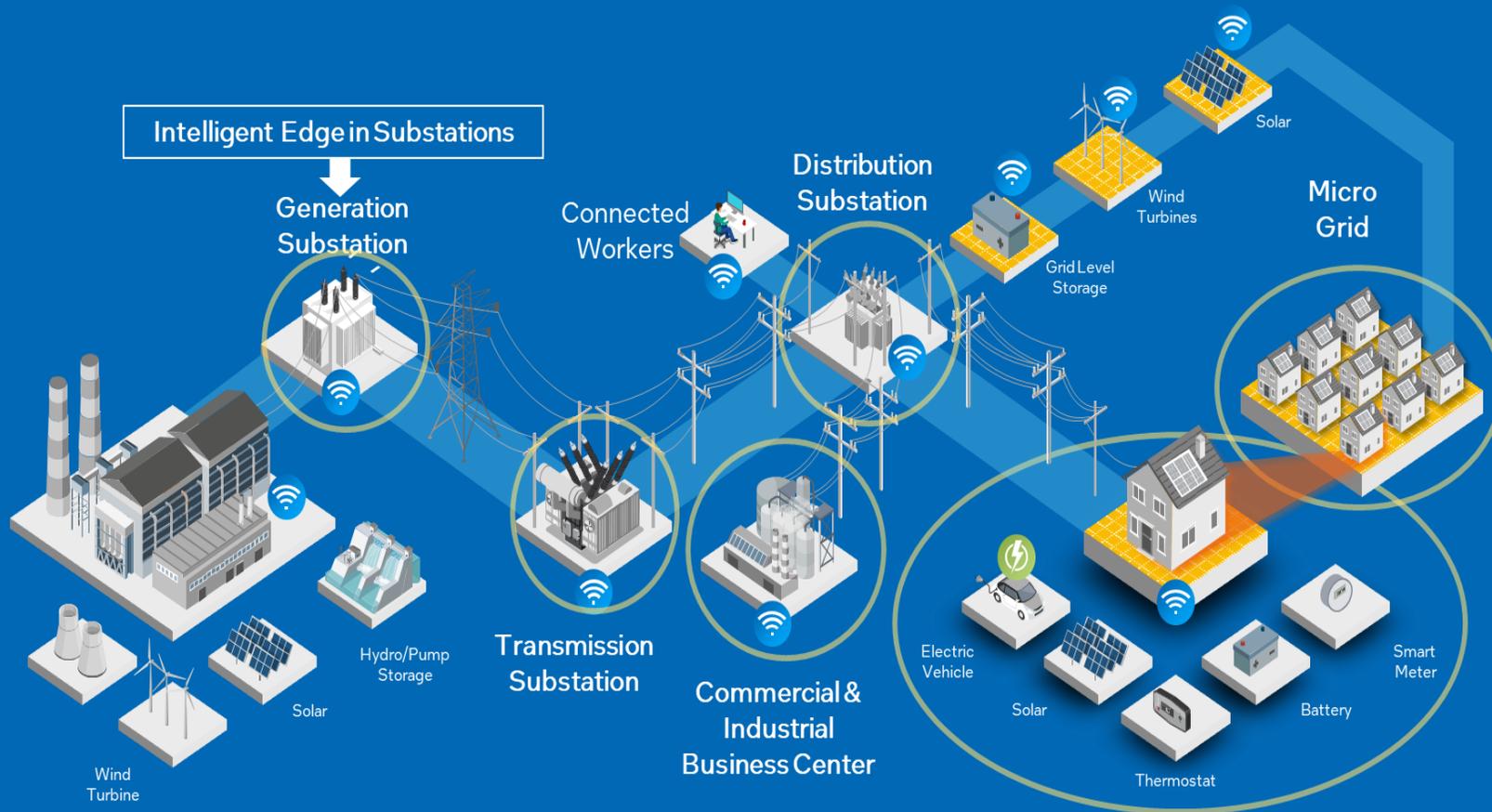
- Power Transmission
- Power Distribution
- Inter-Connectors
- Connect Renewables



Data Source – Thundersaidenergy

Grid Modernization & Transformation

Intelligent Edge for Feeder Optimization and Renewables Integration



Data Driven Power Grid

- Grid of Microgrids
- Feeder Load Balancing
- DER impact on feeders
- Demand & Generation flexibility
- Feeder storage management
- Localized weather impact

Security & Manageability

- Multilayer security availability
- Software defined networking
- Secure remote upgrades

Benefits to Society

- Integrate more renewables
- Reduce Energy Cost
- Reduce spinning reserves

Current → Future

enhance Reliability, Safety, Security, Manageability and Edge Analytics

2024 Substation



- **Appliance Sprawl**
 - Custom hardware and software tools
 - Limited Security and Manageability
 - Increasing O & M Costs
 - Capital Intensive

Future Substation



IEC 61850 – 3 Class 2

SDI

— Real-Time Virtualization Software

OT Applications

— High Voltage Protection & Control
— Medium Voltage Protection & Control
— Fault Analysis and Classification
— Event Correlation
— Advance Restoration Schemes

IT Applications

— vFirewall, vRouter, vSwitch, Log Analysis, Security

- **Benefits to Utilities**
 - Standardized Hardware Platform
 - Reduce Capital and O&M Costs
 - Enhance Reliability, Safety and Security

Digitalize To Optimize

Software Defined Automation & Control

enhance Reliability, Safety, Security, manageability and Edge Analytics

Substation in 2024



Future Substation



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

Rugged Servers
(IEC 61850 – 3 class 2 & ANSI 1613)

- Partition
- Isolation
- Encapsulation
- Hardware Independence

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

50% Reduction in Devices

76% Reduction in O&M Cost

Virtualization of Automation & Control

enhance Reliability, Safety, Security, manageability and Edge Analytics

Automation & Control Work Loads

- Distributed ADMS@eDge
- Edge Analytics & Asset Monitoring
- Security Firewall and Anomaly Detection
- Business Intelligence and Autonomous Control
- RTU and HMI
- Asset Health Monitoring
- Frequency and Voltage Regulation
- Transformer Tap Position Monitoring
- Load Curtailment and Balancing
- Capacitor Bank Controller
- Fault Detection & Event Recorder
- Transformer Monitoring using Infra-red Cameras
- Phasor Measurement Unit(PMU)
- Protocol Translation & Data Aggregation
- Analytics' using ML
- Advanced Restoration Schemes*
- Fault Type Classifications*
- Event Correlation*

Standardized Rugged Hardware



IEC 61850 - 3 Class 2

SDI

— Virtualization Software Stack

OT Applications

- RTU/SCADA Software
- HMI Software
- Phasor Measurement Unit(PMU)
- Asset Health Monitoring & Analytics
- Automation Controllers
- Event Recorder & Anomaly Detection

IT Applications

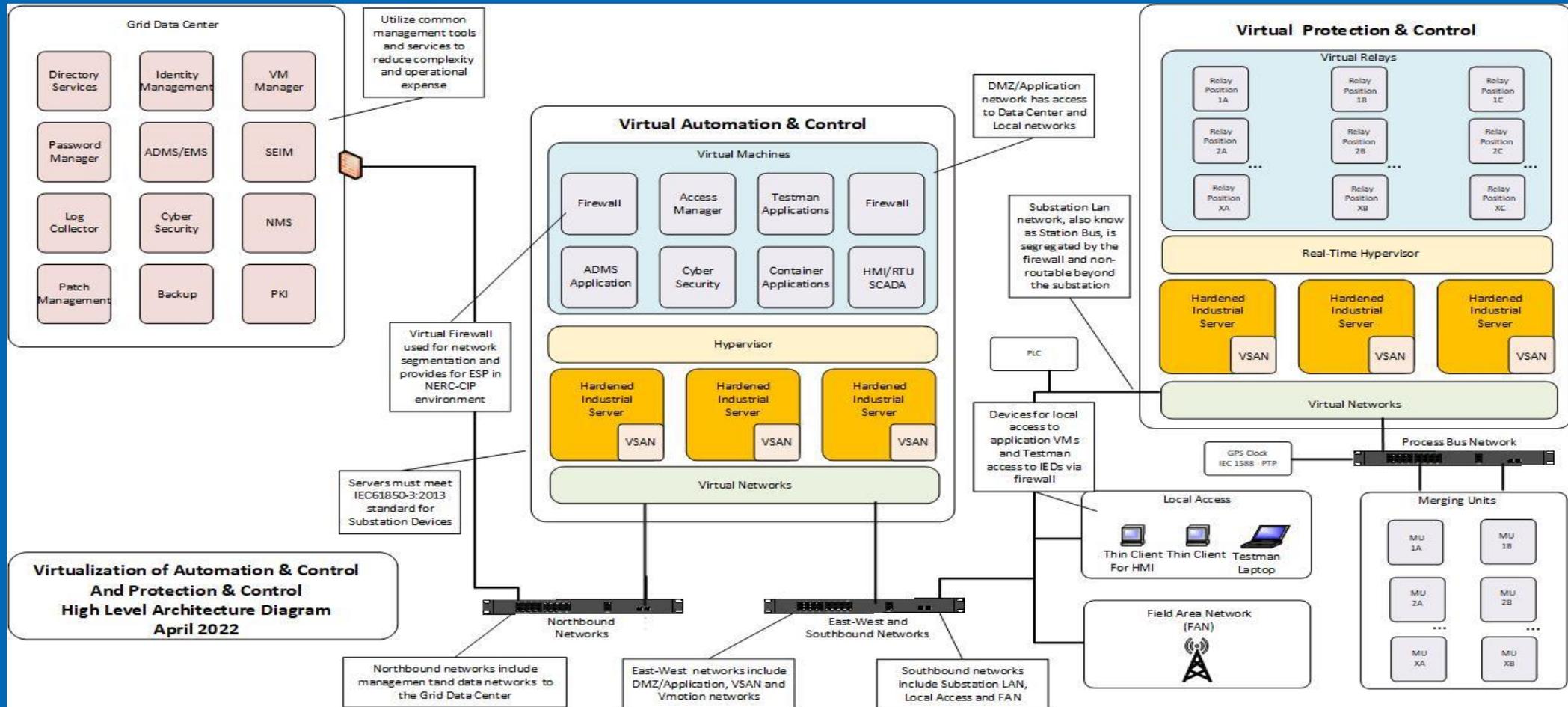
— vFirewall, vRouter, vSwitch, Security

Protection & Control Work Loads

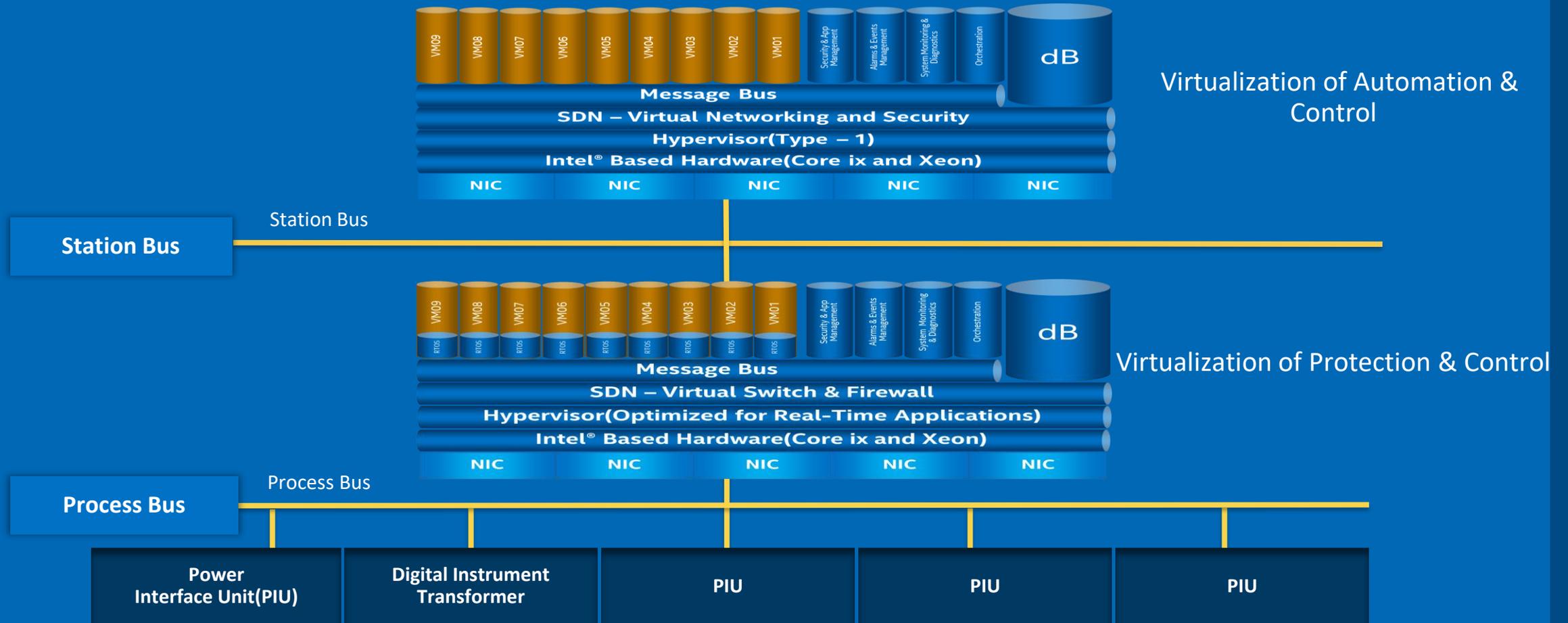
- Linear Protection
- Distance Protection
- Differential Protection
- Feeder Protection
- Transformer Protection
- Motor Protection
- Generation Protection
- Bus Protection
- CapBank Protection
- Asset Health Management
- Analytics using ML
- Advanced Restoration Schemes*
- Fault Type Classifications*
- Event Correlation*

Maximize Utilization of Renewables

Next Generation Station and Process Bus Architecture for Substations



Software Defined Station & Process Bus

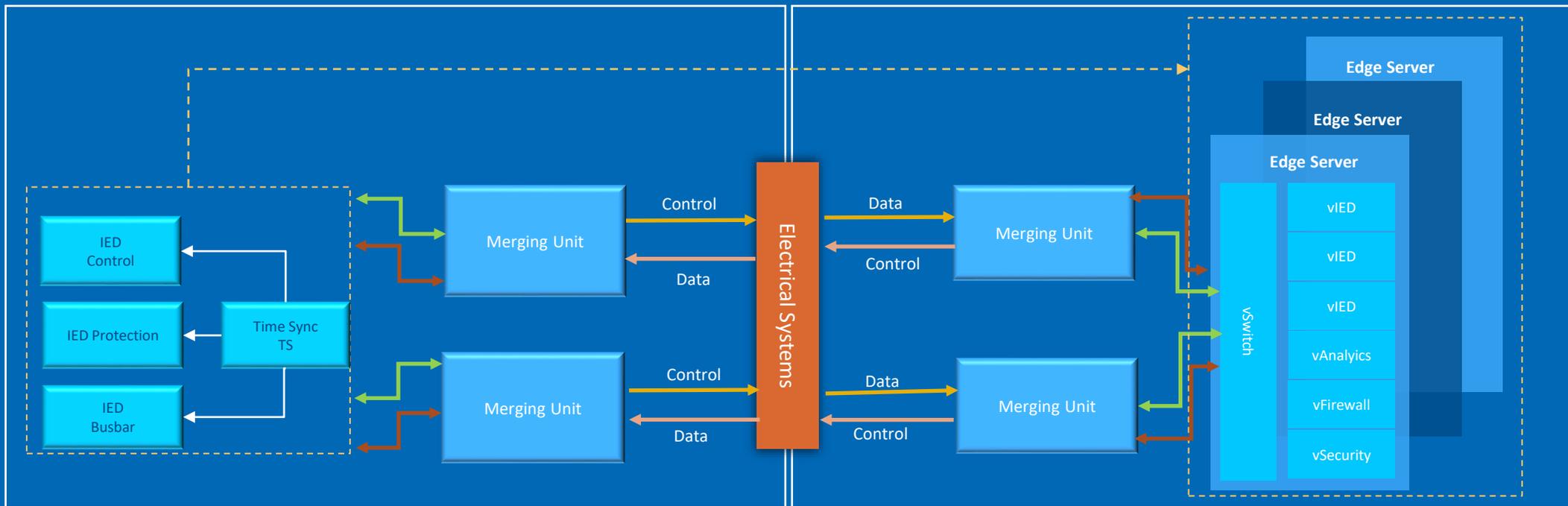


Virtualization of Protection & Control

enhance Reliability, Safety, Security, Manageability AND Edge Analytics

Current Architecture

New Architecture using virtualization



Physical Layer Protocol – Ethernet with PRP
Control System Protocol – IEC61850

Benefits of Software-Defined automation & Control System for utilities

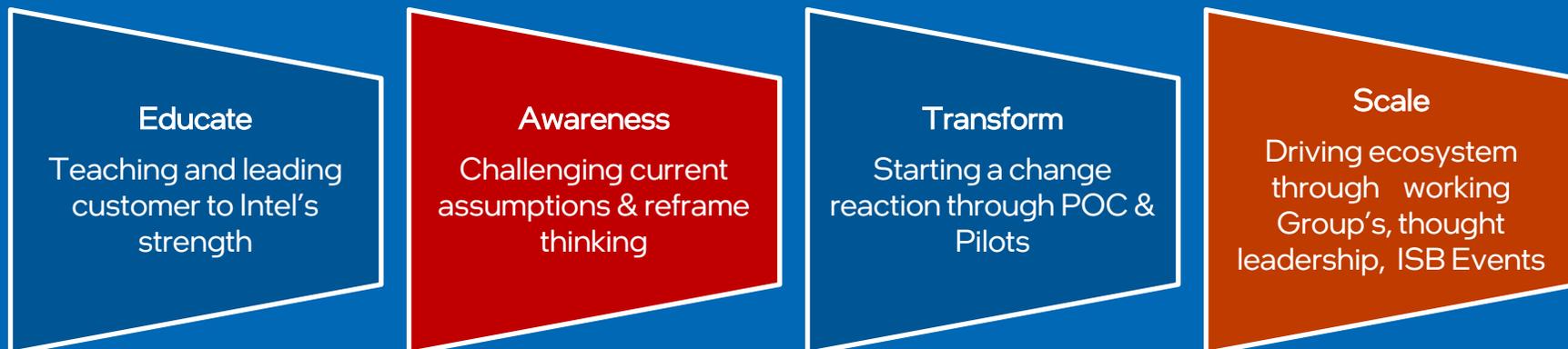
enhance Reliability, SAFETY, Security, manageability and Edge Analytics

Benefits for Utilities

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

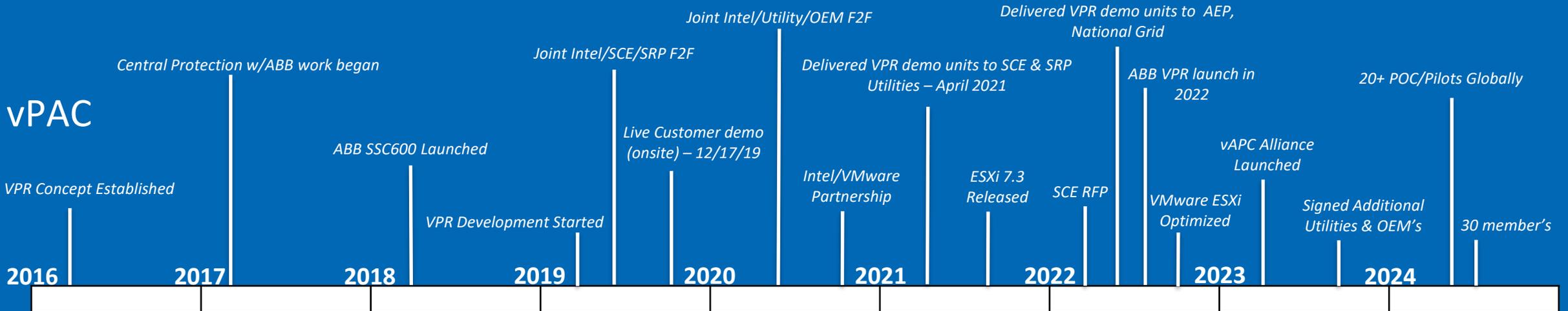
Benefits for OEMs

- Reduce Development Cost
- Accelerate Time to Market
- Increase Profitability
- Increase Revenue from Software and Services



Power Sector Journey

enhance Reliability, Safety, Security, Manageability and Edge Analytics



Alliances – vPAC

vPAC – Virtualization of Protection, Automation and control

- Building Flexible, Scalable and Secure Infrastructure in T&D



Utility Infrastructure Modernization

Improve Safety, Security, Reliability, Manageability AND add Edge Analytics

2024 Substation



Future Substation – Software Defined Infrastructure



Centralized (SSC600) & Virtualized (SSC600SW)

+ AI fault analysis
& prediction



Marco Nunes, 24.06.2024
ABB, Digital Substation Products
Electrification Division

Smart substation control and protection SSC600

Introducing Hybrid Protection and Control

Evolution of protection and control

300-500 Electromechanical relays (single functions)



100 Microprocessor-based, multifunction relays



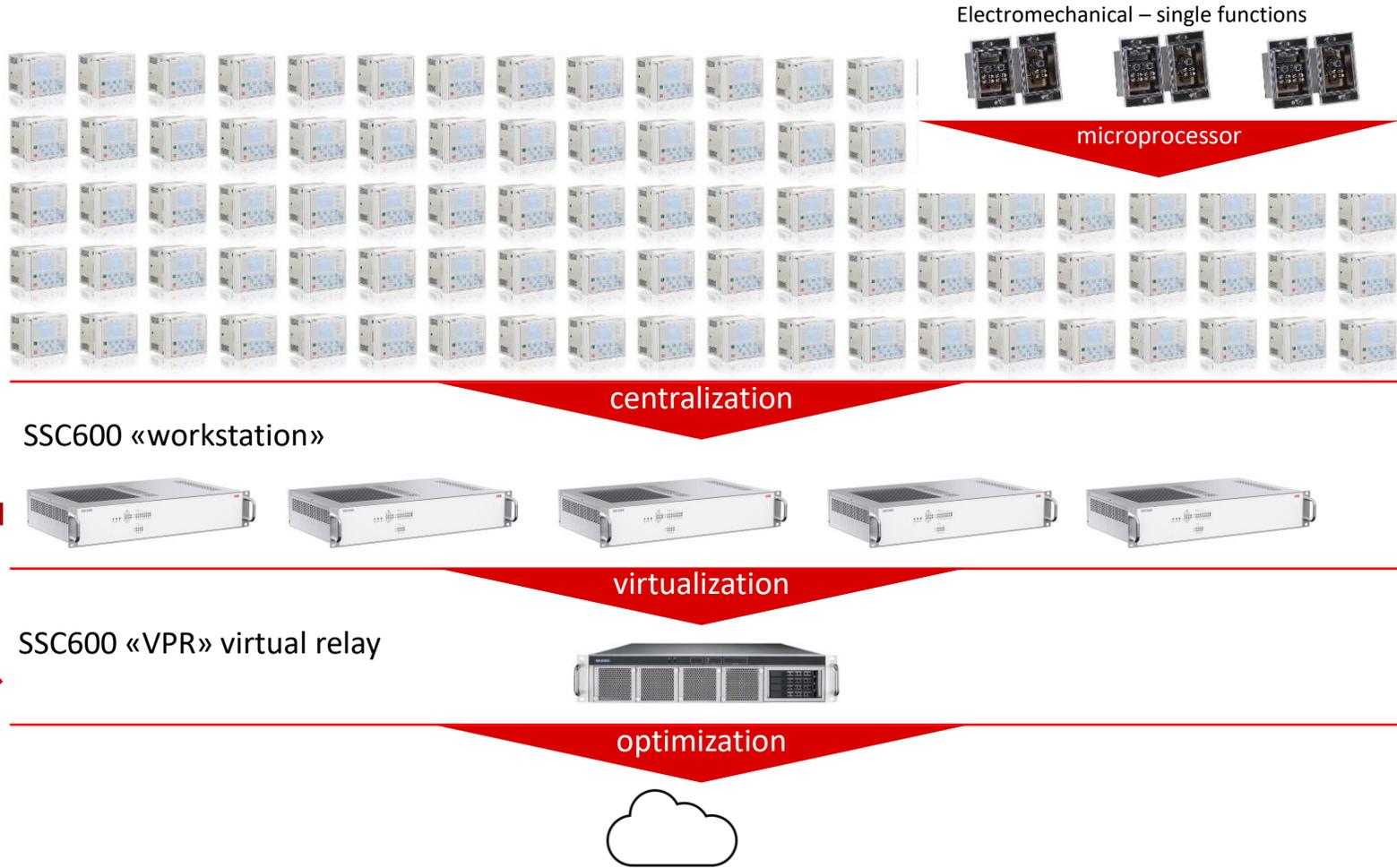
5 centralized protections



1 high-computing server, virtual machines-hypervisors



Cloud, 5G/6G





Introduction

IEC 61850-compliant EDGE / centralized protection and control



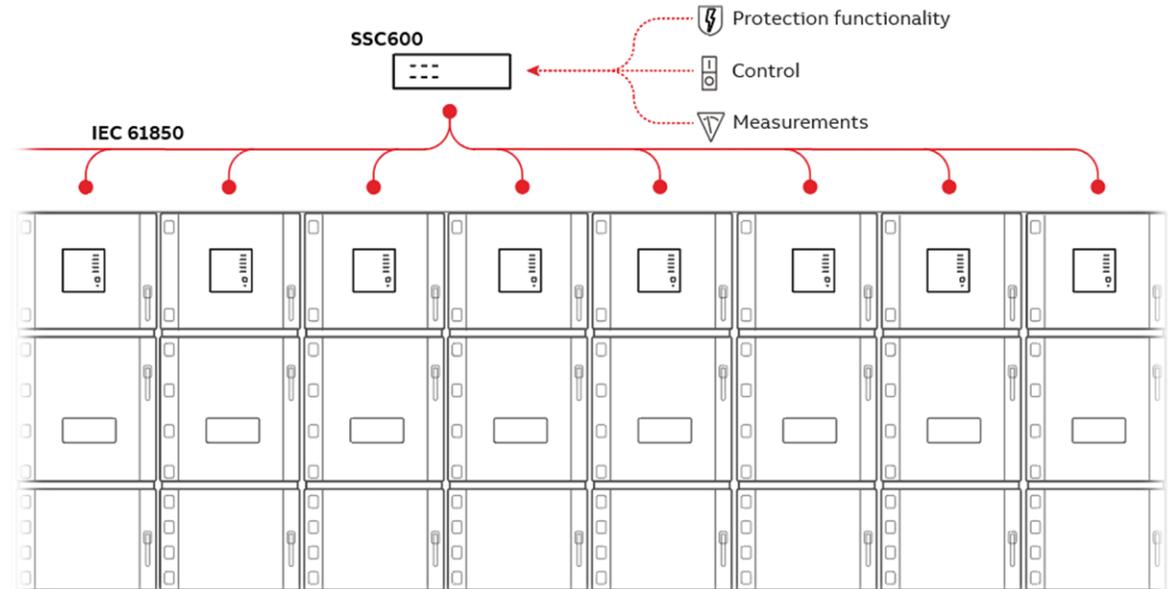
Customer need

- All settings, configurations and applications centralized in one device
- Dynamically allocate the applications per bay with the possibility to change or adapt at anytime depending on the substation evolution (for instance, a feeder needs to be converted into a transformer bay in a very short time)



Solution

- SSC600 combined with IEC 61850 merging units (MU)
- All settings, configurations and application in one device
- Any capable protection relay suitable as backup time master
- Substation gateway doubles up as human-machine interface (HMI)
- Combined or separated IEC 61850 network for process and station bus
- System visualization using SSC600 and its Web HMI (WHMI)
- Time synchronization via the IEEE 1588 v2 GPS (Global Positioning System) master



- Equipment availability (Protection Relays/MU's)
- High resolution data (4/4.8 or 14.4 kHz)
- Reduced Cloud Storage due to local EDGE processing

Centralized protection SSC600

Standards and communication

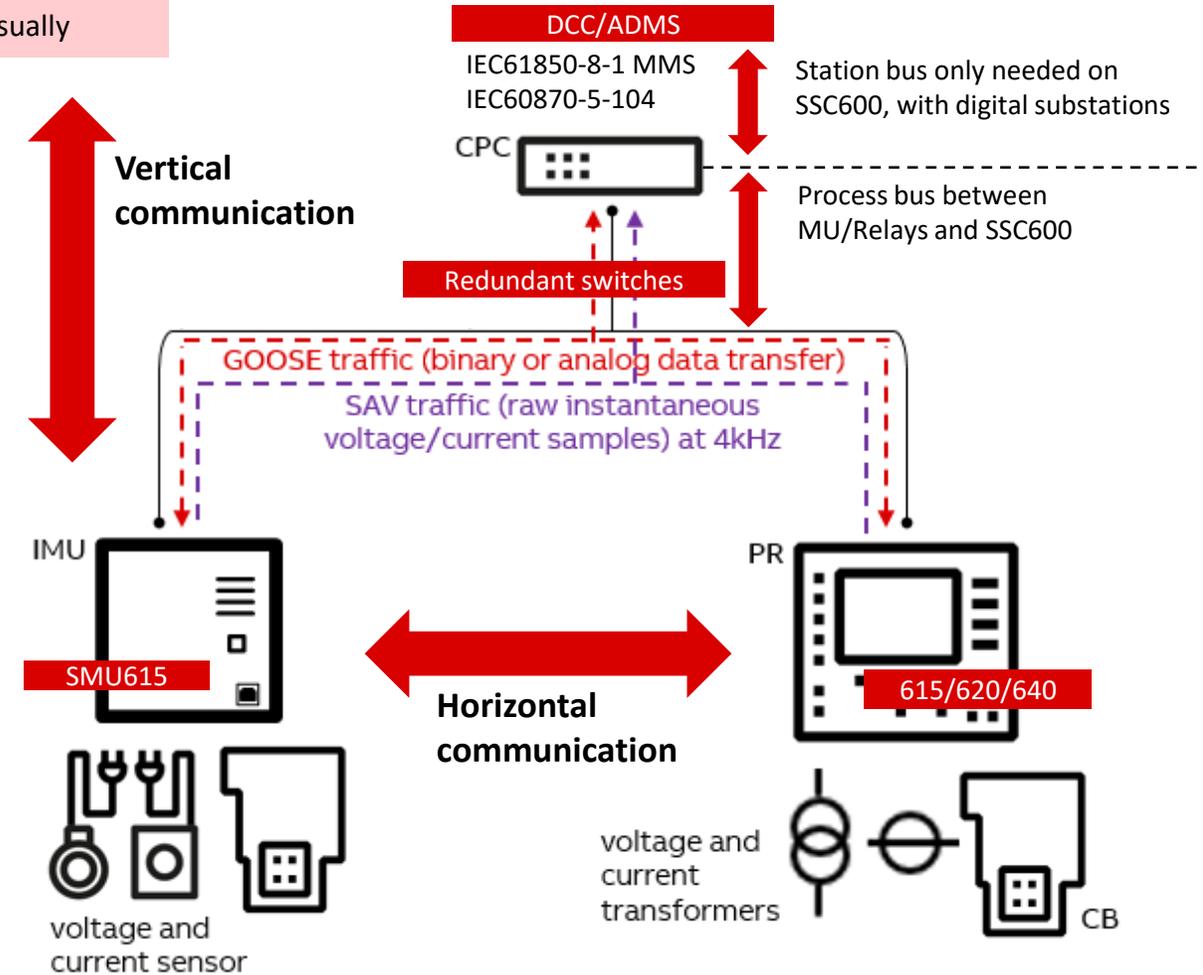
Open standards

- Time synch: IEEE 1588 v2 PTP (in addition to SNTP), according to IEEE C37.238-2011 Power Profile for high accuracy time synchronization.
- GOOSE: IEC 61850-8-1 Ed2, tripping type 1A, Class P1 (<=3 ms.)
- Process bus/sampled values: IEC61850-9-2LE
- Disturbances recorder: 60255-24 Comtrade files format
- Redundant communication: PRP as per IEC 62439-3 Edition 1 and 2
- Station bus: 61850 MMS + IEC60870-5-104
- Cybersecurity: ISO 2700x, IEC 62443, IEEE P1686 and IEC62351, NERC CIP and BDEW.
- WebHMI: HTTPS, FTPS, self-signed X.509 certificate, RSA key-pair with key-length of 2048 bits, RFC2617 HTTP Authentication
- EMC/LV: 60255-26 / 60255-1 / EN 60255-27
- Server certifications: CE, FCC, CCC, Electricity IV level for China, IEC-61850-3, IEEE-1613, UL, CB, LVD
- Environment: EU RoHS directive (2011/65/EU).

Time stamped Sampled values (1 us precision)

1 ms processing cycle on centralized protection vs 2.5/5 ms usually

- SSC600 has 8 Ethernet ports, incl. PRP/FO SFP
- SSC600 can combine or segregate process bus and station in the communication network.
- Network overload is not a problem, as 30 streams of SMV represent only 15% network consumption on a 1Gb/s network



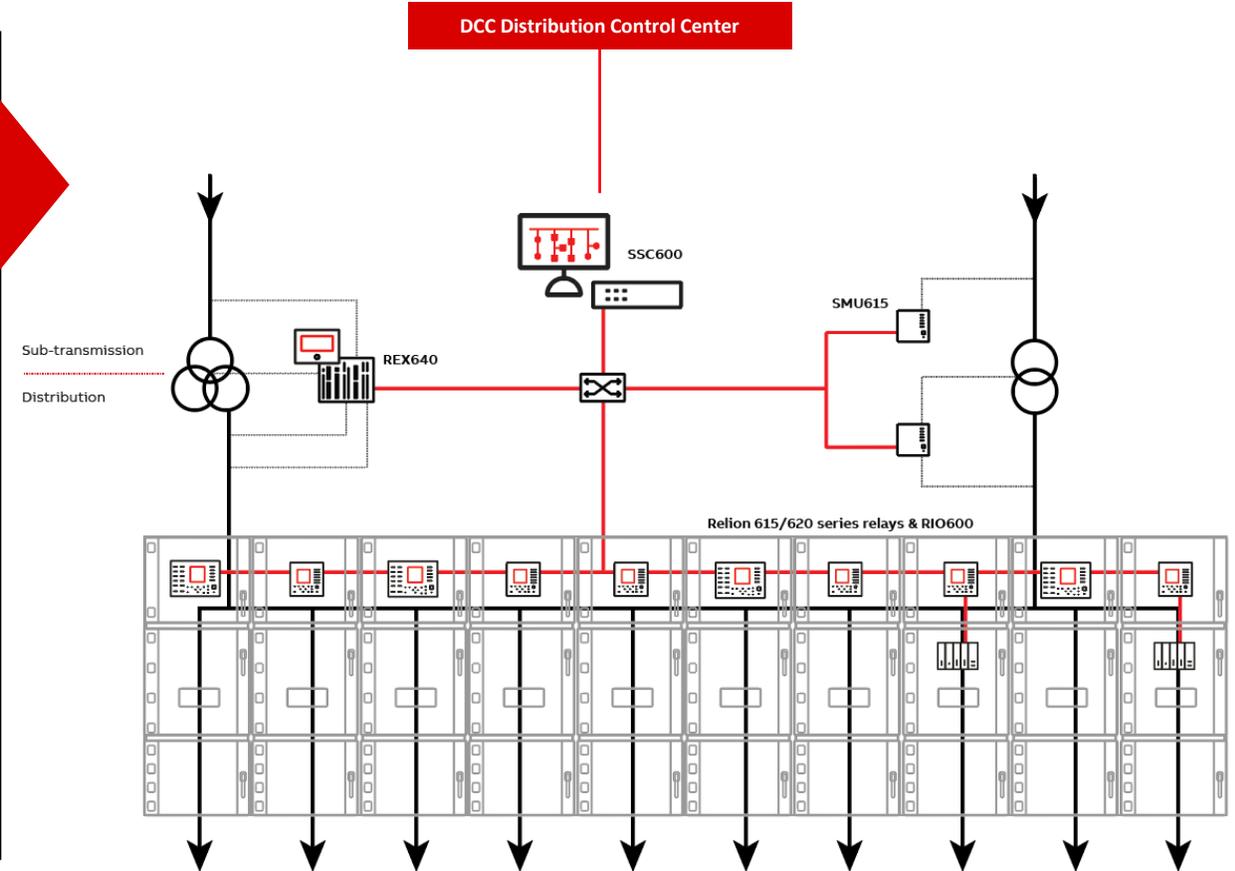
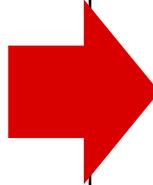
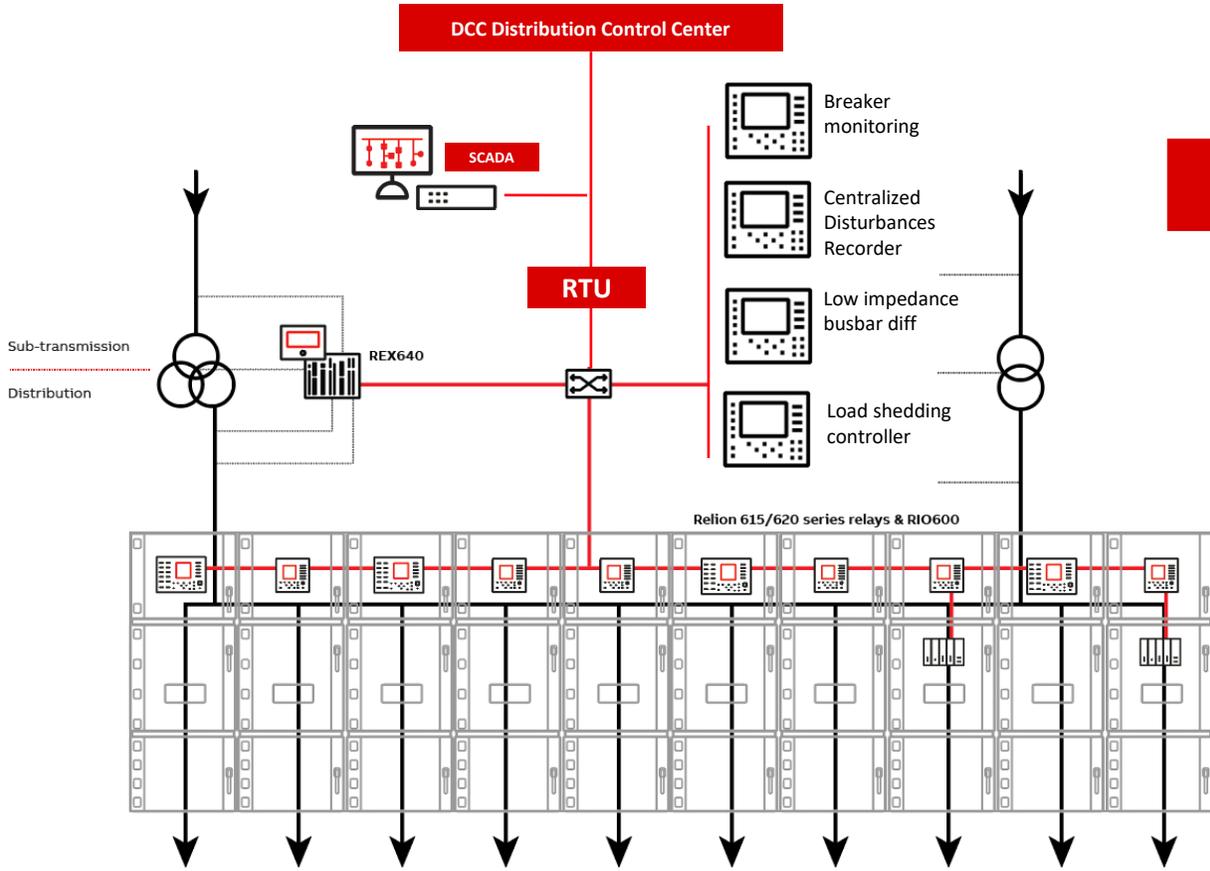
- 1) Station bus: IEC61850-8-1, IEC60870-5-104, DNP3 (End 2023)
- 2) Sampled values, 4 kHz streams: IEC61850-9-2LE or IEC61869-9 (End 2024)
- 3) Goose messages (analog/binary – 500 ms): IEC61850 / GOOSE Trip: max 3 ms

Smart substation control SSC600

Application feature: additional added-value

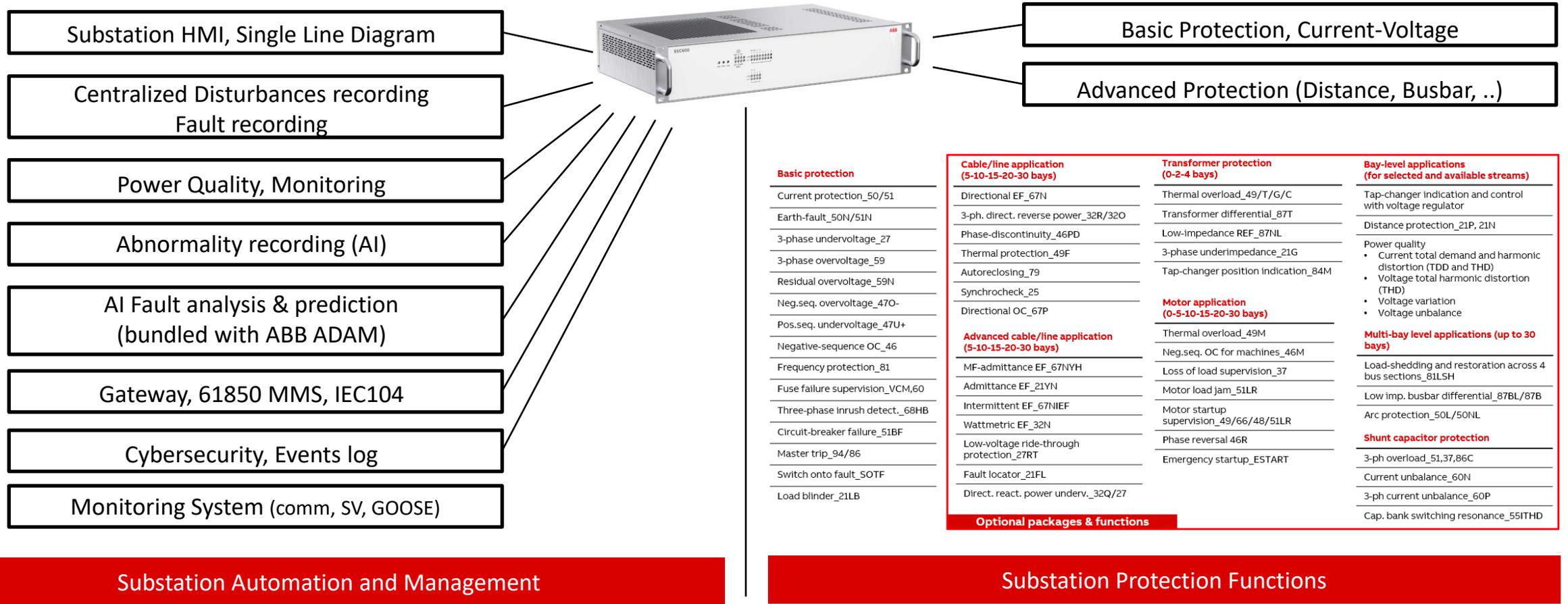
Conventional substations

Digital substation – centralized protection / SSC600



Centralized protection and control with SSC600/SW

Technology CPC (centralized 30 bays) or VPAC/VIED (virtual machines up to 150 bays)



Protection virtualization technology

ABB Digital Substation: SSC600 CPC Workstation or SSC600 SW VPAC Virtual Machine

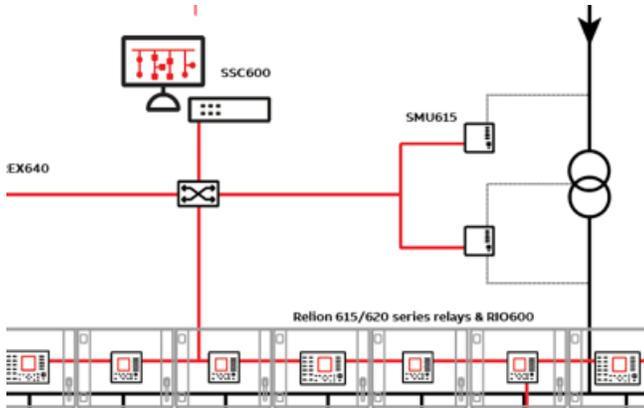
Centralized Protection and Control (CPC)

- ✓ All-in-one turnkey box, with full warranty and support from a single vendor
- ✓ The hardware, OS and applications have been type tested all together a turnkey solution
- ✓ Safe environment, one single engineering tool
- ✓ Native development on 61850 standard, and compatible with 61850-9-2LE 3rd party IED's
- ✓ Applicable flexibility, including station SLD, centralized recorders, fault recorder
- ✓ Hybrid architectures possible, with conventional IED's as bay backup merging units

ABB SSC600 workstation



Turnkey Centralized 61850-based platform.
Intel CPU 4 cores up to 30 bays.



Virtualized Protection and Control (VPR)

ABB SSC600 SW as Virtual Machine

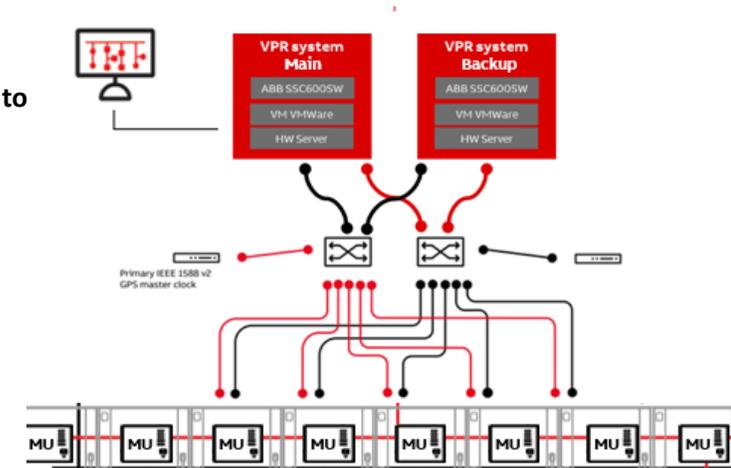
XR-12



ECU-579

Centralized 61850-based platform, running on Virtual Machines.
Intel Xeon Gold CPU up to 24 cores up to 150 bays.

- ✓ Full scalability in terms of hardware and software
- ✓ Multi-vendor integration on same hardware platform
- ✓ Remote asset and apps management through VM centralized asset management tools
- ✓ Compatible with open-source and commercial vendors for the VM layer (hypervisor), KVM and VMWare
- ✓ Allow EPC's and Utilities to utilize always the same components worldwide, and customizing only the apps needed in the VM's/containers



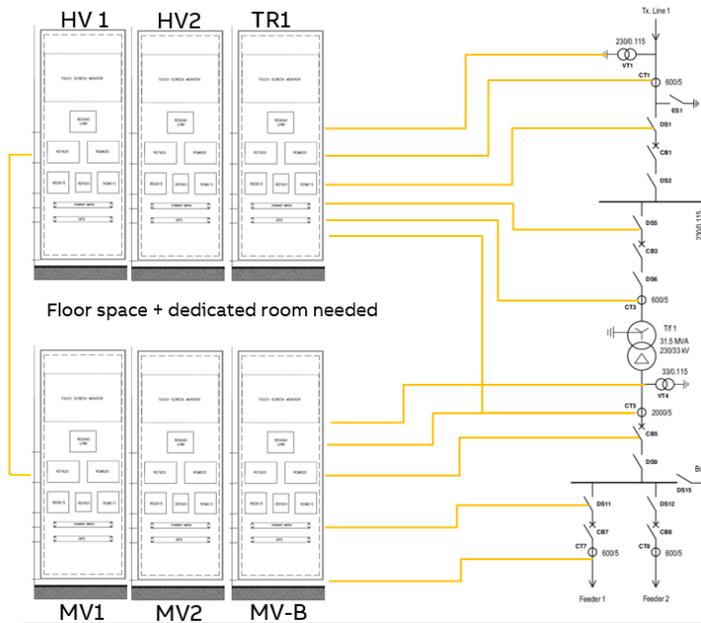
Smart substation control and protection SSC600

Migration from CONVENTIONAL → DIGITAL SUBSTATION

1

Conventional architecture
(copper hardwiring – conventional IED's)

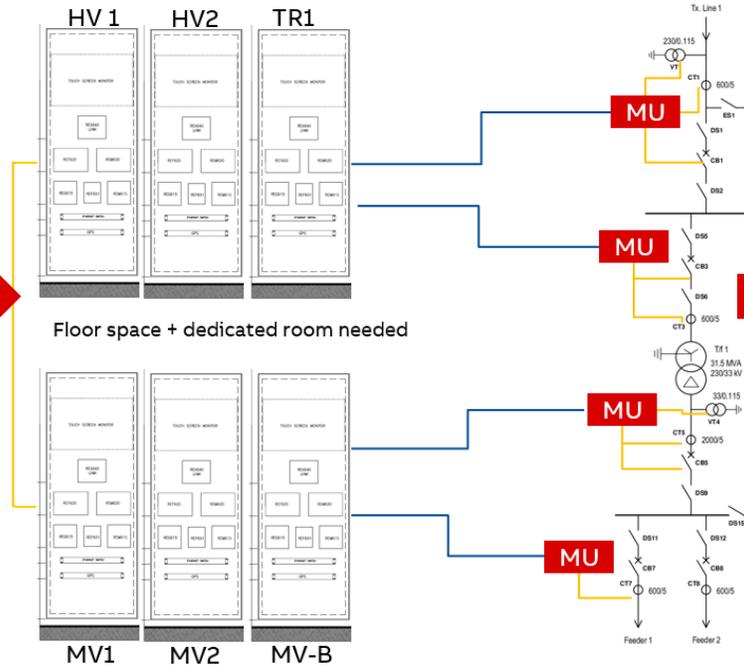
Protection and Control



2

Digital Substation «light»
hardwiring replaced by process bus FO

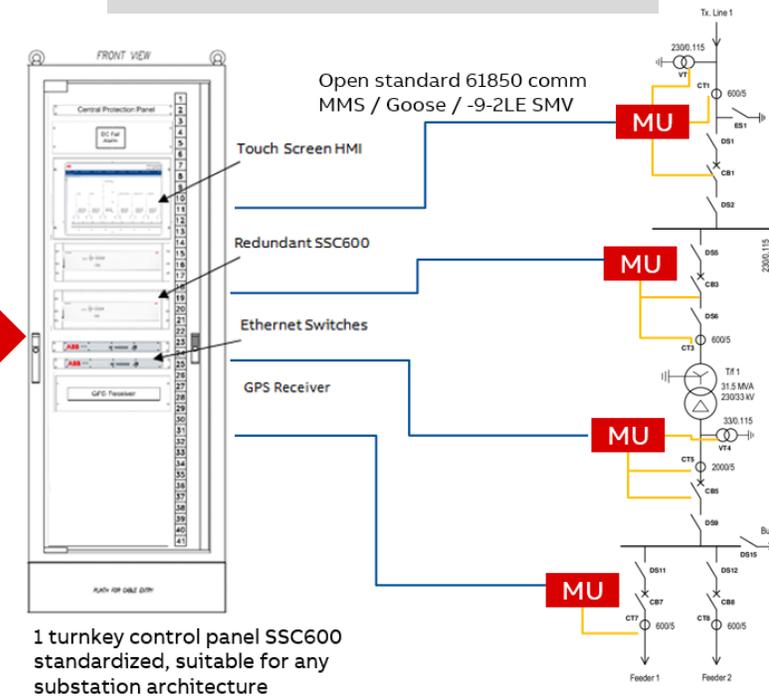
Protection and Control



3

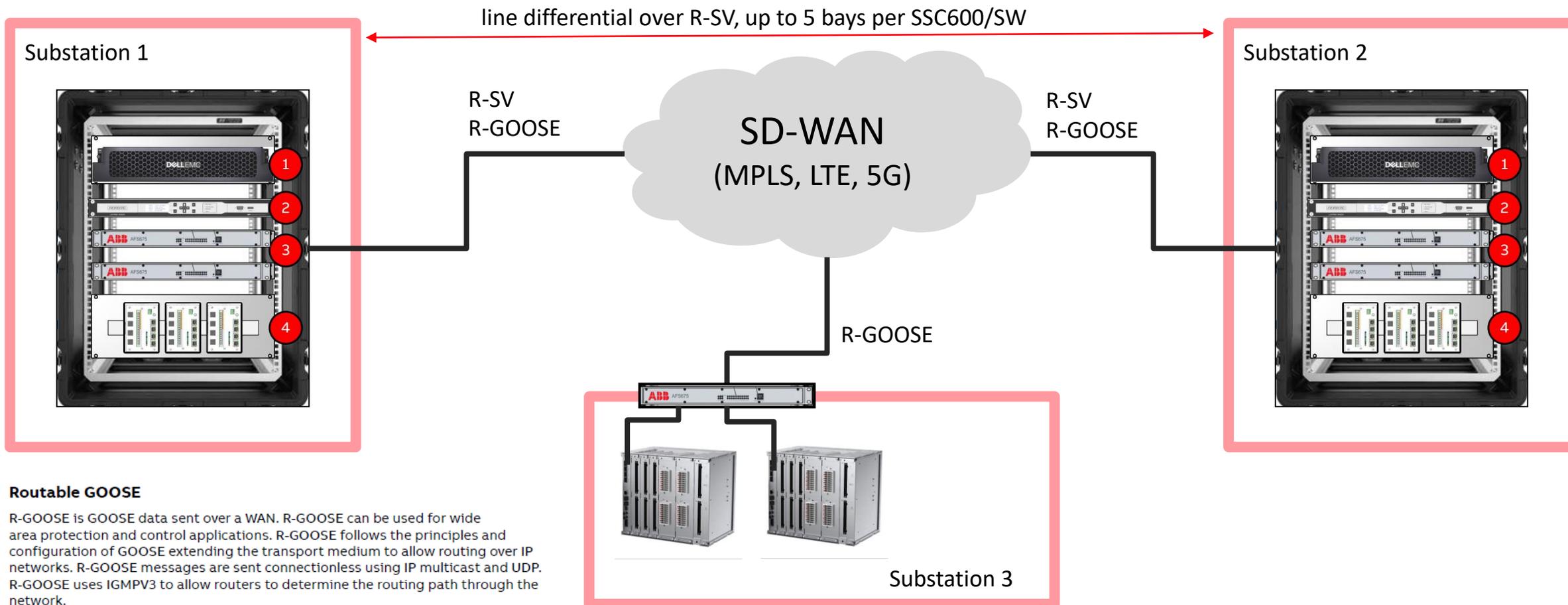
Digital Substation «FULL»
process bus FO + Centralized PACS

Protection and Control



Centralized CPC + Virtualized Protection and Control VPAC / SSC600-SW

Teleprotection, Line Diff



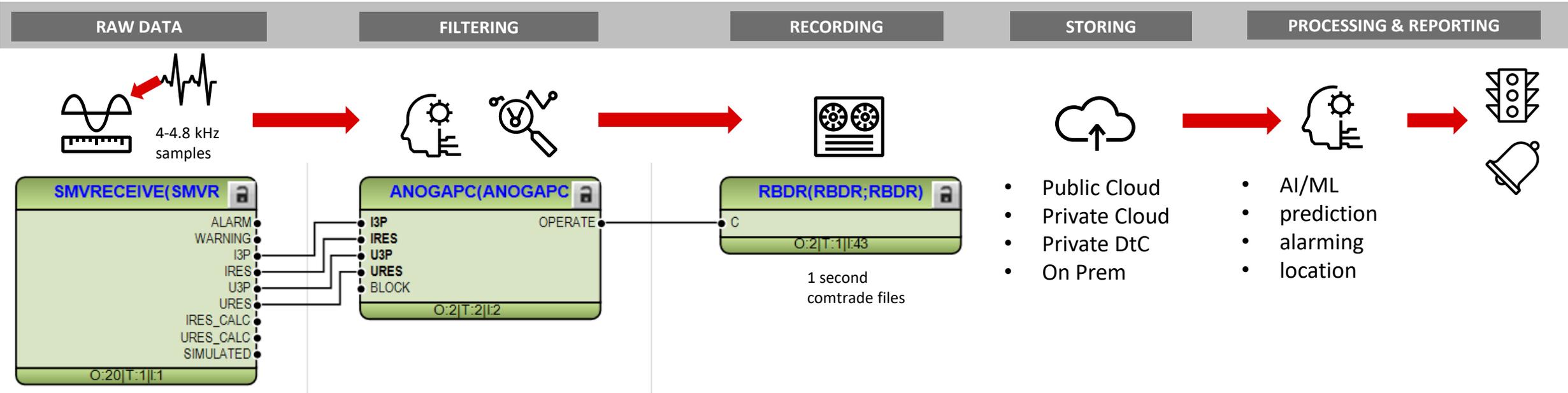
Routeable GOOSE

R-GOOSE is GOOSE data sent over a WAN. R-GOOSE can be used for wide area protection and control applications. R-GOOSE follows the principles and configuration of GOOSE extending the transport medium to allow routing over IP networks. R-GOOSE messages are sent connectionless using IP multicast and UDP. R-GOOSE uses IGMPV3 to allow routers to determine the routing path through the network.

- 1 x SSC600/SW v1.5 support 5x line differential max, for each SSC600 workstation or VM, multi-ends
- 3rd party devices supporting R-GOOSE and R-SV as per 61850-90-5 are compatible
- SD-WAN = Software Defined Wide Area Network, creating virtual WAN's over MPLS/LTE
- C37.94 Network Interface Cards are not available with CPC/VPAC technology on high-computing servers

ABB Digital Substation Products – SSC600/SSC600 SW as AI enabler

SSC600 FP4 – Anomaly detector (Abnormal Events Recorder) function



ANOGAPC is intended to detect abnormal behavior in distribution network by monitoring the measured currents and voltages. **The intention is that ANOGAPC would trig the disturbance recorder before the real fault is even detected** by any other protection function. After ANOGAPC has indicated the anomalous events in the measured data, these recorded occurrences can be used to create more refined analysis of the electrical network equipment status. The refined analysis might mean for example **artificial intelligence algorithms predicting future fault conditions.**

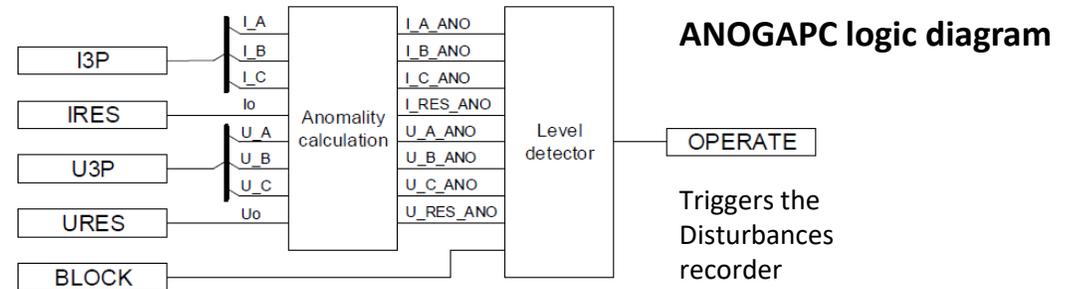
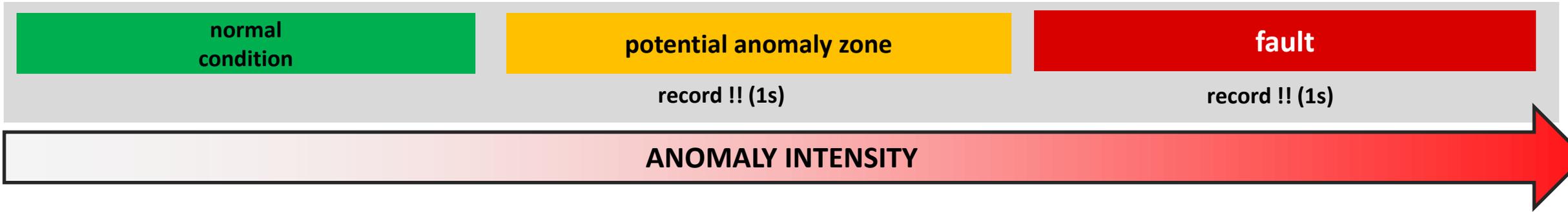
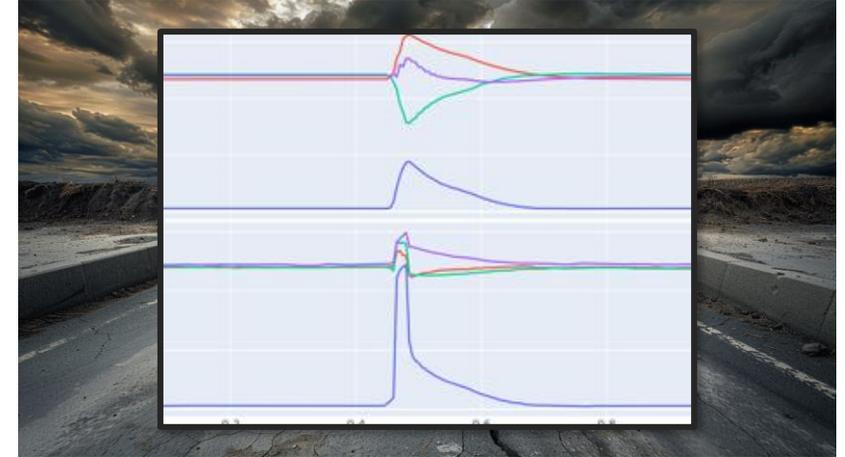
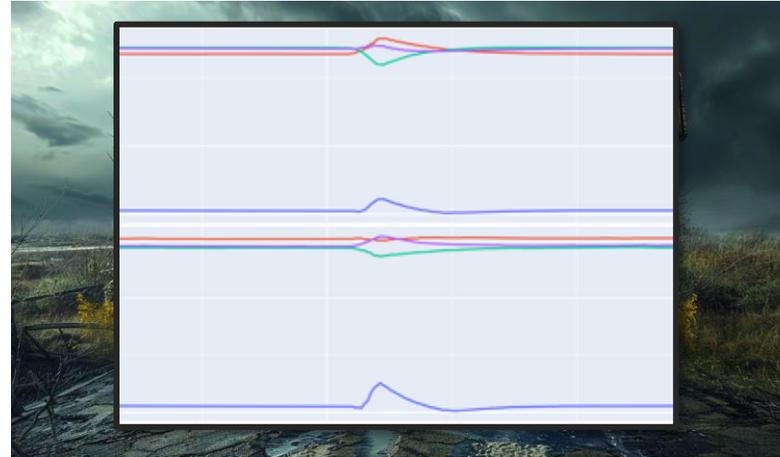
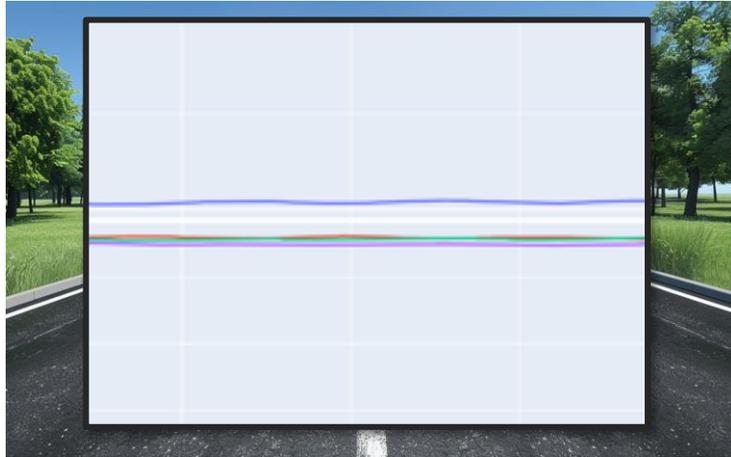


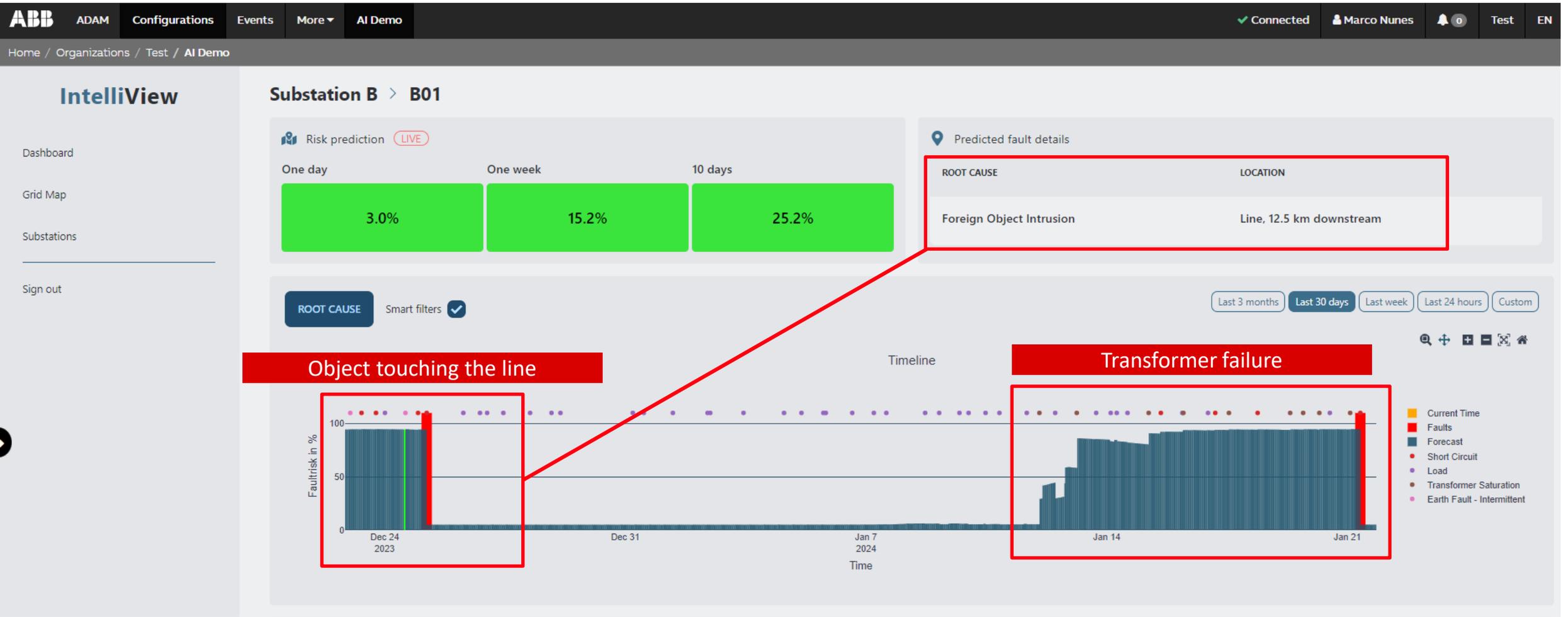
ABB Digital Substation Products – SSC600/SSC600 SW as AI enabler

What is an “anomaly” – how does the Anomaly Detector work on SSC600 ?



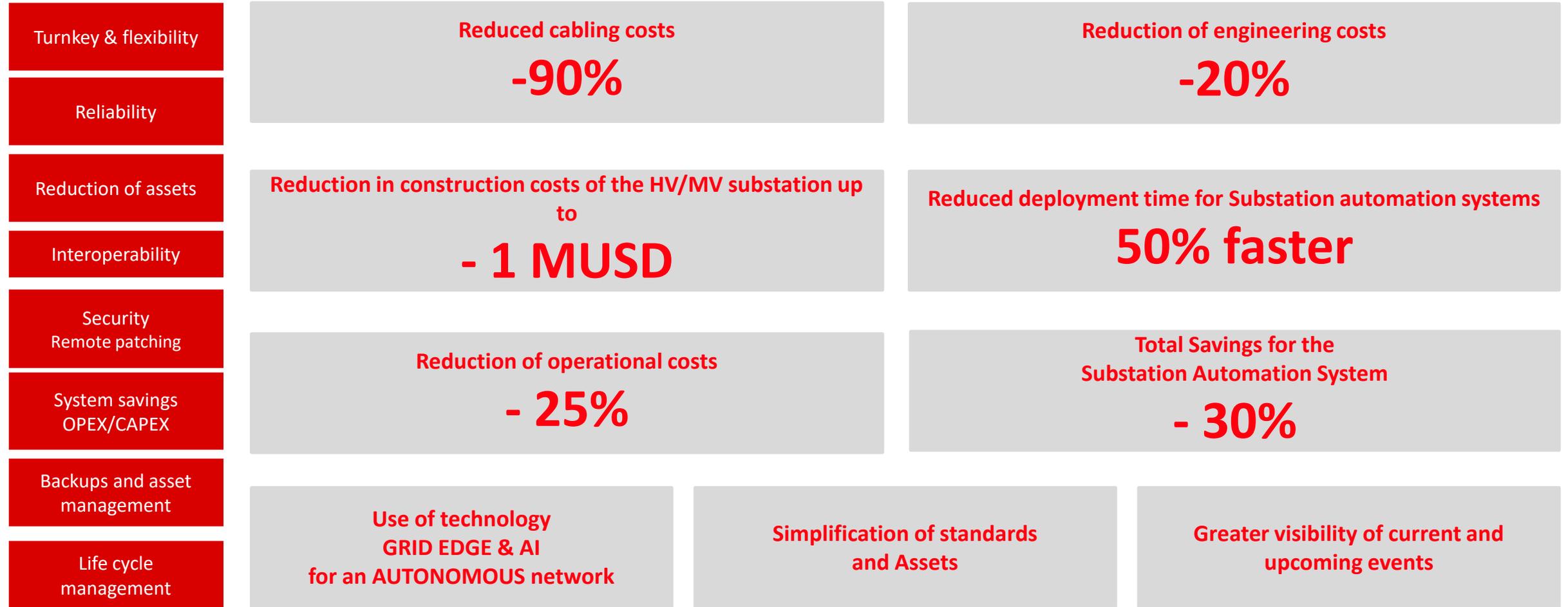
ADAM "AI/ML Fault Prediction" Intelliview module

Long term monitoring of events, prediction events, faults, including anomalies and fault recordings



On the way to intelligent and autonomous networks

Conclusion



ABB

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