



Digitizing Substation Operations

Modernize Grid operations with secure, enhanced Substation networks

Utilities are facing greater challenges than ever before. Their grids are being asked to handle more sustainable, distributed and variable energy sources. Their grids are being buffeted by environmental impacts such as fires and extreme weather conditions. The business models are evolving as they serve a greater variety of customers. In more developed countries, much of the utility workforce is retiring creating skill and resource gaps. And they are being asked to expand electrical capacity as the world reduces carbon emissions. All this while their operations are under constant threat from ever-evolving cybersecurity risks.

Benefits

Digital Substation Automation solution:

- Improve Grid Reliability and Safety
- Support the move to renewable energy sources
- Reduce operational costs and improve efficiency

The Digital Substation enables Utilities to support new business models, meet regulatory requirements, expand capacity, integrate renewable energy sources, reduce operational costs and reduce risks to grid operations. The solution supports more than the core Supervisory Control and Data Acquisition (SCADA) systems adding key use cases around protection of

key assets and power management. Cisco technology upgrades and network management capabilities reduce operational costs by reducing the network footprint and automating key tasks. The network infrastructure is capable of supporting more devices and handling more bandwidth with more resiliency and capabilities, such as time synchronization and hosting applications. The solution builds upon the visibility and security in our Grid Security solution. Our portfolio addresses the needs of the range of transmission and distribution substations. The updated digital solution helps Utilities overcome the following challenges:

- Connect more grid devices with higher bandwidth requirements
- Reduce equipment footprint due to limited space, cooling, and power in substations for equipment
- Reduce Cybersecurity risks by providing visibility and segmentation of substation devices and communication
- Automation tools to address the lack of networking skills in Utility organizations

- Support for connecting and monitoring legacy grid devices
- Meet regulatory requirements, especially NERC-CIP and NIS2 security
- Scale up to support more sites (Substations and DER locations)

The Digital Substation solution helps Utilities overcome these challenges and lays the foundation for more reliable, sustainable, efficient Grid operations at lower costs. Key features delivered in this solution include:

- More ports, faster speeds: Introduction of the IEC 61850-3/IEEE 1613 compliant IE9300 switch with 28 Gb fiber ports for secure, reliable, low-latency Station and Process bus communication
- Higher-density: IE9320 switches stackable up to 4 units
- Reliability: Support for range of resiliency and synchronization protocols (PRP, HSR, PTP)
- Multi-functional router: Introduction of IEC 61850-3/IEEE 1613 certified IR8340 and IR1100 routers for a combination of scalable WAN connectivity, firewall security and application hosting into a variety of substations
- Resiliency: Support for range of resiliency and synchronization protocols
- Security: supports a range of firewall features, including IPS/IDS, Trustsec and MACsec
- Flexible: Highly modular platforms to support switching, routing, synchronization and edge compute needs
- Availability: Support for lossless network topologies and protocols (such as HSR and PRP)
- Precise: Support for substation-wide time synchronization (such as IEC61850-9-3 PUP and IEEE Power profile)
- Critical functions: Support for substation communications such as IEC61850 MMS/GOOSE/SV, Modbus and DNP3
- Simple: Range of management options including Cisco Catalyst Center for switching and Cisco WAN Manager for SD-WAN routing capabilities
- Secure: Updates to the Grid Security Solution with MACsec support

The following sections will provide an overview of the key additions: the new infrastructure, new network management Cisco Catalyst Center and WAN Manager for SD-WAN, cyber-security updates and a review of the new Substation Automation reference architecture.

New Infrastructure - More capability, higher performance, smaller footprint

The Digital Substation solution includes enhanced network infrastructure for modern grid and substation automation. The addition of new industrial routers and switches will help Utilities improve grid operations and security as well as reduce cost. The new infrastructure supports more features, more connectivity, higher performance and more management options than the previous set of network infrastructure, in a similar or smaller footprint and with fewer boxes. This will enable Utilities to connect more devices with higher bandwidth requirements, support more resilient topologies, improve cybersecurity and more easily deploy and manage...at scale and with lower operating costs.

The key new network infrastructure additions include the IE9320 & IR8340 for primary substation networks. Each support utility specific features including:

- IEC 61850-3/IEEE1613 and IEC62443 certifications,
- Support for the IEEE Precision Time Protocol – IEEE Power Profile and IEC61850-9-3 PUP
- Support for lossless resiliency protocols HSR and PRP on both the IE9320 and the IR8340 integrated switchports

The solution also introduces the IR1100 series router to interconnect secondary substations and monitor distributed critical assets.

Catalyst IE9320 rugged rackmount, stackable industrial switch

The IE9320 was designed as an industrial edge switch for Substation Station and Process bus networks. Key capabilities include:

- Industrial rackmount, high-density switch with 28 all fiber/SFP Gb ports to securely and reliably connect substation devices and assets
- Stack up to 8 units managed as one device for increased density and resiliency
- Cybersecurity rich with support for MACsec, TrustSec, IEEE 802.1x, Cisco Trust Anchor and hosting the Cyber Vision sensor for traffic analysis
- Improved visibility and telemetry with support for full-flexible Netflow and Network Based Application Recognition (NBAR2)
- Range of management support including Cisco Catalyst Center, running Cisco software-defined IOS-XE operating system, and support for automated network provisioning

The Catalyst IE9300 Rugged Series portfolio

Stackable, high performance, ruggedized industrial rackmount switches

 <p>IE-9310-26S2C 26x 1GE SFP ports 2x 1GE combo ports</p>	 <p>IE-9320-24T4X 24x 1GE ports 4x 10G SFP ports Stackable</p>	 <p>IE-9320-24P4S 24x 1GE with PoE/PoE+ Up to 385W PoE budget 4x 1GE SFP ports Stackable</p>	 <p>IE-9320-24P4X 24x 1GE with PoE/PoE+ 4x 10G SFP ports Up to 720W PoE budget Stackable</p>
 <p>IE-9320-26S2C 26x 1GE SFP ports 2x 1GE combo ports Stackable PRP,HSR</p>	 <p>IE-9320-22S2C4X 22x 1GE SFP, 4x 10G SFP 2x 1GE combo ports Timing input Conformal coating Stackable PRP,HSR</p>	 <p>IE-9320-16P8U4X 8x mGig with 90W 4-pair PoE 16x 1GE with PoE/PoE+ ports Up to 720W PoE budget 4x 10G SFP ports Stackable</p>	 <p>PWR-RGD-AC-DC-400 720W of PoE power with 2 PSUs</p>



Precision timing

50ns per-hop accuracy for IED synchronization within 1µs over 16 switch hops



IEC 61850 certified

substation switch to connect fiber IEDs
Shock, Vibration, EMF standard compliance for substations



Lossless convergence

REP, PRP, MRP, and HSR redundancy

The most comprehensive industrial rackmount portfolio in the market

Catalyst IR8340 rugged rackmount industrial router

The IR8340 is the high-end, flexible Substation router to securely interconnect the Substation networks to the Utility WAN and the Operations Centers. Its range of functions (switch, router, application hosting, timing, and firewall) allows for consolidation of network and security infrastructure devices saving critical space and cost in tight substation designs. Its key features include:

- Modular design to support a range of connectivity with modules for LTE & 5G, GNSS timing, WAN, (E1/T1) lines and serial ports
- Timing module to handle a variety of timing inputs and outputs (including GNSS)
- Integrated 14 Gb ports switch (mixed fiber and copper) to connect Process & Station bus and multi-service networks with PoE+ on 4 copper ports
- Integrated compute and storage to support hosting edge (IOx) applications
- Cybersecurity support for IPS/IDS, various VPN technologies, MACsec, TrustSec, IEEE 802.1x, Cisco Trust Anchor and operating a Cyber Vision sensor to support the Electronic Security Perimeter role reducing the need for a separate firewall
- Range of management support including Cisco Catalyst Center, WAN Manager for SD-WAN and operating Cisco software-defined IOS-XE operating system

Catalyst IR8300 Rugged Series Routers

High performance modular router for mission-critical industrial assets

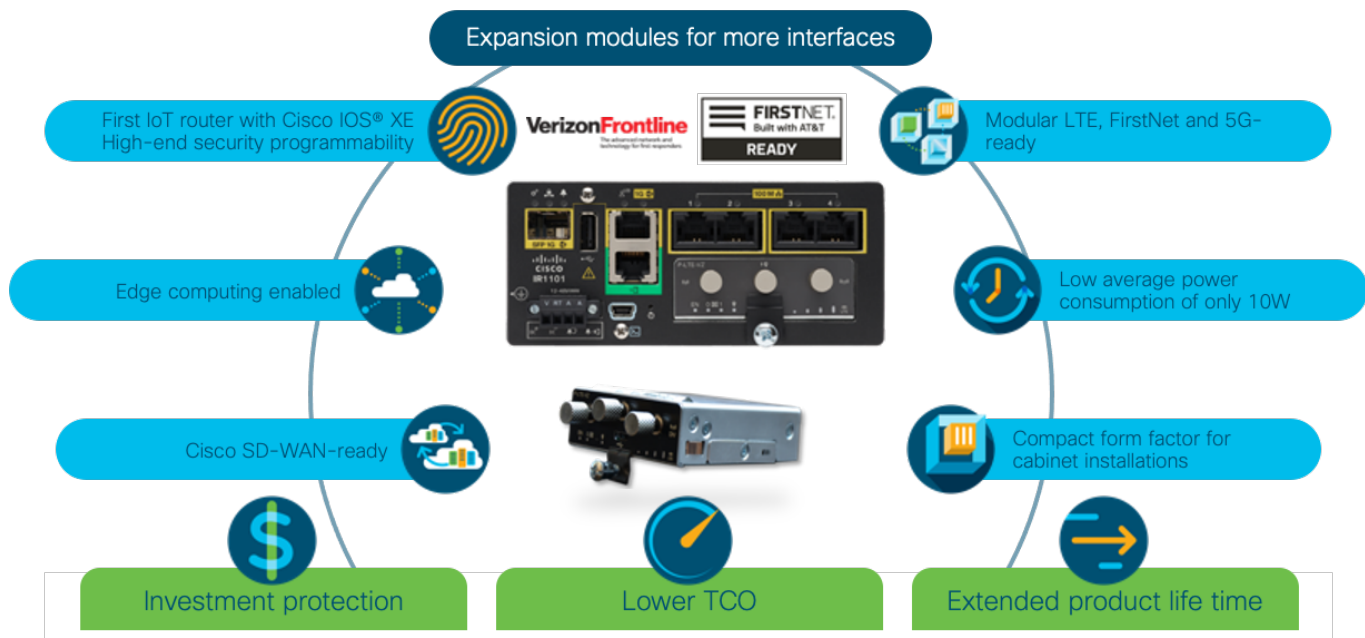


Catalyst IR1101 rugged DIN-rail mount industrial Router

The IR1101 is the compact, flexible industrial router for secure connectivity of secondary substations and remote monitoring of distributed assets. Its range of functions (switch, router, compute, and security) allows for consolidation of network/security infrastructure devices saving critical space and cost in tight designs. Its key features include:

- Modular design to support a range of connectivity with modules for LTE & 5G, GPS, WAN and serial ports
- Expansion modules to add switch ports, serial ports, local storage and WAN redundancy
- Integrated 4 copper FE and 1 Gb WAN ports switch to connect secondary substation and remote asset devices
- Support for TCP/UDP raw socket protocol to transport SCADA data from serial based RTUs
- Supports native DNP3 and IEC 60870 substation protocol translation
- Integrated compute and storage to support hosting edge (IOx) applications
- Cybersecurity support for zone-based Firewall, MACsec, various VPN technologies, TrustSec, IEEE 802.1x, Cisco Trust Anchor, and operating a Cyber Vision sensor to support Electronic Security Perimeter role reducing the need for a separate firewall
- Range of management support including Cisco Catalyst Center, WAN Manager for SD-WAN, and operating Cisco software-defined IOS-XE operating system

Figure 1: IR1101 Expansion modules



Automated, Scalable Network Management

Benefits

Cisco Catalyst Center and WAN Manager improve industrial operations by:

- Increasing Grid uptime and asset utilization
- Lowering operational costs
- Simplifying network management for IT & OT

A key challenge facing Utilities in this Digitization initiative is the ability to deploy and manage at scale the number of Substations in their network. Often the Substation Automation system may cover 100s or 1000s of Substations with 1000s of switches, routers and firewalls all interconnected via large Wide-Area Networks. It is a significant challenge to deploy and manage these networks, especially given the lack of networking expertise in Field personnel. The substation and network equipment is located in un-manned substations and therefore remotely managed. The network and its reliable operation is critical to Grid operations.

Our Digital Substation solution applies the best of Cisco management tools and capabilities to help Utilities manage large deployments of substation network infrastructure. Cisco Catalyst Center manages substation switches, routers and wireless infrastructure. Cisco WAN Manager focuses on the WAN network, Substation routers and enables SD-WAN using a software-defined WAN controller to fully automate the WAN operations.

Cisco Catalyst Center for the Digital Substation

Catalyst Center for the Digital Substation adds a broad new capability to manage and operate the network infrastructure in and around the Substation. It adds a capability to centrally (on-premise) configure and manage the various networks in the substations as part of the Substation Operations.

Key challenges Cisco Catalyst Center helps address include:

- Reduce manual operations and simplify activities with Automated workflows and templates to streamline configuring and maintaining network deployments
- Reduce network and Grid downtime with network Assurance that provides proactive monitoring, predictive maintenance, and guided remediation of network issues.
- Reduce discrepancies in network and security configurations with compliance checks on network operating system and configurations

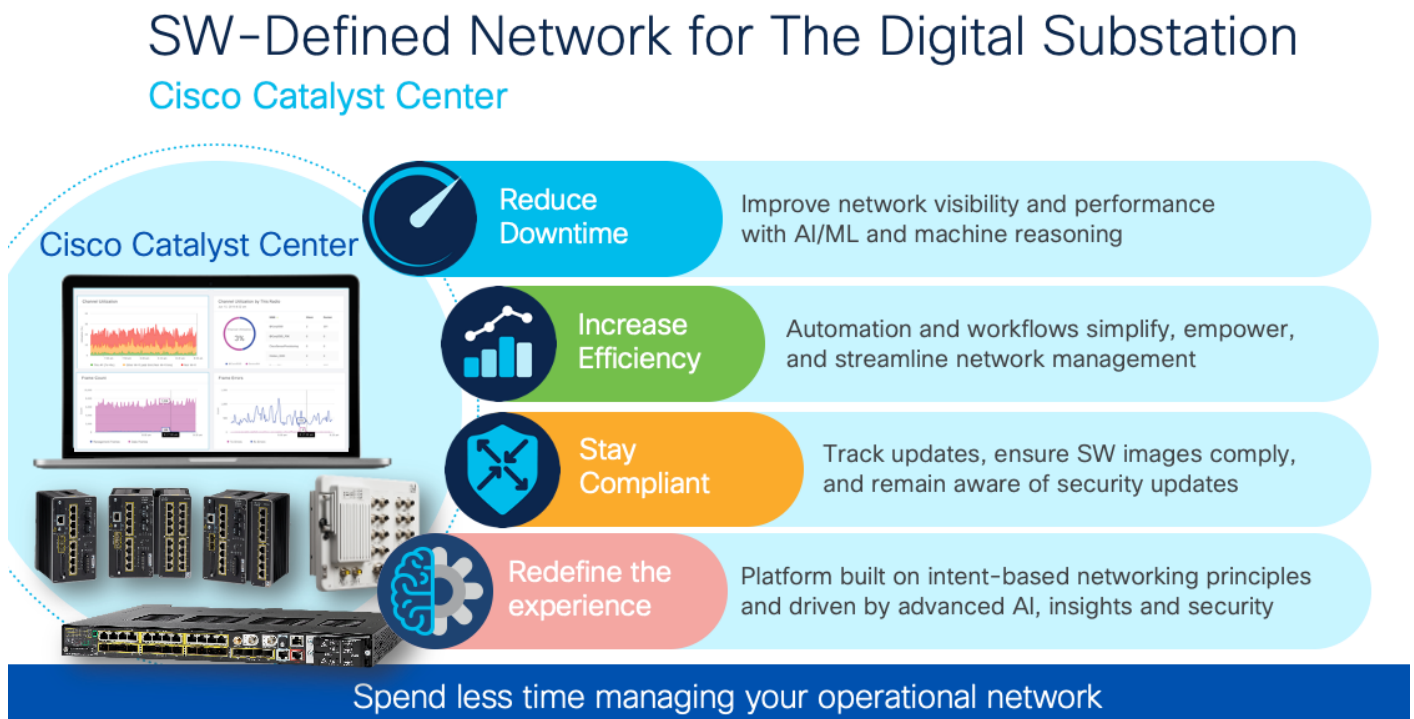
Cisco Catalyst Center has two key capabilities valuable to the operations of a Digital Substation.

First, the Automation features allow utilities to consistently, securely and at-scale configure and maintain the networks in the substations. From the start of this transition to standards-based networking for substation networks, the operational teams have lacked the skills and expertise typically found in the IT networking organizations. The industrial Ethernet infrastructure is often installed and maintained by personnel with minimal networking background. Cisco Catalyst Center focuses on deploying and maintaining network infrastructure with automation bringing consistency, reduced effort, and reliance on simplified workflows for both IT and OT personnel.

Key use cases supported by Cisco Catalyst Center automation features include:

- Discovers existing network infrastructure devices, adds devices to the inventory, and establishes telemetry (for example: SNMP, syslog, and end-device tracking)
- Provide network topology view with key status information
- Network Plug and Play – Automatically detect and provision new network infrastructure
- Backup network configurations and replace malfunctioning network infrastructure (RMA process)
- Check for inconsistent configurations and deploy updates scalably and consistently
- Deploy QoS values based on templates
- Deploy network software images and patches automatically and at-scale
- Compliance checks for configurations and SW images
- Deploy applications onto the edge-capable network infrastructure1
- Prepare network infrastructure for Cyber Vision sensor deployment
- Maintain an audit log for all network changes for accountability

Figure 1: Cisco DNA Center network automation functions



Second, Cisco Catalyst Center Assurance features allow IT and OT teams to monitor the network infrastructure and connectivity status of end-devices. Outages and downtime in production environments result in significant loss, whether caused by network failures, human error or equipment failure. Bringing production networks back on-line quickly reduces the impact. Cisco Catalyst Center Assurance suite of features and functions help IT and OT quickly identify network outages or performance issues and resolve them quickly. The key use cases this solution incorporates include:

- Discover the network infrastructure and network topology, visualized in an easy-to-configure view

- Collect and analyze network telemetry information including SNMP, syslog, and IPFIX/Netflow data
- Identify and profile end-devices connected to the network and their connectivity status including substation devices, sensors, IEDs and RTUs, as identified by Cyber Vision and communicated via ISE
- Proactively identify issues in the network that impact grid operations
- Collect contextual information for accurate root-cause analysis without the need for recreating the issue
- Help step-through remediation options to speed issue resolution
- Examine VLAN settings for solving reachability issues
- Provide Network and Device health monitoring status and history
- Use Machine Reasoning Engine to accelerate remediation of issues
- Provide security compliance views to indicate potential risks
- Employ tools such as path trace and packet capture to aid in problem resolution
- Customize to allow OT and IT specific roles based on feature-set and location/site

WAN Manager and SD-WAN for the Digital Substation

With Cisco SD-WAN, Utilities can deliver routing, threat protection, efficient offloading of expensive circuits, and simplification of WAN network management.

- High availability, with predictable service, for all critical applications and multiple hybrid active-active links for all network scenarios
- Dynamically routed application traffic with application-aware routing, for efficient delivery and improved experience
- Improved OpEx, replacing or augmenting expensive Multiprotocol Label Switching (MPLS) services with more economical and flexible backhaul services (including secure VPN connections)

Security focus with application-aware policies with end-to-end segmentation (both macro and micro) and real-time access control

- Secure traffic across the backhaul network, with automatic certificate-based VPN and zero-touch secure onboarding for edge gateways
- Integrated threat protection enforced at the right place (substation edge or Datacenter), with distributed security to the substation and remote endpoints with NGFW, DNS security, and IPS

Cyber Security for the Substation

Grid Security Features:

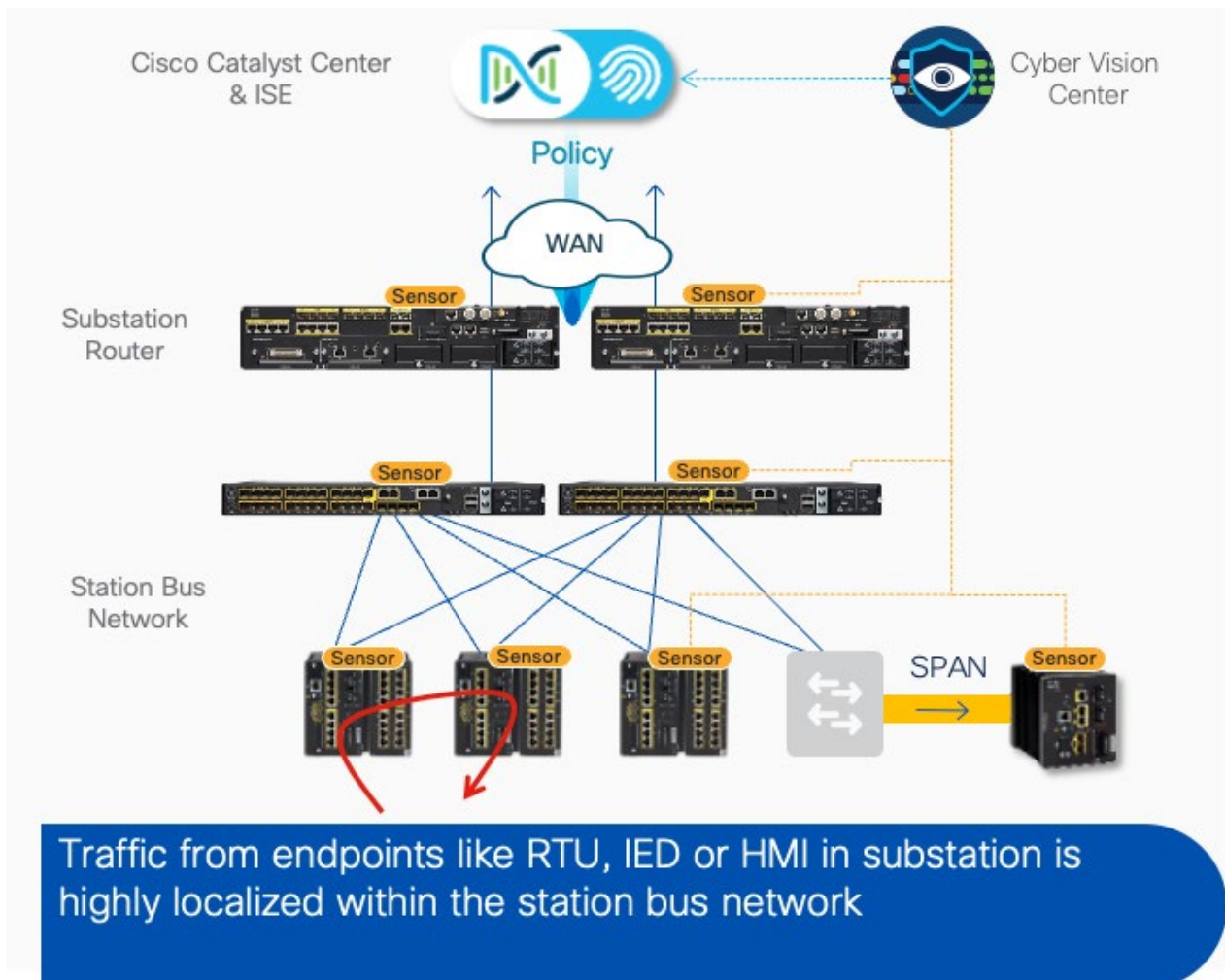
- Build a dynamic inventory of Substation devices and their communication patterns
- Segment communications within the Industrial Zone and IDMZ
- Monitor and detect abnormal substation behaviors

Cisco introduced the Cisco Validated Design for Grid Security in 2020. The Grid Security CVD provides a holistic cybersecurity architecture to protect utility networks and processes while addressing the key security and compliance concerns of the utility grid operators. The solution is applicable to Substation and Distribution Automation. The updated Digital Substation solution reflects and enhances the Grid Security concepts and models. The Digital Substation solution incorporates the new network infrastructure and tools into Grid Security reference architecture, including:

- Incorporating the IR 8340 Substation router as the firewall to establish the Electronic Security Perimeter for the critical substation Process and Control networks and systems.
- Incorporating the IR 8340 and IE 9320, both capable of running Cyber Vision sensors to provide visibility and monitoring of Substation devices and communication from a Cyber Security perspective as well as supporting a range of network security features such as Cisco Trustsec, MACsec encryption, full-flexible Netflow, IEEE 802.1x network access control and IEC 62443 4-1 and 4-2 certification
- Easy and simple support for macro- and micro-segmentation and advanced security with WAN Manager and SD-WAN
- Cisco Catalyst Center, interfacing with Cyber Vision and ISE can help secure your operations:
 - Establish a security profile to manage the industrial network
 - Create authentication and authorization policies in ISE

- Visualize connected industrial assets in Cisco Catalyst Center as discovered and profiled by Cyber Vision and grouped in ISE
- Monitor communications patterns between asset groups using NetFlow traffic and help define and validate access policies
- Create and manage cybersecurity segmentation policy (Trustsec and Scalable Group Tags (SGTs)) for the substation network
- Deploy policies with confidence and segment the network to restrict unnecessary access
- Allow usage of other Cisco security applications such as Umbrella, Secure Network Analytics and FMC for further security integrations

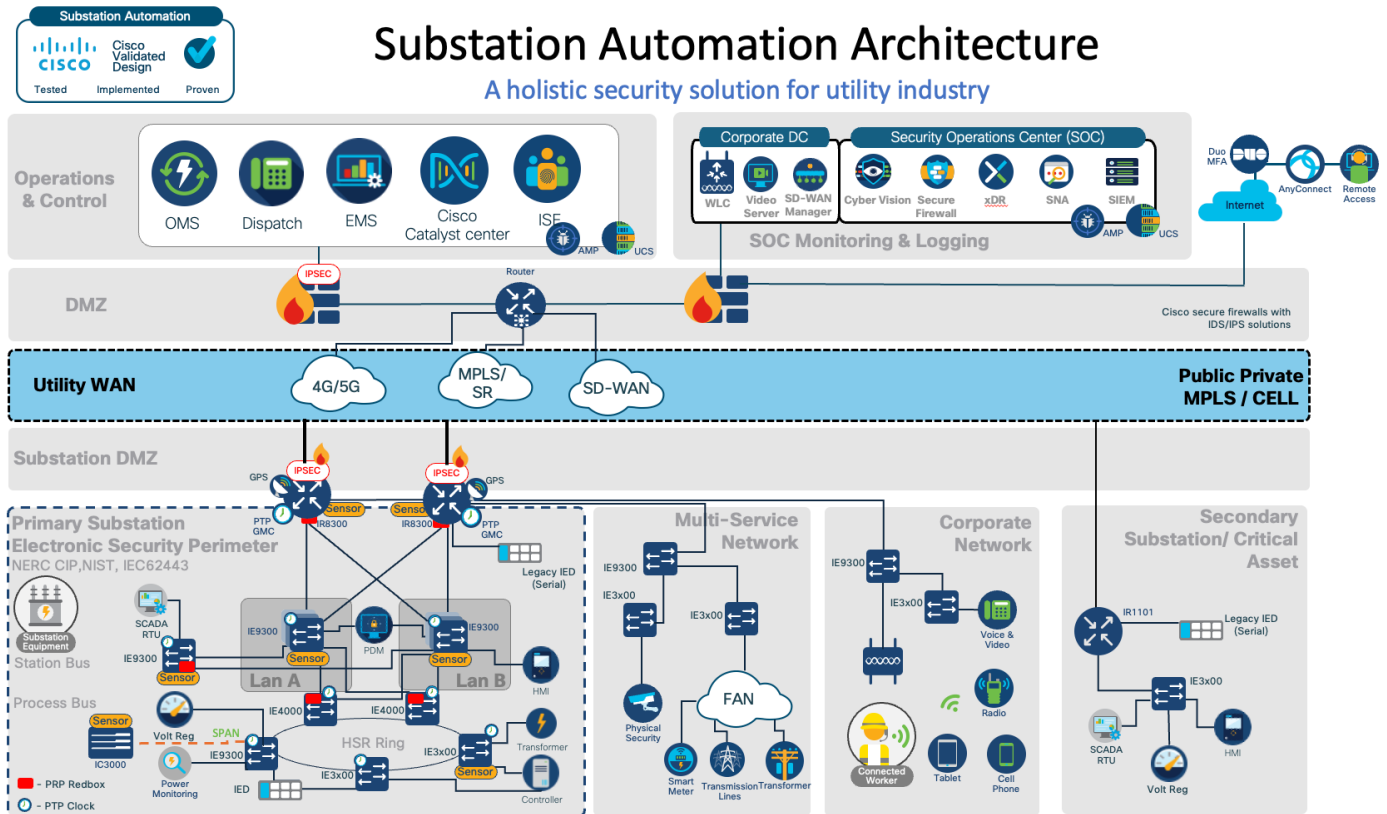
Figure 2: Cisco Cyber Vision integration with Cisco Catalyst Center and Identity Services Engine



Digital Substation Reference Architecture

The Digital Substation reference architecture depicts the core network and security infrastructure needed for reliable, secure Substation Automation.

Figure 3: Substation Automation reference architecture



Substation Automation CVD

Key Use Cases:

- Secure and Resilient connectivity for Process and Station bus equipment in primary substations
- Support connectivity of secondary substation and multi-service networks
- Automated and proactive network management
- Visibility of Substation end-devices and communications
- WAN interconnectivity via Cellular, MPLS or SD-WAN
- Secured remote access to production assets
- Availability of IACS devices and data for IoT applications

Key Design and Implementation considerations

The Digital Substation Validated design represents a significant update to Substation Automation operations, including:

- Added the new Cisco IE 9320 ruggedized, rack-mount switch as a industrial access switch to the architecture along with IE 3x00 DIN rail platforms
- Added the new IR 8340 ruggedized, rack-mount modular router for primary Substation interconnection with the WAN and the Operations Center
- Added the new IR 1101 ruggedized, DIN-rail modular router as the WAN connectivity for Secondary substations and critical asset monitoring
- Deploying Cisco Catalyst Center on-premises appliance and software as part of the Operations Center to monitor and manage network infrastructure in the Substation enabling SD-WAN option for the Utility WAN

- Interface Cisco Catalyst Center with Identity Services Engine deployment Integration of substation device information discovered by Cyber Vision into ISE

The Solution is designed to meet the demanding requirements of Substation Automation operations. The Solution guidance provides customers, partners and system implementers with design and implementation guidance to successfully deploy Cisco network infrastructure and technologies. The Solution supports key Substation Automation requirements including:

- Support for a range of Substations: Transmission and Distribution
- Support for Process and Station bus communications, IEC 61850 MMS, Sampled Values and Goose, Wide-Area Measurement Systems (WAMS), DNP3, Modbus/TCP, and others.
- Resilient network topologies supporting a range of loss-less (for example: HSR, PRP) and fast ring (REP) resiliency protocols
- Power Profile based precise timing distribution (IEEE C37.238 and IEC61850-9-3) across the substation network based on a variety of timing inputs
- Legacy device interconnectivity via Serial ports and backhauled to Operations Centers
- Support legacy SCADA devices - Serial/TDM to IP transition
- Support Tele-protection and power management (Synchrophasor/PMU, Volt/Var) applications
- Cybersecurity support for NERC CIP compliance, including:
 - Visibility of substation devices and communications
 - Protect and segment substation devices and communications including establishment of Electronic Security Perimeter
 - Detect and respond to security and network anomalies
 - Data privacy and protection
 - Secure Remote Access
- Proactively identify WAN/LAN network issues and receive remediation suggestions and consistently configure and maintain network infrastructure
- Guidance on refreshing legacy networking equipment

Summary

Cisco Digital Substation solution helps Utilities overcome key challenges such as increase demand for electricity, integration variable and distributed “sustainable” sources of energy while being buffeted by ever more extreme environmental conditions as the business models evolve. The Cisco solution significantly improves Grid operations while reducing operational costs and improving the cybersecurity of the substation. It meets the demanding requirements of the harsh substation condition in the Process and Station bus systems, such as lossless, no-single-point-of-failure resiliency, and Power Profile timing synchronization. The solution provides design and implementation guidance to help customers, implementers, and partners to confidently deploy networking solutions for critical infrastructure. We test with substation equipment and applications from a range of vendors supporting a wide variety of substation protocols. We introduce new network infrastructure and technology including switches and routers, with unparalleled performance at scale, leveraging Cisco cybersecurity technology and simple, scalable management options to reduce operational effort and increase uptime. It is time to refresh the substation network and provide a platform to support services now and in the future.

For more on the Substation Automation solution, please visit the [Cisco Validated designs for digital utilities and renewable energy](#) page.

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