



Parallel Redundancy Protocol within a Converged Plantwide Ethernet Architecture

White Paper

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Rockwell Automation and Cisco Four Key Initiatives:

- **Common Technology View:**
A single scalable architecture, using open EtherNet/IP™ standard networking technologies, is paramount to enable the Industrial Internet of Things for achieving the flexibility, visibility, and efficiency required in a competitive manufacturing environment.
- **Converged Plantwide Ethernet Architectures:**
Collection of tested and validated architectures developed by subject matter authorities at Cisco, Panduit, and Rockwell Automation. The content of CPwE is relevant to both Operational Technology (OT) and Information Technology (IT) disciplines and consists of documented architectures, best practices, guidance, and configuration settings to help manufacturers with design and deployment of a scalable, reliable, safe, secure, and future-ready plant-wide industrial network infrastructure.
- **Joint Product Collaboration:**
Stratix® 5950 industrial firewall, FactoryTalk® Network Manager™ software, Stratix 5700, Stratix 5400, Stratix 5410, and Stratix 5800 Industrial Ethernet Switches, incorporating the best of Cisco and the best of Rockwell Automation.
- **People and Process Optimization:**
Education and services to facilitate Operational Technology (OT) and Information Technology (IT) convergence, which can assist with successful architecture deployment, and helps to enable efficient operations that allow critical resources to focus on increasing innovation and productivity.

Parallel Redundancy Protocol within a Converged Plantwide Ethernet Architecture

The prevailing trend in Industrial Automation and Control System (IACS) networking is the convergence of technology, specifically IACS operational technology (OT) with information technology (IT). Converged Plantwide Ethernet (CPwE) helps to enable IACS network and security technology convergence, including OT-IT persona convergence, through the use of standard Ethernet, Internet Protocol (IP), network services, security services, and EtherNet/IP. A highly-available converged plant-wide or site-wide IACS architecture helps to enable the Industrial Internet of Things (IIoT).

Business practices, corporate standards, policies, industry standards, and tolerance to risk are key factors in determining the degree of resiliency and application availability required within an IACS plant-wide or site-wide architecture, e.g., non-resilient LAN, resilient LAN, or redundant LANs. A highly-available network architecture within an IACS application plays a pivotal role in helping to minimize the risk of IACS application shutdowns while helping to maximize overall plant or site uptime.

A holistic resilient plant-wide or site-wide network architecture is made up of multiple technologies (logical and physical) deployed at different levels within the plant or site. When selecting a resiliency technology, various plant or site application factors should be evaluated, including the physical layout of IACS devices (geographic dispersion), recovery time performance, uplink media type, tolerance to data latency and jitter, and future-ready requirements. For more information on resiliency technology, refer to *Deploying a Resilient Converged Plantwide Ethernet Architecture (CPwE Resiliency) Design and Implementation Guide (DIG)*.

Deploying Parallel Redundancy Protocol within a Converged Plantwide Ethernet Architecture (CPwE PRP) Design and Implementation Guide outlines several use cases for designing and deploying PRP technology with redundant network infrastructure across plant-wide or site-wide IACS applications. CPwE PRP is an extension to CPwE Resiliency and was architected, tested and validated by Cisco Systems and Rockwell Automation with assistance by Panduit.

CPwE Overview

CPwE is the underlying architecture that provides standard network and security services for control and information disciplines, devices, and equipment found in modern IACS applications. The CPwE architectures ([Figure 1](#)) were architected, tested and validated to provide design and implementation guidance, test results, and documented configuration settings. This can help to achieve the real-time communication, reliability, scalability, security, and resiliency requirements of modern IACS applications. The content and key tenets of CPwE are relevant to both OT and IT disciplines.

- **Smart IIoT devices**—Controllers, I/O, drives, instrumentation, actuators, analytics, and a single IIoT network technology (EtherNet/IP)
- **Zoning (segmentation)**—Smaller connected LANs, functional areas, and security groups
- **Managed infrastructure**—Managed Allen-Bradley® Stratix industrial Ethernet switches (IES), Cisco Catalyst distribution/core switches, FactoryTalk Network Manager software, and Stratix industrial firewalls
- **Resiliency**—Robust physical layer and resilient or redundant topologies with resiliency protocols
- **Time-critical data**—data prioritization and time synchronization via CIP Sync™ and IEEE-1588 Precision Time Protocol (PTP)
- **Wireless**—Unified wireless LAN (WLAN) to enable mobility for personnel and equipment
- **Holistic defense-in-depth security**—Multiple layers of diverse technologies for threat detection and prevention, implemented by different persona (e.g., OT and IT) and applied at different levels of the plant-wide or site-wide IACS architecture
- **Convergence-ready**—Seamless plant-wide or site-wide integration by trusted partner applications

Wide Area Network (WAN)
Data Center - Virtualized Servers

- ERP - Business Systems
- Email, Web Services
- Security Services - Active Directory (AD), Identity Services (AAA), TLS Proxy
- Network Services - DNS, DHCP
- Call Manager

Physical or Virtualized Servers

- Patch Management
- AV Server, TLS Proxy
- Application Mirror, Reverse Proxy
- Remote Desktop Gateway Server

Enterprise Zone Levels 4-5

Industrial Zone Levels 0-3 (Plant-wide Network)

Plant Firewalls

- Active/Standby
- Inter-zone traffic segmentation
- ACLs, IPS and IDS
- VPN Services
- Portal and Remote Desktop Services proxy

Cell/Area Zone Levels 0-2

Level 3 - Site Operations (Control Room)

Cell/Area Zone - Levels 0-2

Redundant LAN - Parallel Redundancy Protocol
 Enhanced Interior Gateway Routing Protocol - EtherChannel
 Hot Standby Router Protocol - Active/Standby (Skids, Equipment)

Cell/Area Zone - Levels 0-2

Ring Topology - Device Level Ring (DLR) Protocol
 Redundant Star Topology - Flex Links Resiliency
 Unified Wireless LAN (Lines, Machines, Skids, Equipment)

Cell/Area Zone - Levels 0-2

Linear/Bus/Star Topology
 Redundant Star Topology - EtherChannel Resiliency
 Unified Wireless LAN (Lines, Machines)

**Note**

This release of the CPwE architecture focuses on EtherNet/IP, which uses the ODVA, Inc. Common Industrial Protocol (CIP™), and is ready for the Industrial Internet of Things (IIoT). For more information on EtherNet/IP, CIP, CIP Sync, or PRP, see [odva.org](http://www.odva.org) at the following URL:

- <http://www.odva.org/Technology-Standards/EtherNet-IP/Overview>

CPwE Parallel Redundancy Protocol Solution Use Cases

An IACS is deployed in a wide variety of industries such as automotive, pharmaceuticals, consumer packaged goods, pulp and paper, oil and gas, mining, and energy. IACS applications are made up of multiple control and information disciplines such as continuous process, batch, discrete, and hybrid combinations. One of the challenges facing industrial operations is the industrial hardening of standard Ethernet and IP-converged IACS networking technologies to take advantage of the business benefits associated with IIoT. A high-availability network architecture (Figure 2) can help to reduce the impact of a network failure on a mission-critical IIoT IACS application.

Parallel Redundancy Protocol (PRP) is a standard defined in IEC 62439-3 and is adopted in the ODVA, Inc. EtherNet/IP specification. PRP technology creates seamless network redundancy by allowing PRP enabled IACS devices to send duplicate Ethernet frames over two independent Local Area Networks (LANs). If a failure occurs in one of the LANs, traffic continues to flow through the other LAN uninterrupted with zero recovery time.

An IACS device enabled with PRP technology has two ports that operate in parallel and attach to two independent LANs (Figure 2), e.g., LAN A and LAN B. This type of IACS device is known as a PRP double attached node (DAN). During normal network operation, an IACS DAN simultaneously sends and receives duplicate Ethernet frames across both LAN A and LAN B. The receiving IACS DAN accepts whichever frame arrives first and discards the subsequent copy.

IACS devices that do not support the PRP technology can utilize a PRP Redundancy Box (RedBox) to connect to the two independent LANs (Figure 2). The RedBox functions similarly to the DAN; a PRP enabled IES is an example of a RedBox.

IACS devices that connect to both LAN A and LAN B through a RedBox are referred to as a PRP Virtual DAN (VDAN).

A single attached node (SAN) is an IACS device without PRP support that only resides on either LAN A or LAN B.

PRP supports flexible LAN topologies including linear, star, redundant star, and ring topologies. If both LAN topologies are resilient and single-fault tolerant, PRP architecture can recover from multiple faults in the network.

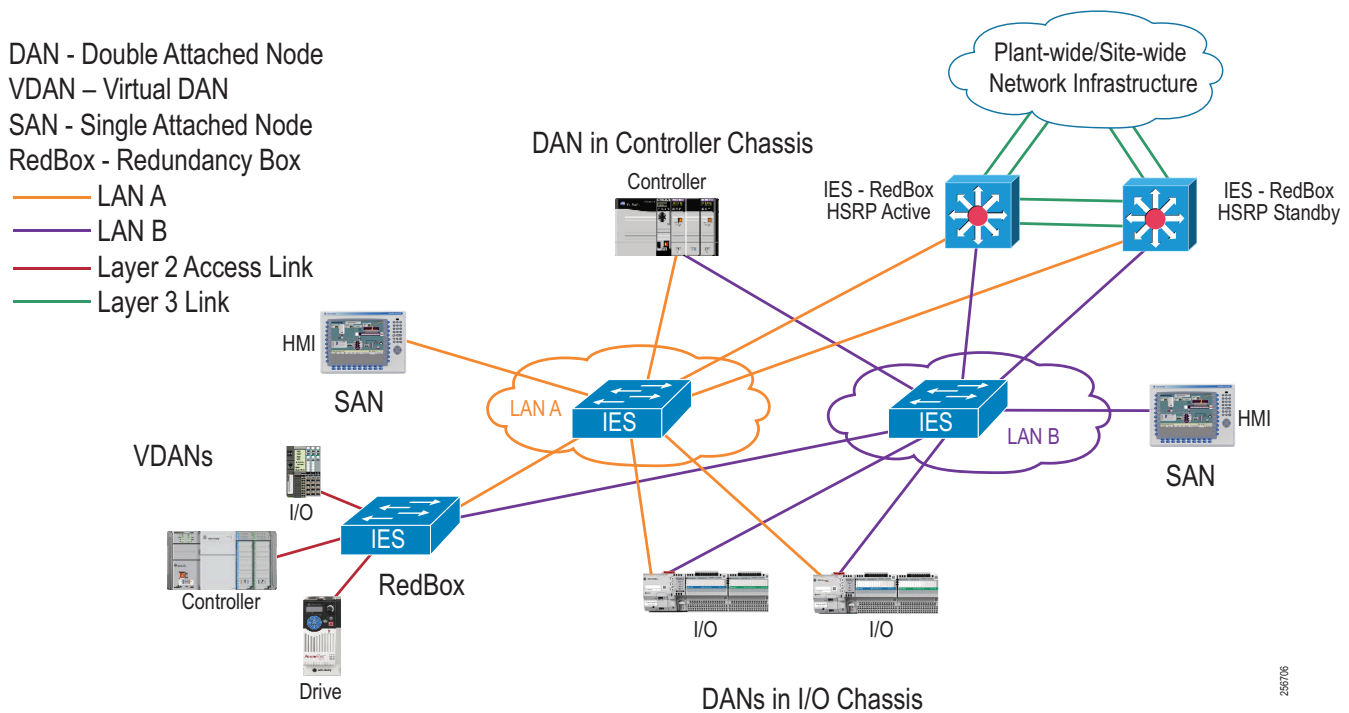
In contrast, other resiliency technologies are typically single-fault tolerant, are a single LAN, and utilize redundant path topologies (e.g., ring and redundant star). A resiliency protocol is used to forward Ethernet frames along one physical path while blocking the other physical path to avoid Ethernet loops. Network convergence times vary across resiliency technologies. Convergence time disruption is defined as the time it takes to discover a failure (e.g., link or device) along a path, unblock the blocked path, then start forwarding Ethernet frames along that unblocked path. For example, the convergence time for the ODVA, Inc. Device Level Ring (DLR) protocol standard is 3 ms.

CPwE PRP outlines the concepts, requirements, and technology solutions for reference designs developed around a specific set of priority use cases. These use cases were tested for solution functional validation by Cisco Systems and Rockwell Automation with assistance by Panduit. This helps support a redundant converged plant-wide or site-wide EtherNet/IP IACS architecture.

The CPwE PRP Design and Implementation Guide includes:

- Parallel Redundancy Protocol technology overview
- Design and configuration considerations for plant-wide or site-wide IACS PRP deployments
 - Topology choices
 - PRP devices— e.g., DAN, VDAN, SAN, and RedBox
 - Distribution switch selection
- Selection of Industrial Ethernet Switches (IES)
 - Allen-Bradley Stratix 5700, Stratix 5400, and Stratix 5800 IES as LAN A/B switches
 - Allen-Bradley Stratix 5400 and Stratix 5410 RedBox IES

Figure 2 Representative Plant-wide or Site-wide PRP Deployment



For more information on PRP, see *EtherNet/IP Parallel Redundancy Protocol Application Technique*
https://literature.rockwellautomation.com/idc/groups/literature/documents/at/enet-at006_-en-p.pdf

CPwE Resilient IACS Architectures Overview

Protecting availability for IACS assets requires a defense-in-depth approach where different solutions are needed to address various network resiliency requirements for a plant-wide or site-wide architecture. This section summarizes the existing Cisco, Panduit and Rockwell Automation CPwE Cisco Validated Designs (CVDs) and Cisco Reference Designs (CRDs) that address different aspects of availability for IIoT IACS applications.

- *Deploying A Resilient Converged Plantwide Ethernet Architecture Design and Implementation Guide* outlines several use cases for designing and deploying resilient plant-wide or site-wide architectures for IACS applications, utilizing a robust physical layer and resilient topologies with resiliency protocols.
 - Rockwell Automation site:
https://literature.rockwellautomation.com/idc/groups/literature/documents/td/enet-td010_-en-p.pdf
 - Cisco site:
https://www.cisco.com/c/en/us/solutions/enterprise/design-zone-manufacturing/landing_ettf.html
- *Deploying Device Level Ring within a Converged Plantwide Ethernet Architecture Design Guide* outlines several use cases for designing and deploying DLR technology with IACS device-level, switch-level, and mixed device/switch-level single and multiple ring topologies across OEM and plant-wide or site-wide IACS applications.
 - Rockwell Automation site:
https://literature.rockwellautomation.com/idc/groups/literature/documents/td/enet-td015_-en-p.pdf
 - Cisco site:
https://www.cisco.com/c/en/us/solutions/enterprise/design-zone-manufacturing/landing_ettf.html

Summary

CPwE is a collection of architected, tested, and validated designs. The testing and validation follow the Cisco Validated Design (CVD) and Cisco Reference Design (CRD) methodologies.

The content of CPwE, which is relevant to both operational technology (OT) and informational technology (IT) disciplines, consists of documented architectures, best practices, guidance, and configuration settings to help industrial operations and OEMs with the design and deployment of a scalable, reliable, secure, and future-ready plant-wide or site-wide industrial network infrastructure. CPwE can also help industrial operations and OEMs achieve cost reduction benefits using proven designs that can facilitate quicker deployment while helping to minimize risk in deploying new technology. CPwE is brought to market through an ecosystem consisting of Cisco, Panduit, and Rockwell Automation emergent from the strategic alliance between Cisco Systems and Rockwell Automation.

The *Deploying Parallel Redundancy Protocol within a Converged Plantwide Ethernet Architecture Design and Implementation Guide* outlines several use cases for designing and deploying PRP technology and topologies throughout a plant-wide or site-wide Industrial Automation and Control System (IACS) network infrastructure. CPwE PRP highlights the key IACS application requirements, technology, and supporting design considerations to help with the successful design and deployment of these specific use cases within the CPwE framework. CPwE PRP was architected, tested, and validated by Cisco Systems and Rockwell Automation with assistance by Panduit.

More information on CPwE Design and Implementation Guides can be found at the following URLs:

- Rockwell Automation site:
 - <http://www.rockwellautomation.com/global/products-technologies/network-technology/architectures.page?>
- Cisco site:
 - http://www.cisco.com/c/en/us/solutions/enterprise/design-zone-manufacturing/landing_ettf.html

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