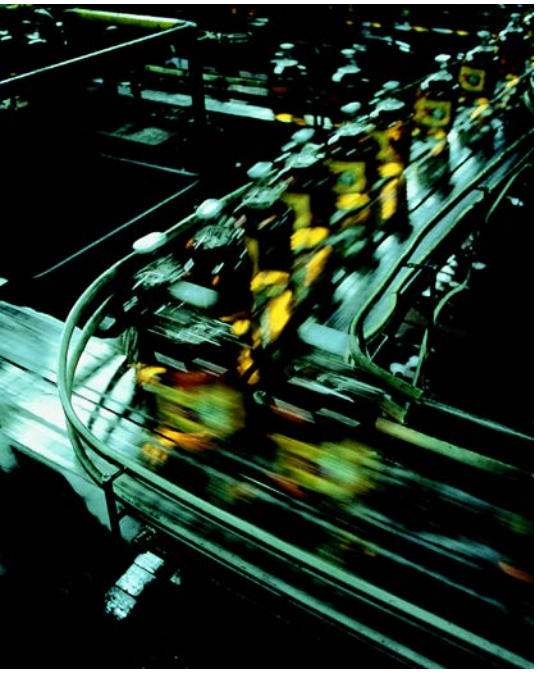


A Resilient Converged Plantwide Ethernet Architecture

White Paper

October 2017

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 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, robust, secure and future-ready plant-wide industrial network infrastructure.
- Joint Product Collaboration:
  Stratix® 5950 Industrial Firewall, Stratix 5100 Wireless Access Point/Workgroup Bridge, and Stratix 5700, Stratix 5400 and Stratix 5410 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, assist with successful architecture deployment, and enable efficient operations that allow critical resources to focus on increasing innovation and productivity.

Document Reference Number: ENET-WP039D-EN-P

A Resilient 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 network technology convergence through the use of standard Ethernet, Internet Protocol (IP) and resiliency technologies, which help to enable the Industrial Internet of Things (IIoT).

Business practices, corporate standards, industry standards, policies and tolerance to risk are key factors in determining the degree of resiliency and application availability required within an IACS plant-wide architecture. A resilient 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 uptime.

An IACS is deployed in a wide variety of industries such as automotive, pharmaceuticals, consumer 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. A resilient network architecture can help to increase overall equipment effectiveness (OEE) of the IACS by reducing the impact of a failure and speed recovery from an outage which lowers mean-time-to-repair (MTTR).

A holistic resilient plant-wide network architecture is made up of multiple technologies (logical and physical) deployed at different levels within the plant-wide architecture:

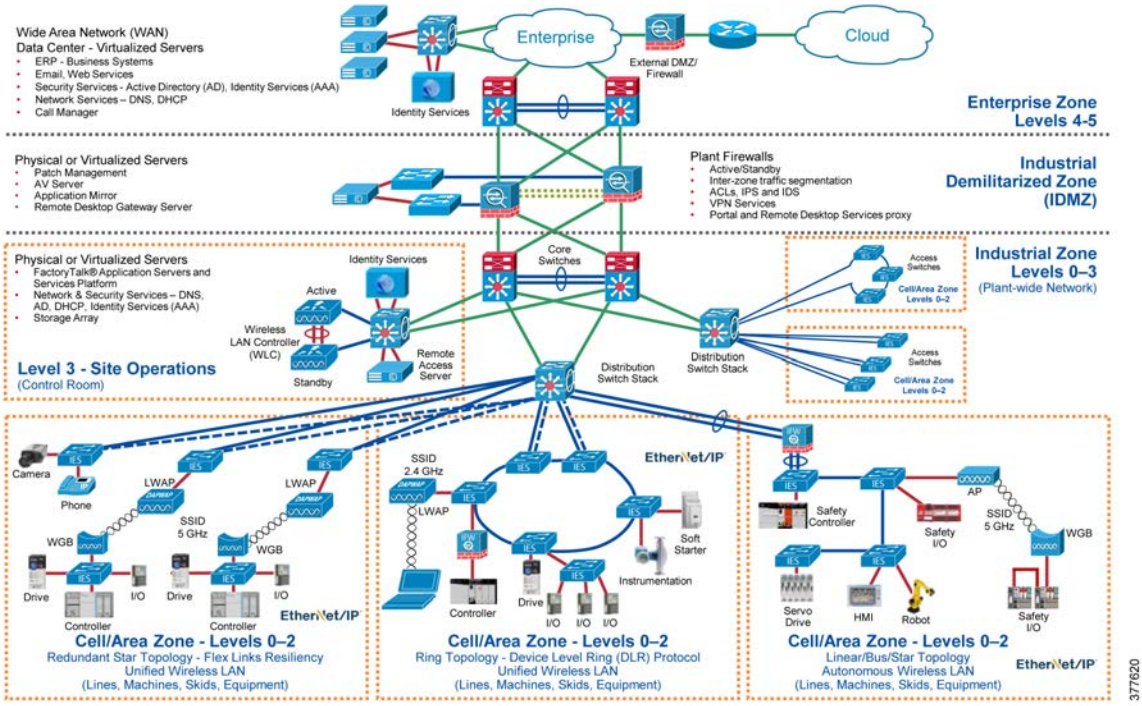
- Robust physical infrastructure
- Topologies and protocols
- Switching and routing
- Wireless LAN Controllers (WLC)
- Firewalls
- Network and device management

Deploying a Resilient Converged Plantwide Ethernet Architecture Cisco Validated Design (CPwE Resiliency CVD), which is documented in the *Deploying a Resilient Converged Plantwide Ethernet Architecture Design and Implementation Guide (DIG)*, outlines several use cases for designing and deploying resilient plant-wide architectures for IACS applications. The CPwE Resiliency CVD was tested and validated by Cisco Systems, Panduit and Rockwell Automation.

CPwE is the underlying architecture that provides standard network services for control and information disciplines, devices, and equipment found in modern IACS applications. The CPwE architectures (Figure 1) provide design and implementation guidance, test results and documented configuration settings that can help

to achieve the real-time communication, reliability, scalability, security and resiliency requirements of modern IACS applications. CPwE is brought to market through a strategic alliance between Cisco Systems and Rockwell Automation.

Figure 1 CPwE Architectures



Converged Plantwide Ethernet Resiliency

The Deploying a Resilient Converged Plantwide Ethernet Architecture CVD, which is documented in the *Deploying a Resilient Converged Plantwide Ethernet Architecture Design and Implementation Guide (DIG)*, outlines key requirements and design considerations to help with successfully designing and deploying a holistic resilient plant-wide network architecture:

- Industrial Zone:
  - Core Switching
  - Aggregation/Distribution Switching
  - Active/Standby WLC
  - Robust Physical Infrastructure
- Cell/Area Zone:
  - Redundant Path Topology with Resiliency Protocol
  - Industrial Ethernet Switching
  - Robust Physical Infrastructure
- Level 3 Site Operations:
  - Virtual Servers

  - Security and Network Services
  - Robust Physical Infrastructure
- Industrial Demilitarized Zone (IDMZ):
  - Active/Standby Firewalls
  - Robust Physical Infrastructure

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

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

Note The Deploying a Resilient Converged Plantwide Ethernet Architecture CVD outlines resiliency use cases for switch-level topologies. For device-level resiliency use cases, see the *Deploying Device Level Ring within a Converged Plantwide Ethernet Architecture White Paper* 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

CPwE Resiliency Use Cases

The CPwE architecture supports scalability which includes the degree of resiliency applied to a plant-wide network architecture. Scalable resiliency comes in many forms; that is, technology choices in topology and distribution switch. For the Deploying a Resilient Converged Plantwide Ethernet Architecture CVD, this section represents a portion of the use cases that were tested, validated and documented by Cisco Systems, Panduit and Rockwell Automation. For more details, refer to the *Deploying a Resilient Converged Plantwide Ethernet Architecture DIG.*

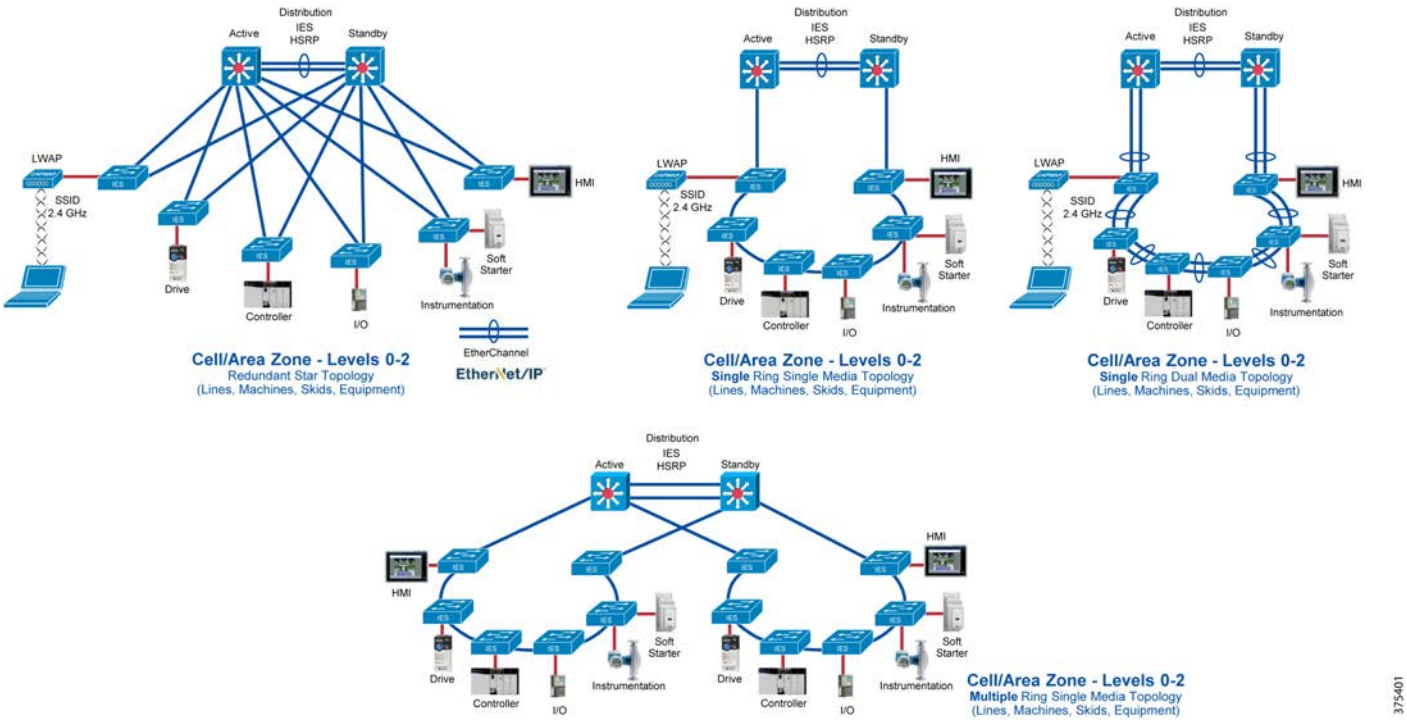
Allen-Bradley® Stratix and Cisco Industrial Ethernet Switches (IES)

Refer to Figure 2.

- Form factor:
  - DIN rail / panel mount
  - 19” rack mount - 1 RU (rack unit)
- Hot Standby Routing Protocol (HSRP) first hop redundancy protocol
- Redundant star switch-level topology:
  - Flex Links resiliency protocol

  - MSTP resiliency protocol
- Ring switch-level topology:
  - Resilient Ethernet Protocol (REP)
  - Multiple Spanning Tree Protocol (MSTP) resiliency protocol
  - Single and dual media ring:
    - EtherChannel for dual media ring only

Figure 2 IES Aggregation/Distribution Switch



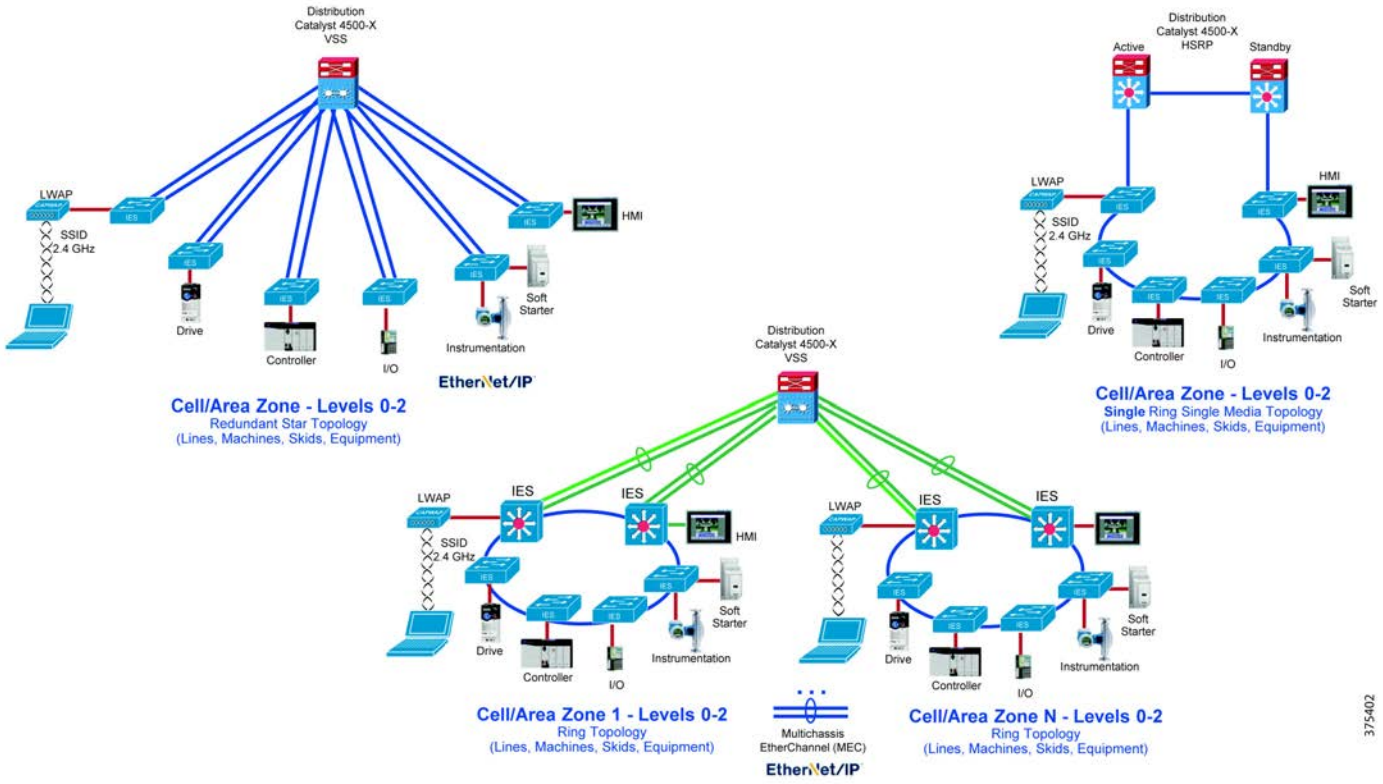
Catalyst 4500-X Aggregation/Distribution Switches

Refer to Figure 3.

- Virtual switching system (VSS) virtualization technology that pools two physical switch chassis into one virtual switch, with stateful switch over (SSO) and non-stop forwarding (NSF)
- Hot Standby Routing Protocol (HSRP) first hop redundancy protocol
- Redundant star switch-level topology:
  - Multi-chassis EtherChannel (MEC) port aggregation
  - Flex Links resiliency protocol
  - MSTP resiliency protocol

- Ring switch-level topology:
  - REP
  - MSTP resiliency protocol
  - Single and dual media ring

Figure 3 Catalyst 4500-X Aggregation/Distribution Switch

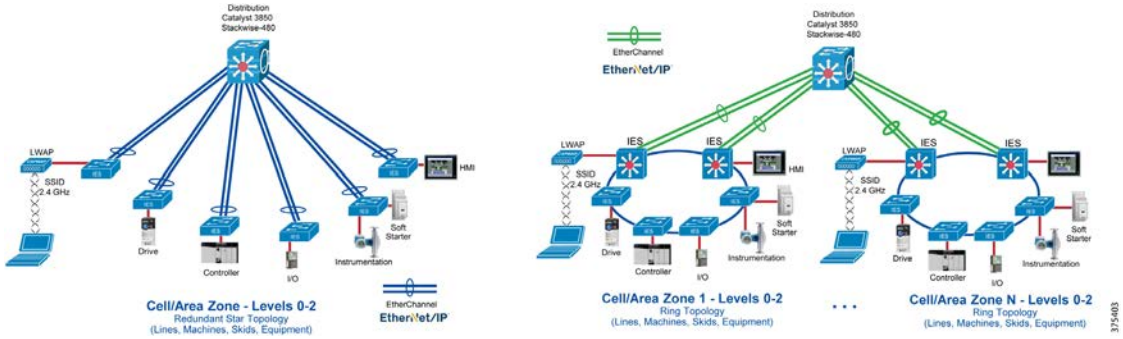


Catalyst 3850 StackWise Aggregation/Distribution Switch

Refer to Figure 4.

- Switch stack, which is a set of up to nine stacking-capable switches, connected through their StackWise-480 ports, and united to form a logical unit
- Redundant star switch-level topology:
  - EtherChannel port aggregation
  - Flex Links resiliency protocol
  - MSTP resiliency protocol
- Ring switch-level topology:
  - REP
  - MSTP resiliency protocol
  - Single and dual media ring

Figure 4 Catalyst 3850 Aggregation/Distribution Switch

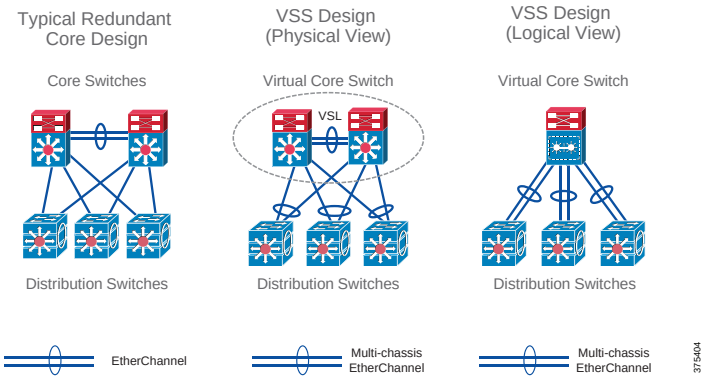


Catalyst 6800 Core Switches

Refer to Figure 5.

- VSS virtualization technology that pools two physical switch chassis into one virtual switch, with SSO

Figure 5 Core Switches - Traditional vs. VSS Design

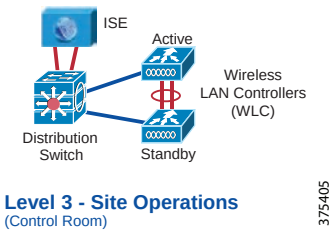


5508 Wireless LAN Controller

Refer to Figure 6.

- High availability (HA) in Cisco Wireless LAN Controllers (WLC) allows you to reduce the downtime of the wireless networks that occurs due to the WLC failure.
- In an HA architecture, one WLC is configured as the primary controller and another WLC as the secondary (standby-hot) controller. The standby-hot controller continuously monitors the health of the active controller through a direct wired connection over a dedicated redundancy port. Both the controllers share the same configuration.
- Unified WLAN architecture supports stateful switchover of access points (APS) and clients. Access points establish a control and provisioning of wireless access points (CAPWAP) tunnel with the active WLC and share a mirror copy of the AP database with the standby WLC.

Figure 6 Active/Standby Wireless LAN Controllers

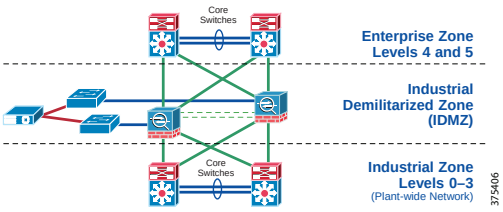


Adaptive Security Appliance 5500-X Firewalls with FirePOWER™

Refer to Figure 7.

- Active/standby stateful failover mechanism enabling a standby Adaptive Security Appliance (ASA) to take over the functionality of a failed unit. When the active unit fails, the standby unit changes to the active state and the failed unit becomes standby when it comes up.
- When stateful failover is enabled, the active unit continually passes per-connection state information to the standby unit. After a failover occurs, the same connection information is available at the new active unit therefore allowing supported end-user applications to keep the same communication session.

Figure 7 Active/Standby Firewalls



Robust Physical Infrastructure

Refer to Figure 8.

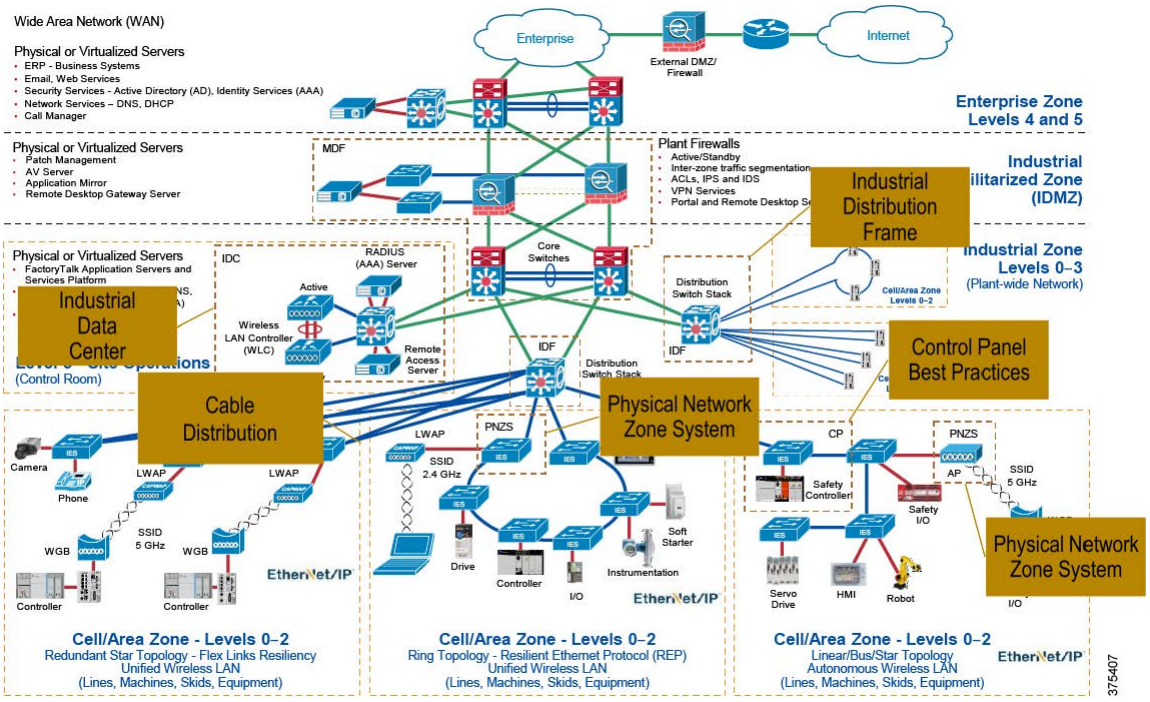
Successful deployment of CPwE logical architectures depends on a robust physical infrastructure network design that addresses environmental and performance challenges with best practices from OT and IT. For the Deploying a Resilient Converged Plantwide Ethernet Architecture CVD, Cisco and Rockwell Automation have collaborated with Panduit® to include their building block approach for physical infrastructure deployment. This approach helps customers address the physical deployment associated with converged plant-wide EtherNet/IP. As a result, users can achieve resilient, scalable networks that support proven and flexible CPwE logical architectures designed to optimize plant-wide IACS network performance.

For the *Deploying a Resilient Converged Plantwide Ethernet Architecture DIG*, the following use cases were documented by Panduit:

- Robust physical infrastructure design considerations and best practices
- Control Panel:
  - Electromagnetic interference (EMI) noise mitigation through bonding, shielding and grounding
  - IES deployment within the Cell/Area Zone
- Physical Network Zone System:
  - IES and AP deployment within the Cell/Area Zone

- Cable distribution across the Industrial Zone
- Industrial Distribution Frame (IDF):
  - Industrial aggregation/distribution switch deployment within the Industrial Zone
- Industrial Data Center (IDC):
  - Physical design and deployment of the Level 3 Site Operations

Figure 8 Robust Physical Infrastructure for the CPwE Architecture



Summary

CPwE is a collection of tested and validated architectures that are developed by subject matter authorities at Cisco and Rockwell Automation and that follow the Cisco Validated Design (CVD) program. The content of CPwE, which is relevant to both OT and IT disciplines, consists of documented architectures, best practices, guidance and configuration settings to help manufacturers with design and deployment of a scalable, reliable, secure and future-ready plant-wide industrial network infrastructure. CPwE can also help manufacturers achieve the benefits of cost reduction using proven designs that help facilitate quicker deployment while helping to reduce risk in deploying new technology. CPwE is brought to market through a strategic alliance between Cisco Systems and Rockwell Automation.

Resilient plant-wide network architectures play a pivotal role in helping to confirm overall plant uptime and productivity. IACS application requirements such as availability and performance drive the choice of resiliency technology. A holistic resilient plant-wide network architecture is made up of multiple technologies (logical and physical) deployed at different levels within plant-wide architectures. When selecting resiliency technology, various IACS application factors should be evaluated, including physical layout of IACS devices (geographic dispersion), resiliency performance, uplink media type, tolerance to data latency and jitter and future-ready requirements.

The *Deploying a Resilient Converged Plantwide Ethernet Architecture Design and Implementation Guide (DIG)* outlines several use cases for designing and deploying a holistic resilient plant-wide IACS network infrastructure. This DIG 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 framework of CPwE. The CPwE Resiliency CVD was tested and validated by Cisco Systems, Panduit and Rockwell Automation.

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

Publication ENET-WP039D-EN-P October 2017