Migrating Legacy IACS Networks to a Converged Plantwide Ethernet Architecture

Rockwell Automation and Cisco Four Key Initiatives:

- **Common Technology View:**
  A single system architecture, using open, industry standard networking technologies, such as Ethernet and IP, is paramount for achieving the flexibility, visibility and efficiency required in a competitive manufacturing environment.

- **Converged Plantwide Ethernet Architectures:**
  These manufacturing focused reference architectures, comprised of the Rockwell Automation Integrated Architecture® and Cisco’s Ethernet to the Factory, provide users with the foundation for success to deploy the latest technology by addressing topics relevant to both engineering and IT professionals.

- **Joint Product and Solution Collaboration:**
  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 and allow successful architecture deployment and efficient operations allowing critical resources to focus on increasing innovation and productivity.

White Paper

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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 enable network technology convergence through the use of standard Ethernet and Internet Protocol (IP) technology. A converged IACS network technology enables the Industrial Internet of Things and helps to facilitate:

- Multi-discipline application convergence, including discrete, continuous process, batch, drive, safety, motion, power, time synchronization, supervisory information, asset configuration/diagnostics and energy management
- Standard IT technology that is future-ready, with increased sustainability and reduced risk of deployment
- Better asset utilization through a common network infrastructure that can also help support lean initiatives
- Common toolsets and required skills/training, including assets for design, deployment and troubleshooting, as well as human assets
- Standard and established IT security technology, best practices, policies and procedures
- Seamless plant-wide/site-wide information sharing due to IP pervasiveness—routability and portability across data links (such as Ethernet and Wi-Fi)

Although technology has been the enabler behind OT and IT convergence, business aspects have also sustained a continual trend:

- Integration—Converging business systems with plant-wide/site-wide systems for more Key Performance Indicators (KPIs), regulatory compliance (such as genealogy and track and trace) and supply chain management
- Connectivity—More IACS devices connected for better IACS asset utilization, optimization and management
- Applications—Expanded application support (such as energy management and sustainability initiatives)
- Collaboration—OT and IT groups, who previously had little interaction, are now collaborating to share standards, best practices, innovations and security policies, procedures and technology

The Migrating Legacy IACS Networks to CPwE Cisco Validated Design (CVD) that is documented in the *Migrating Legacy IACS Networks to CPwE Design and Implementation Guide (DIG)* outlines one application use case for migrating a traditional IACS network architecture to a standard Ethernet and IP network.
technologies. 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 architecture (Figure 1) provides design and implementation guidance that can help to achieve the real-time communication, reliability, scalability, security and resiliency requirements of the IACS.

The Migrating Legacy IACS Networks to CPwE CVD is brought to market through a strategic alliance between Cisco Systems® and Rockwell Automation. The Migrating Legacy IACS Networks to CPwE CVD highlights the key IACS application requirements, technology and supporting design considerations to help with the successful design and deployment of migration use cases within the framework of CPwE.

**Figure 1** CPwE Architectures

IACS Migration Use Case Requirements

An IACS is deployed in a wide variety of discrete and process manufacturing 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.

Manufacturers traditionally deployed multiple disparate network technologies (Figure 2) for their IACS applications to address multiple control and information disciplines. One of the challenges facing manufacturers is the complexities of migrating traditional IACS network technologies to standard Ethernet and IP networking technologies (Figure 3) to take advantage of the business benefits associated with the Industrial Internet of Things.
The Migrating Legacy IACS Networks to CPwE CVD outlines the concepts, requirements and technology solutions for one specific application use case that was tested, validated and documented by Cisco and Rockwell Automation to migrate a traditional IACS network architecture (Figure 4) to a converged EtherNet/IP™ architecture (Figure 5).

The Migrating Legacy IACS Networks to CPwE CVD promotes the following (Figure 4):

- Maintain existing Programmable Automation Controllers (PAC) and replace Network Interface Cards (NIC)
- Maintain existing PAC subnet and IP addressing schema
- Maintain existing plant-wide virtual LAN (VLAN) structure for inter-PAC communications
- Maintain existing IACS input/output (I/O) platform and replace NICs and/or I/O adapter modules:
  - Migrate legacy IACS I/O network (non IP) to EtherNet/IP
- Maintain existing IACS devices, replace NICs - such as Variable Frequency Drives (VFD), instrumentation and Human Machine Interface (HMI):
  - Migrate legacy IACS device network (non IP) to EtherNet/IP
- For maintenance simplification, maintaining identical IP addressing for I/O and IACS devices across each skid/machine such as I/O, VFD, instrumentation and HMI
- For maintenance simplification, support by IACS OT personnel such as plant engineer, control system engineer and maintenance engineer
- Keep IACS I/O traffic local
- Keep IACS PAC traffic local
- Support plant-wide data acquisition
- Support plant-wide IACS asset management
IACS Migration Technology

A variety of standard Ethernet and IP networking technology was applied to the Migrating Legacy IACS Networks to CPwE CVD to accomplish the requirements of specific application use cases (Figure 5):

- EtherNet/IP—Single IACS Network Technology
- Layer 2 Industrial Ethernet Switches (IES)
- Network Address Translation within the Layer 2 IES
- Routing within the Layer 2 IES—Connected and Static

The Migrating Legacy IACS Networks to CPwE CVD builds atop Network Address Translation (NAT) defined in the Deploying Network Address Translation in a Converged Plantwide Ethernet Architecture DIG. NAT within CPwE enables the reuse of IP addressing without introducing a duplicate IP address error into the IACS architecture. NAT translations have two forms: one-to-one (1:1) and one-to-many (1: n). The Migrating Legacy IACS Networks to CPwE CVD includes tested and validated use cases utilizing one-to-one NAT, implemented from the Allen-Bradley® Stratix 5700™ or Cisco IE 2000 Layer 2 IES.

NAT within the Layer 2 IES helps to address the use case requirements of:

- For maintenance simplification, must maintain identical IP addressing for I/O and IACS devices across each skid/machine such as I/O, VFD, instrumentation and HMI
- For maintenance simplification, must be capable of being supported by IACS OT personnel such as plant engineer, control system engineer and maintenance engineer

The Migrating Legacy IACS Networks to CPwE CVD introduces routing, specifically connected and static routing, within the Layer 2 IES to help keep control and information traffic closer to the edge of the IACS application. Routing helps to:

- Forward IACS control and information traffic between IACS devices on different IP subnets
- Create smaller broadcast domains by connecting yet segmenting multiple Layer 2 VLANs
Table 1 describes the different types of routing. Note that only connected and static routing are included in the Migrating Legacy IACS Networks to CPwE CVD.

### Table 1 Routing Types

<table>
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<th>Type</th>
<th>Network Path</th>
<th>Routing Paths</th>
<th>Supported by</th>
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| Connected | Network path is automatically populated into the routing table when subnets are manually assigned to the local interface ports of the IES | Limited to routing between subnets directly connected to the IES (example - Figure 5, Skid/Machine #2)  
• Subnets 10.10.30.0/24 and 192.168.1.0/24 are connected to the Layer 2 IES  
• The Layer 2 IES forwards (routes) I/O traffic between the PAC and I/O connected subnets  
• The Layer 2 IES forwards (switches) PAC traffic between the PACs | Layer 2 and Layer 3 IES |
| Static  | Network path is manually entered into the routing table and remains static until manual updates are made | Supports routing to local and remote subnets (not directly connected to the IES) (example - Figure 5, Skid/Machine #2)  
• Static route is required to forward (route) information to plant-wide subnets beyond 10.10.30.0/24 | Layer 2 and Layer 3 IES |
| Dynamic | Dynamically learns remote network paths and automatically populates the paths into the routing table | Handshaking protocol between Layer 3 switches and routers to determine optimal network topology/path to subnets, and forwarding packets along those paths - that is, OSPF (Open Shortest Path First) and EIGRP (Enhanced Interior Gateway Routing Protocol) | Layer 3 IES |

Connected and static routing within a Layer 2 IES helps provide a cost effective and simplified solution that addresses the use case requirements of:

- Maintaining existing PAC subnet and IP addressing schema
- Maintaining existing plant-wide virtual LAN (VLAN) structure for inter-PAC communications
- Keeping IACS I/O traffic local
- Keeping IACS PAC traffic local
- For maintenance simplification, must be capable of being supported by IACS OT personnel such as plant engineer, control system engineer and maintenance engineer
- Supporting plant-wide data acquisition
- Supporting plant-wide IACS asset management
- Supporting plant-wide network management

Figure 5 Use Case—Converged EtherNet/IP Network Architecture
Connected routing, when used in conjunction with NAT functionality, helps enable routing between several NAT-connected IACS applications (skids, machines and lines) within the Cell/Area Zone. Several use cases have been tested and validated, allowing for architectural selections to be made based upon small (skid/machine) to large-scale (Line or Cell/Area Zone) plant-wide deployments.

Layer 2 Industrial Ethernet Switches

The Allen-Bradley Stratix 5400™, 5700 and Cisco Industrial Ethernet 2000 and 4000 IES support routing (connected and static) routing and NAT today. IES that supports Layer 2 spans nine models of the Allen-Bradley Stratix and Cisco IES, including:
- Select models of the Cisco IE 2000 and IE 4000 series IES
- Select models of the Allen-Bradley Stratix 5400 and 5700 series IES

Connected routing and NAT are network switch functions that allow control system engineers to build IACS applications using reused IP (IPv4) addresses behind separate IES, while also allowing those IACS applications to integrate into the larger plant-wide architecture where unique IP addressing is required. With NAT, the IES is configured to translate only specific IP addresses from inside the IACS application to the outside plant-wide architecture.

Connected routing within the CPwE architecture also addresses two key challenges:
- Limiting Layer 2 broadcast domains by segmenting with VLANs within the Cell/Area Zone
- Keeping all control traffic local, by routing locally between the VLANs within the IACS application such as skid/machine or Cell/Area Zone
- Reusing IP addresses across multiple skids/machines while providing direct access from the plant-wide network by using NAT within the Layer 2 IES

Summary

The Migrating Legacy IACS Networks to CPwE CVD outlines use cases for migrating a traditional IACS network architecture to standard converged Ethernet and IP network technologies. A converged IACS network enables the Industrial Internet of Things and helps to facilitate convergence across many industrial segments where manufacturers traditionally deploy multiple disparate network technologies for their IACS applications. CPwE helps to overcome complexities introduced by such disparate networks through network convergence based upon standard Ethernet and IP technology. Connected Routing and NAT, which are switch functions supported in select IES, enable the reuse of IP addressing, thus overcoming IP address challenges commonly found during the process of network migration and convergence. The Migrating Legacy IACS Networks to CPwE CVD helps to maintain existing IP addressing schemas while simplifying operations for the plant engineer, control system engineer and maintenance engineer.