THE REYNOLDS COMPANY
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TRC Tech Talks

Online Seminars

Resilient Networks – Parallel Redundant Protocol (PRP)

June 16th, 2020

Introductions

Brandon Singh
Presenter
Network Specialist
The Reynolds Company
– Dallas / Fort Worth

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– Houston

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Automation Specialist
The Reynolds Company
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2020 Online Events - Register to receive a calendar invite

User Group

Thursday, June 18
ControlLogix Redundancy
10:00 am

Tech Talks

Wednesday, June 17th
Industrial Networking Series Part 5: Connected Plantwide Ethernet Architectures
10:00 am

Tuesday, June 23rd
Industrial Networking Series Part 6: Securing Control System Network with CIP Security
10:00 am

https://www.reynoldsonline.com/eventsUnit.action

Deploying Parallel Redundancy Protocol (PRP) within a CPwE Architecture

Agenda

1 PRP Technology Overview

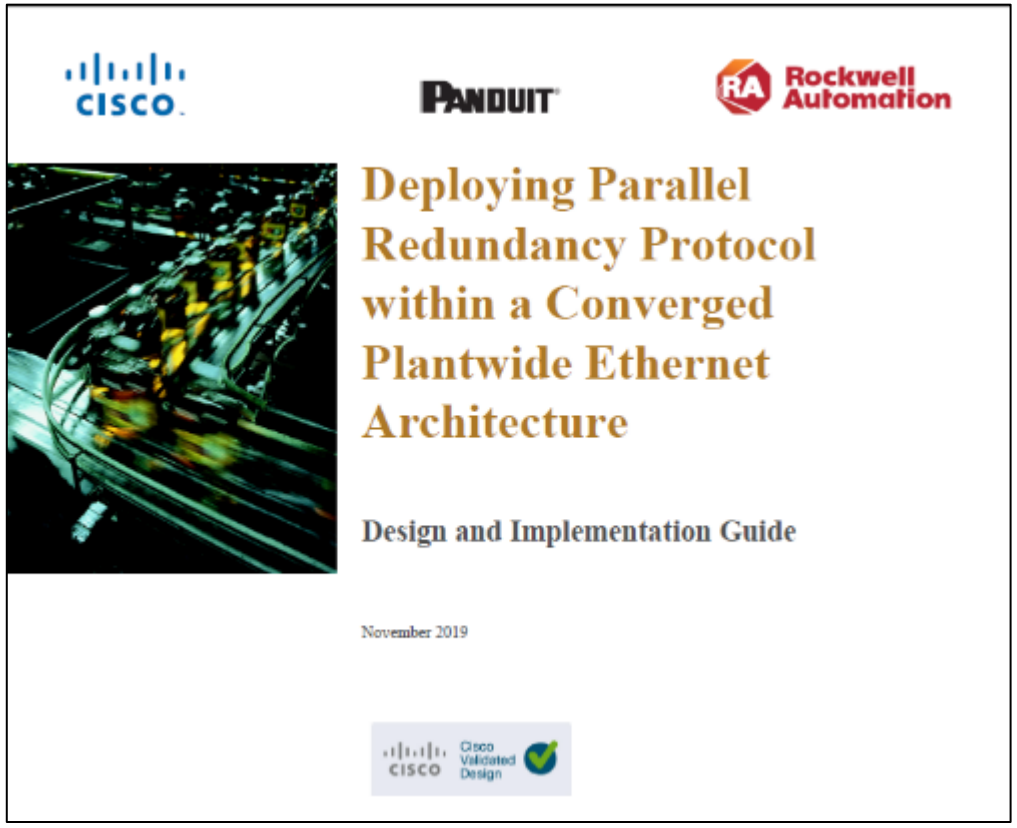
2 PRP Topology Examples

3 PRP Design for CPwE Architecture

4 PRP Considerations for Network Services and Protocols

CPwE PRP Design and Implementation Guide

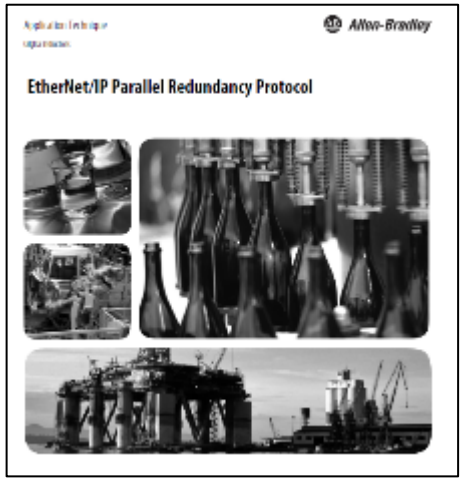
- Publication ENET-TD021 “Design Guide, Deploying Parallel Redundancy Protocol within a CPwE Architecture”



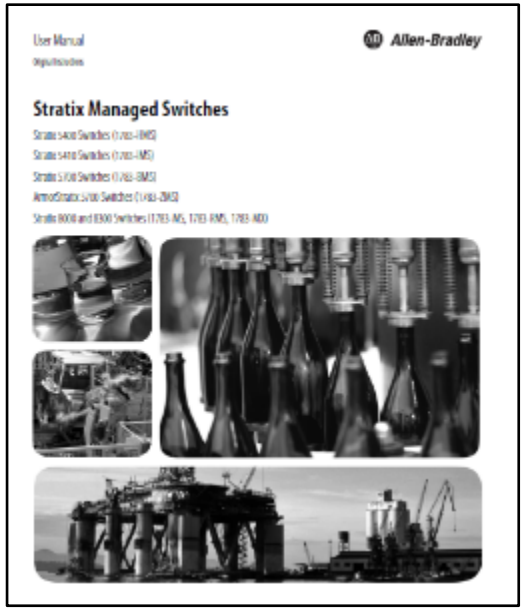
- CPwE Parallel Redundancy Protocol Overview
  - CPwE Overview
  - CPwE Parallel Redundancy Protocol Use Cases
  - CPwE Resilient IACS Architectures Overview
- CPwE Parallel Redundancy Protocol Design Considerations
  - Parallel Redundancy Protocol Overview
    - Parallel Redundancy Protocol Components
    - Parallel Redundancy Protocol Operation
  - Parallel Redundancy Protocol Network Design Recommendations
    - Parallel Redundancy Protocol Topology Examples
      - Unsupported Topologies
    - Connectivity to the Industrial Zone Network
    - Connectivity to Device Level Ring (DLR)
    - Network Services Recommendations
      - VLAN Segmentation (Zoning) and Trunking
      - Spanning Tree Protocol
      - Multicast Management
      - Network Address Translation
      - Precision Time Protocol (CIP Sync)
    - Applying Parallel Redundancy Protocol with IACS Applications
- CPwE Parallel Redundancy Protocol Configuration
  - IES Configuration
  - IACS Configuration
- CPwE Parallel Redundancy Protocol Monitoring and Troubleshooting
  - RedBox IES
  - Studio 5000 Logix Designer

Other Publications

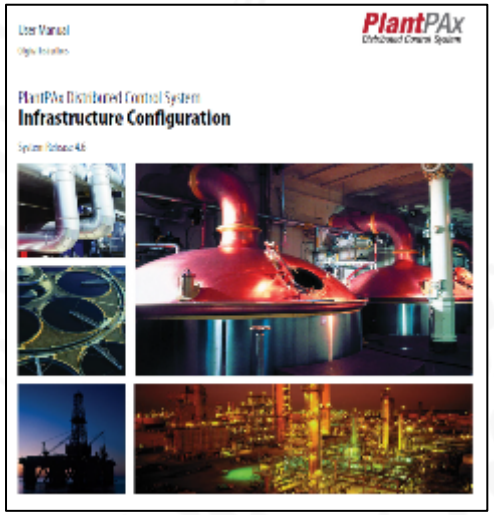
- ENET-AT006 “EtherNet/IP Parallel Redundancy Protocol Application Technique”



- 1783-UM007 “Stratix Managed Switches User Manual”



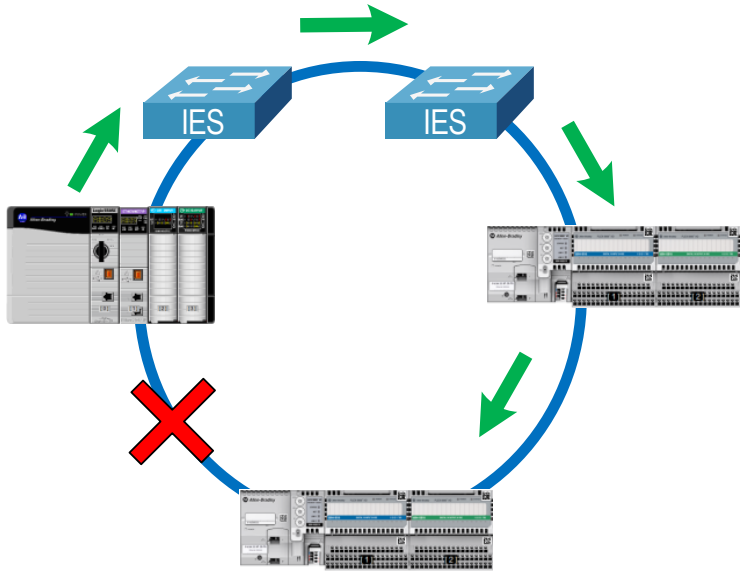
- PROCES-UM001 “PlantPAx Distributed Control System Infrastructure Configuration User Manual”



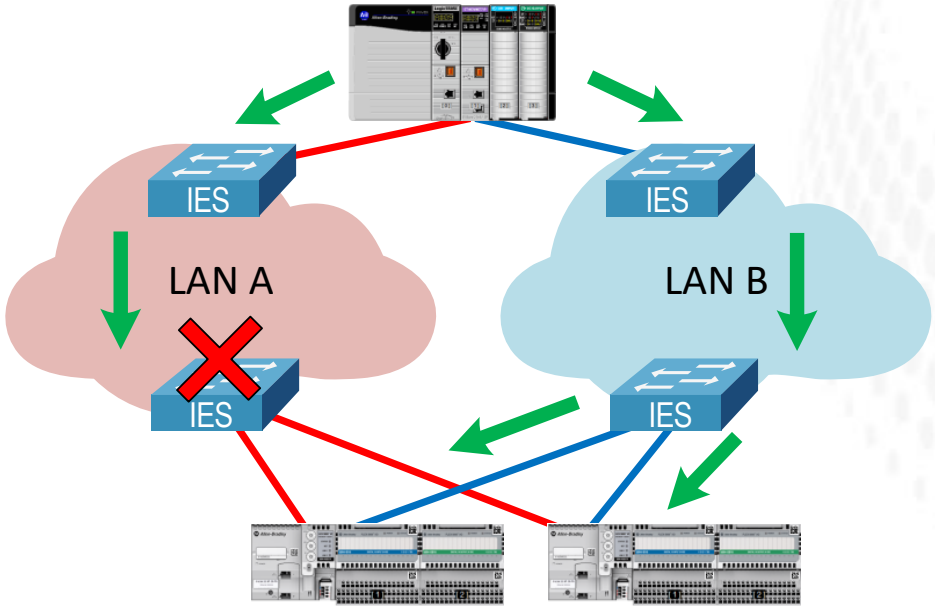
PRP Technology Overview

Resiliency Protocols vs. Redundancy Protocols

Redundant Path Ethernet Network
- Common LAN
- Resiliency protocol



Redundant Ethernet Networks
- Independent LANs
- Redundancy protocol

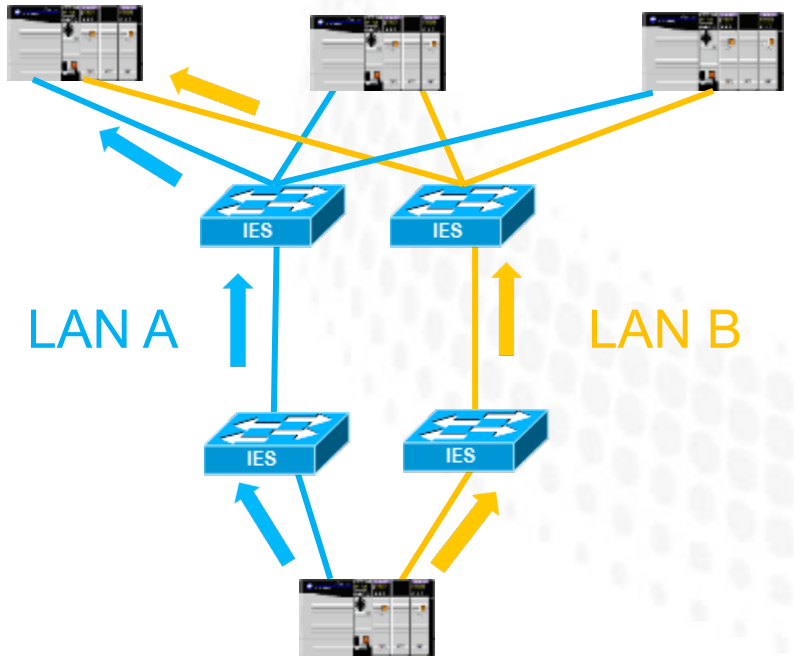


No one fits all solution – what to use depends on many factors

- Protocol support by devices and network infrastructure
- Cost of hardware, physical layout
- Compatibility with other network services and protocols

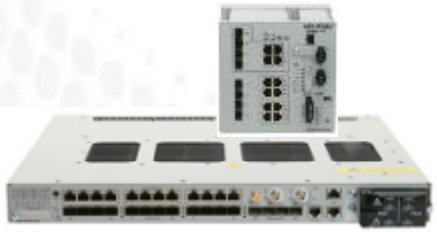
PRP (Parallel Redundancy Protocol)

- What is PRP?
  - IEC standard 62439-3
  - Supported by ODVA EtherNet/IP standard (CIP objects)
  - Redundant, fault-independent Ethernet infrastructure at Layer 2
  - Same packet is sent on both LANs
  - Zero data loss during a single LAN fault
  - Independent of LAN topology
  - Resiliency protocols like DLR, REP, Spanning Tree or EtherChannel can be used in each LAN
- Typical applications for PRP
  - Where redundant network infrastructure is desired
  - Process applications with 24x7x365 operational requirements
  - ControlNet redundant media migration opportunities, such as transportation tunnels, dual media rings

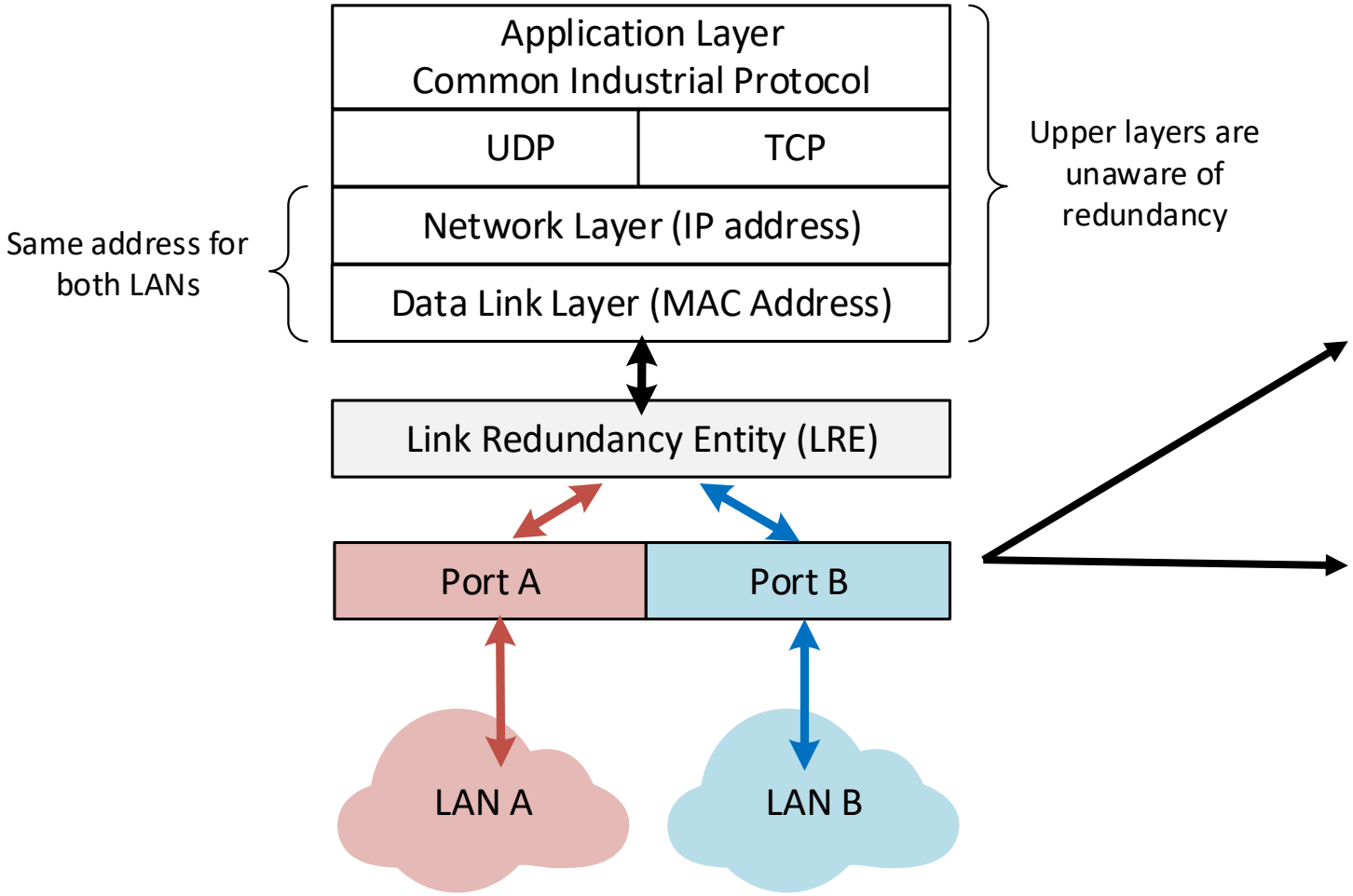


PRP Components

Component	Description	Examples
Double attached node (**DAN**)	A device with PRP technology that connects to both LAN A and LAN B.	1756-EN2TP ControlLogix® EtherNet/IP module Flex 5000™ EtherNet/IP modules (e.g. 5094-AENTR and other catalog numbers)
Single attached node (**SAN**)	A device without PRP technology that connects to either LAN A or LAN B. A SAN typically is a non-critical device or its function is duplicated in both LANs.	HMI terminals, EWS
Redundancy box (**RedBox**)	A device (switch) with PRP technology that connects non-PRP devices or non-PRP part of the network to both LAN A and LAN B.	Stratix 5400, Stratix 5410 managed switches
Virtual double attached node (**VDAN**)	A device without PRP technology that connects to both LAN A and LAN B through a RedBox. A VDAN appears to other nodes in the network as a DAN.	
LAN A and **LAN B**	Redundant, active Ethernet networks that operate in parallel and are **fault independent**.	
Infrastructure switches	Switches in LAN A or LAN B (other than RedBoxes).	Stratix managed switches



PRP Communication Layers

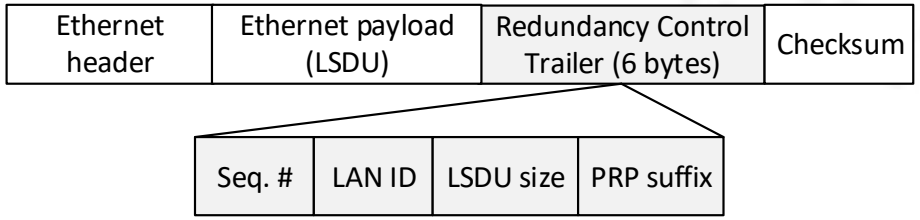


PRP Supervision frames

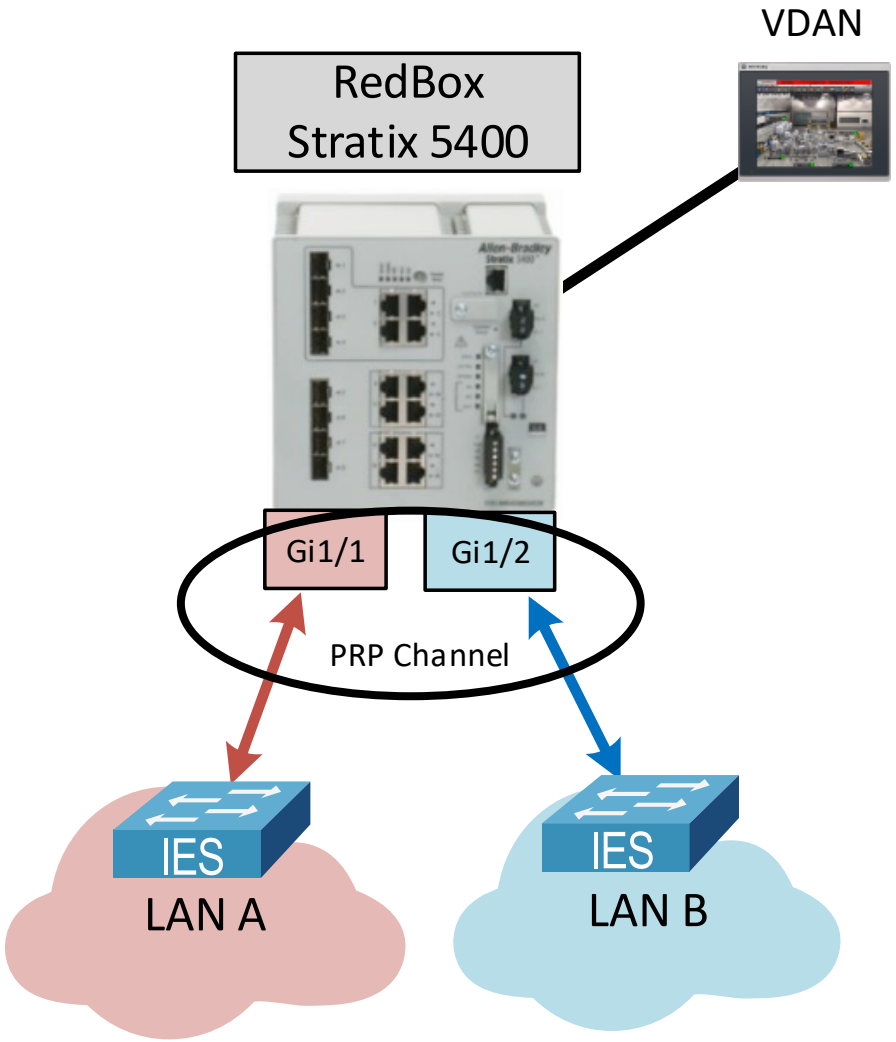
- Sent periodically by DANs to announce its presence on the network and to allow other nodes to check health of the PRP network
- Layer 2 multicast Ethernet frames to a reserved MAC address 01-15-4E-00-01-XX with EtherType 0x88FB

Data frames

- PRP trailer adds 6 bytes
- Switch MTU should be 1506 bytes or higher



PRP RedBox Operation

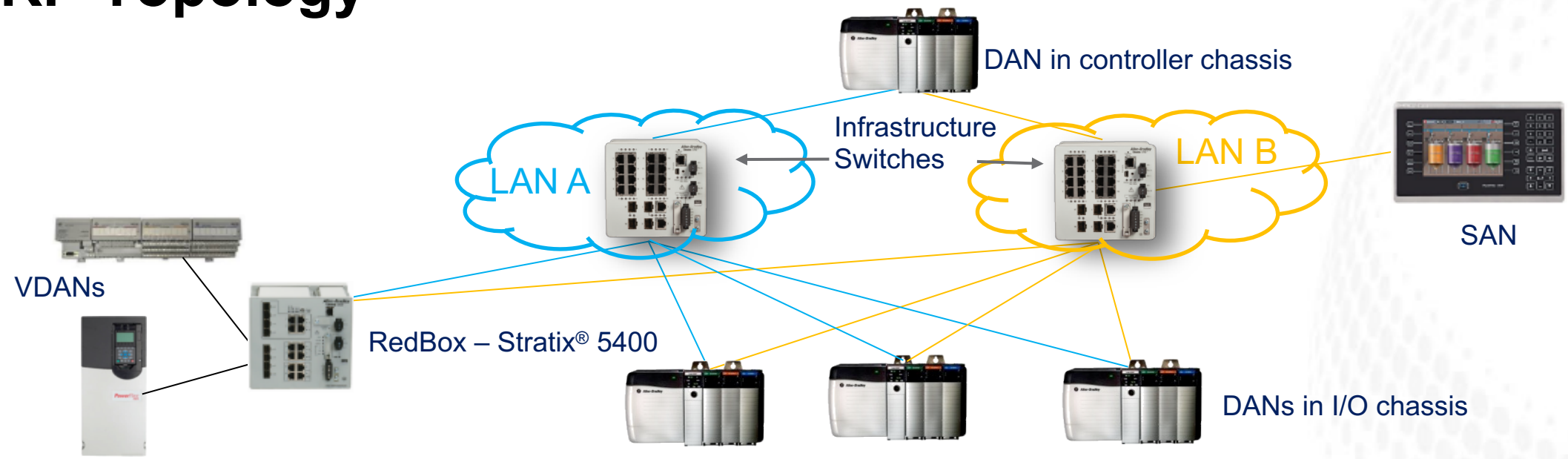


- Logical PRP channel is formed between two ports
  - Stratix 5400 – one PRP channel
  - Stratix 5410 – up to two PRP channels
- PRP channel can be trunk or access mode
- Maximum 512 VDANs in the switch table
- Switch sends PRP supervision frames on behalf of VDANs

Rockwell Automation

PRP Topology Examples

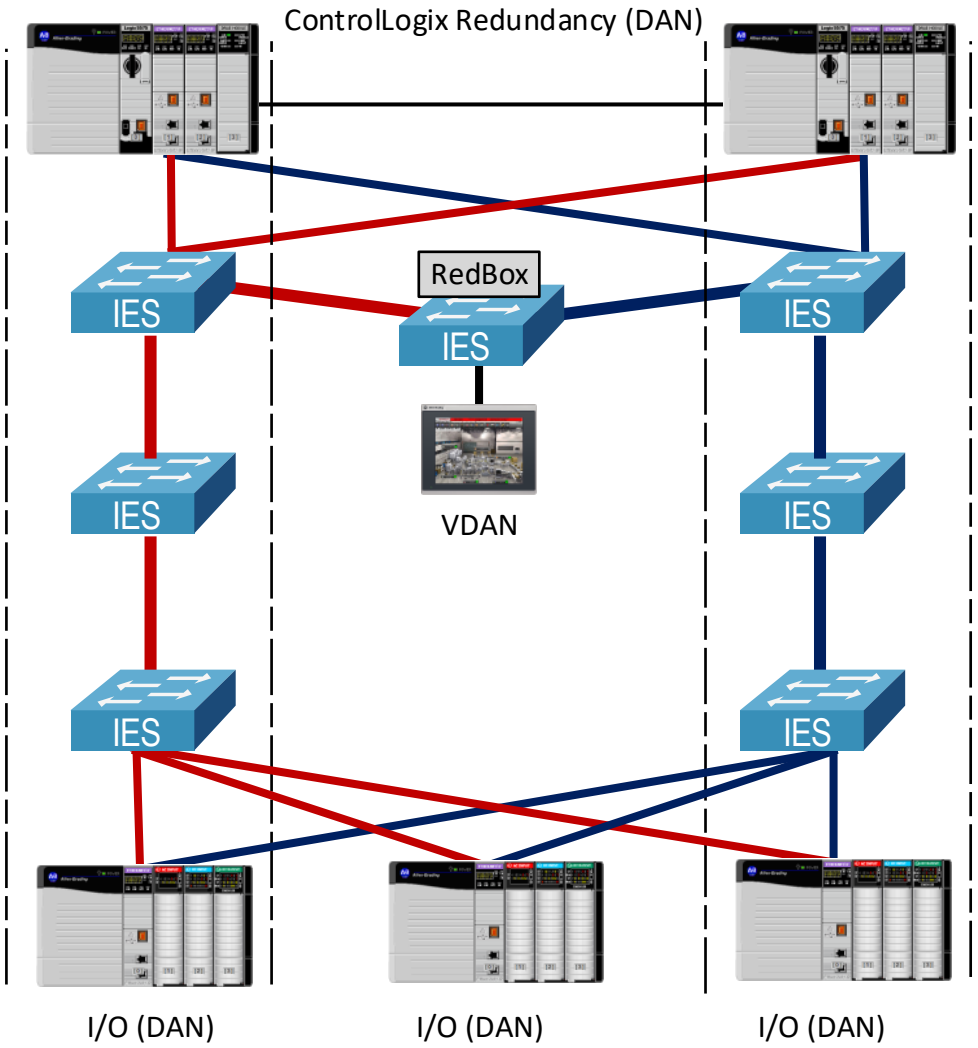
PRP Topology



- Supports any LAN A/B topology as long as LANs are independent
- The infrastructure switch passes the PRP-marked packets just like any other packet
- Managed switches required due to larger frame sizes (up to 1506 bytes)
- Network faults are seamless to the application – detection via monitoring is critical
- Different network addressing for infrastructure devices for monitoring
- Best practices for physical media, network design and security still apply!

PRP Application Example

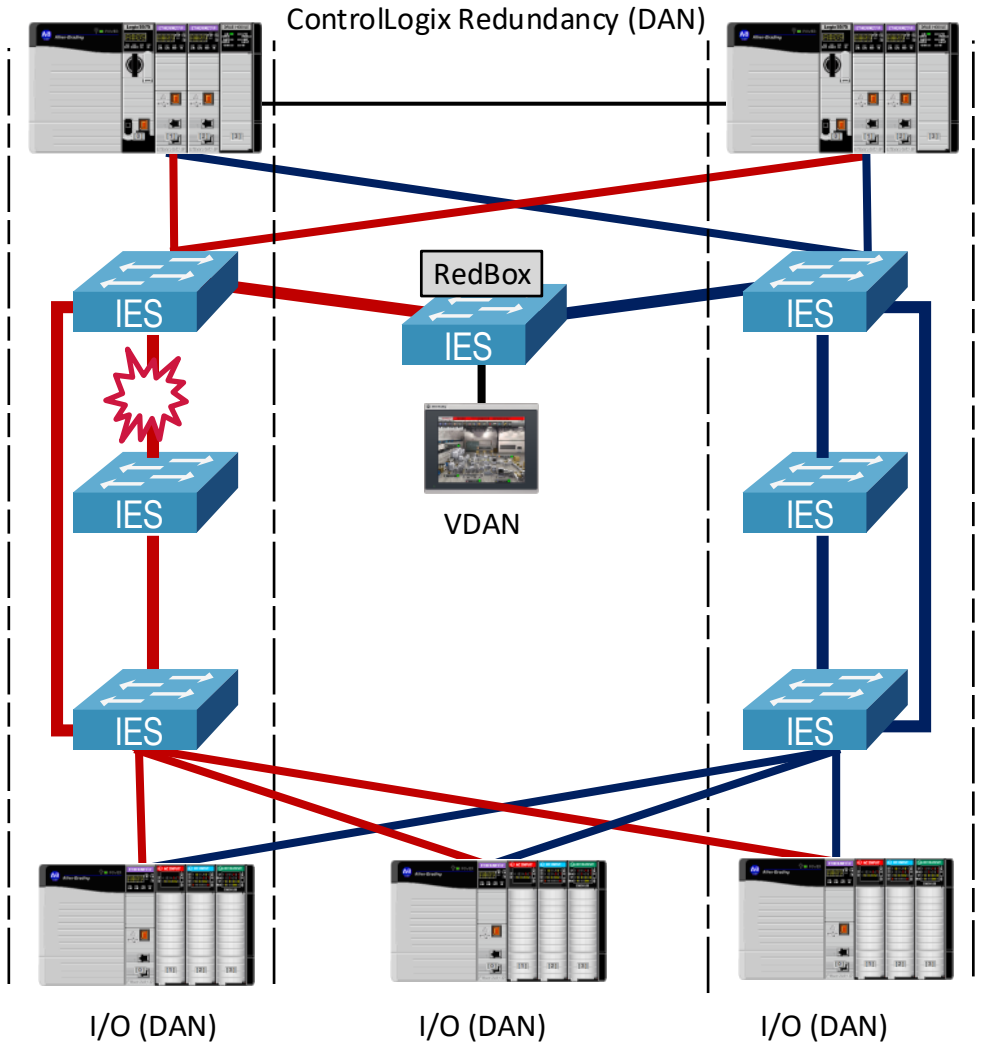
Parallel Paths – Linear Topologies



- Examples: transportation tunnels, mining tunnels, two sides of a ship
- Linear LAN topologies are simple but non-resilient

PRP Application Example

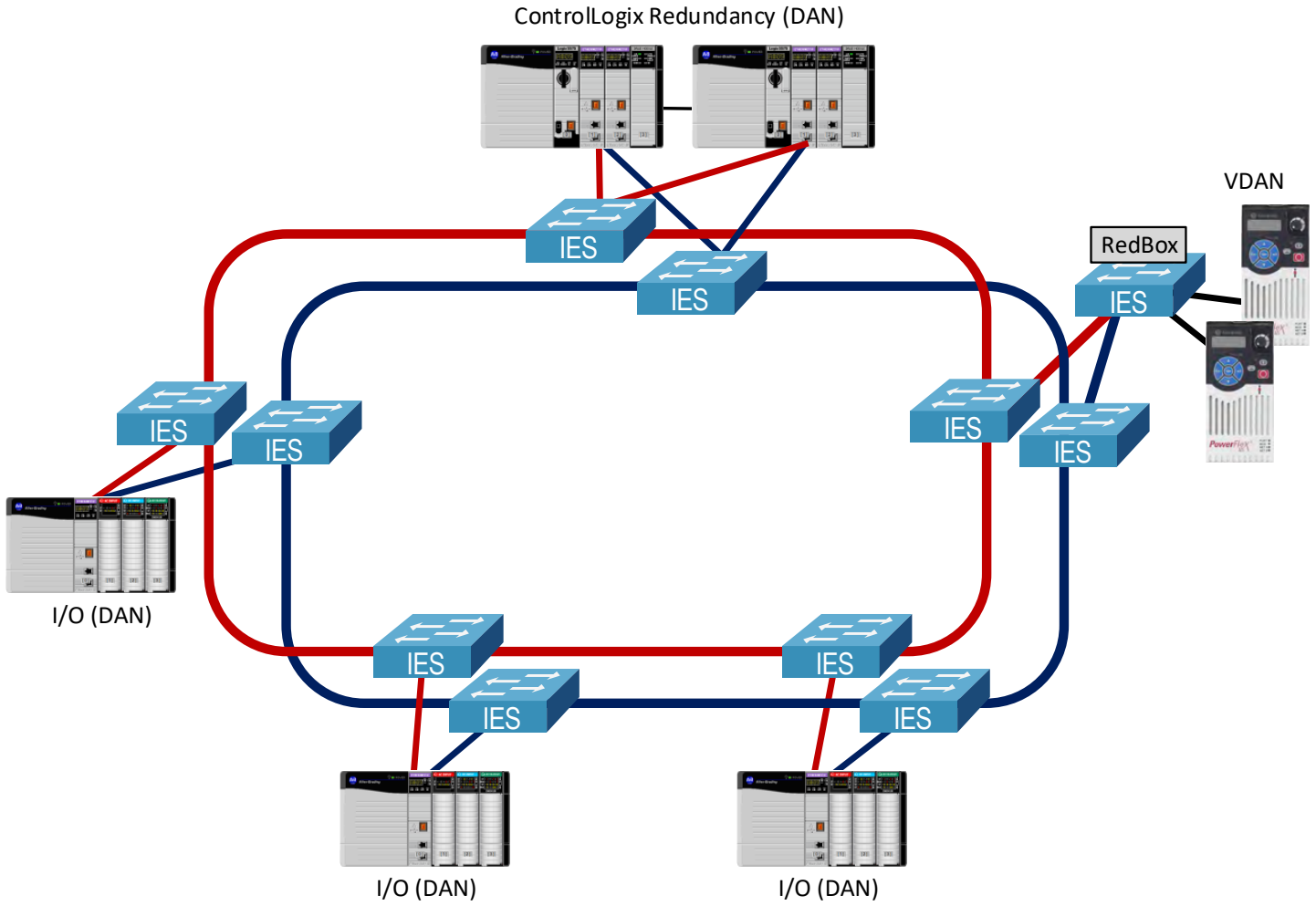
Parallel Paths – Ring Topologies



- Resilient ring protocol (REP, DLR, Spanning Tree)
- LAN A or B recovers after the fault
- Cost of additional cabling could be minimal for a new installation

PRP Application Example

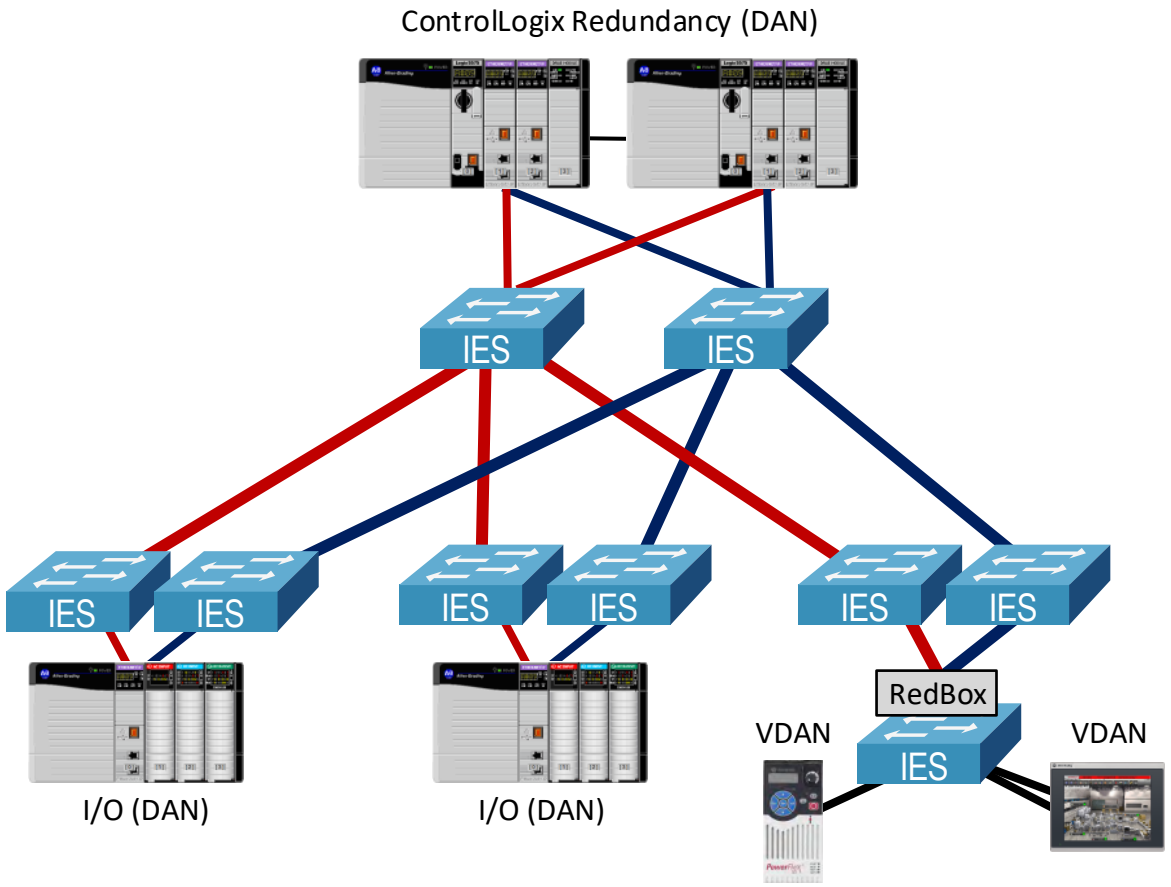
Dual Ring Topologies – Redundant PAC



- Examples: water/wastewater, mining, oil and gas, and other industries over large geographical area
- Rings must be fault independent (power, cable path)

PRP Application Example

Star Topologies – Redundant PAC

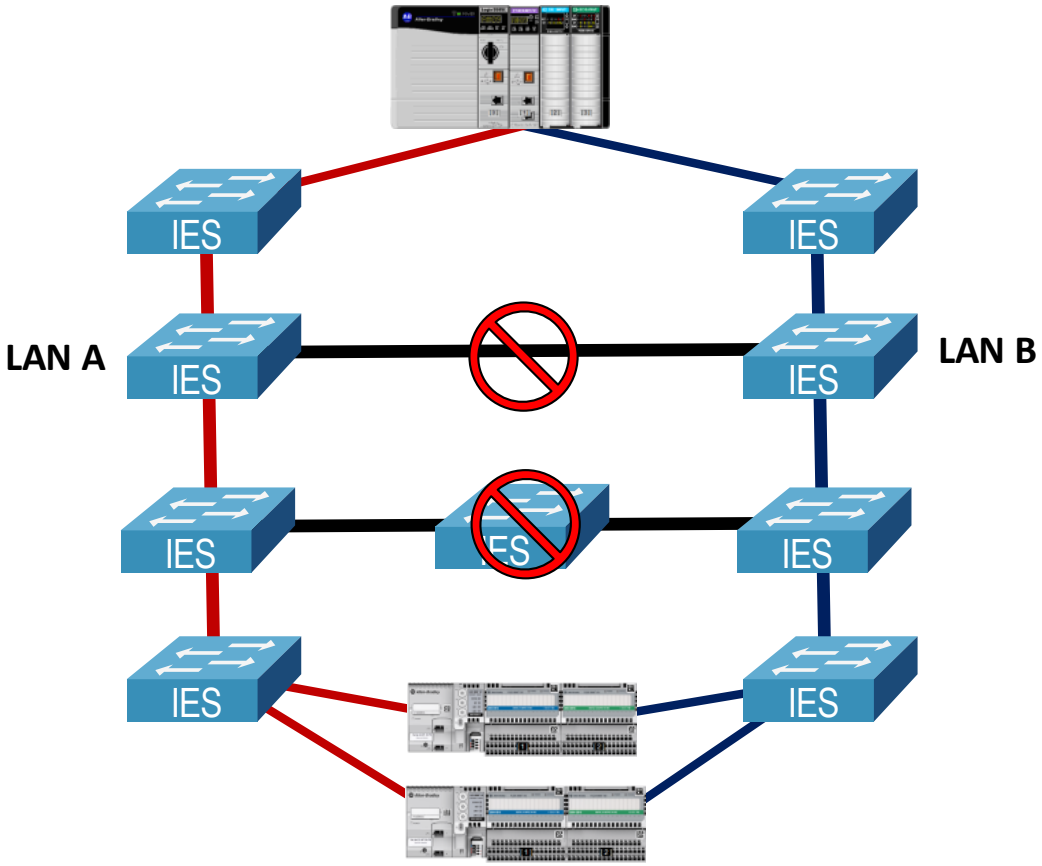


- Can be redundant star for additional resiliency
- Switches must be fault independent (power, cable path)

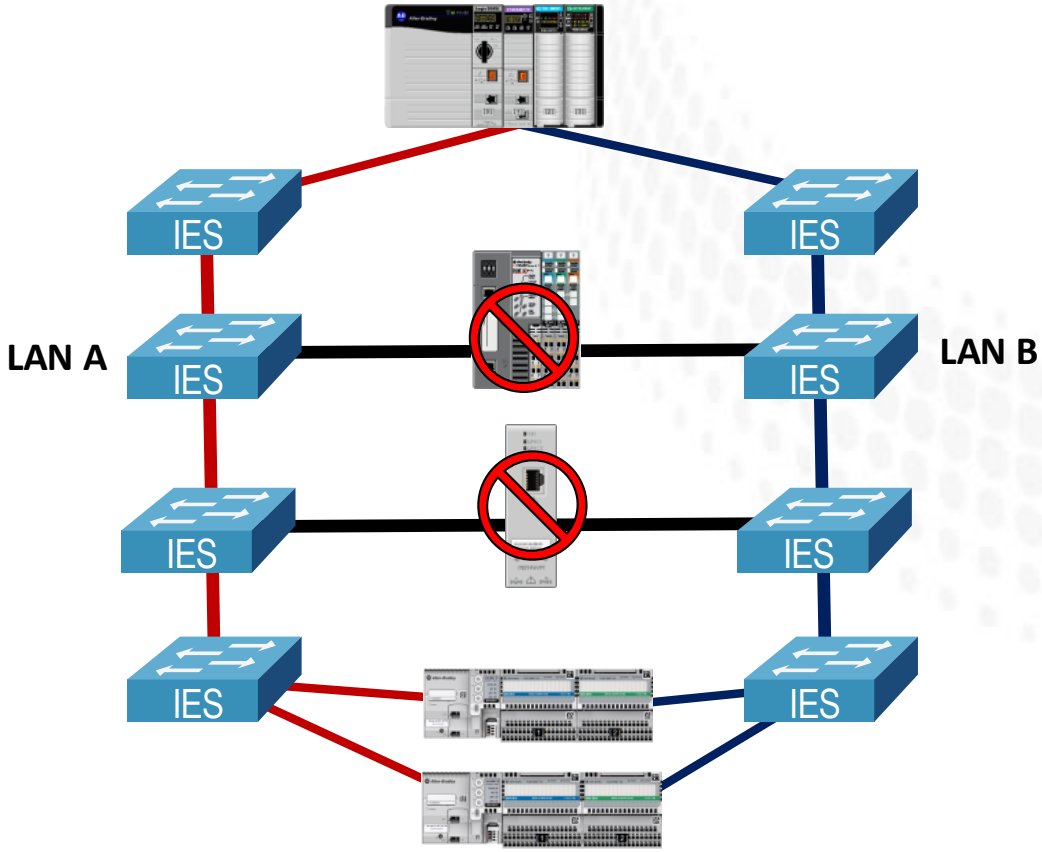
Invalid Topologies

Bridging LAN A and LAN B

Not allowed:
- Connecting LAN A and LAN B switches
- Connecting a non-RedBox switch to both LANs



Not allowed:
- Connecting two-port embedded switch devices to LAN A and LAN B

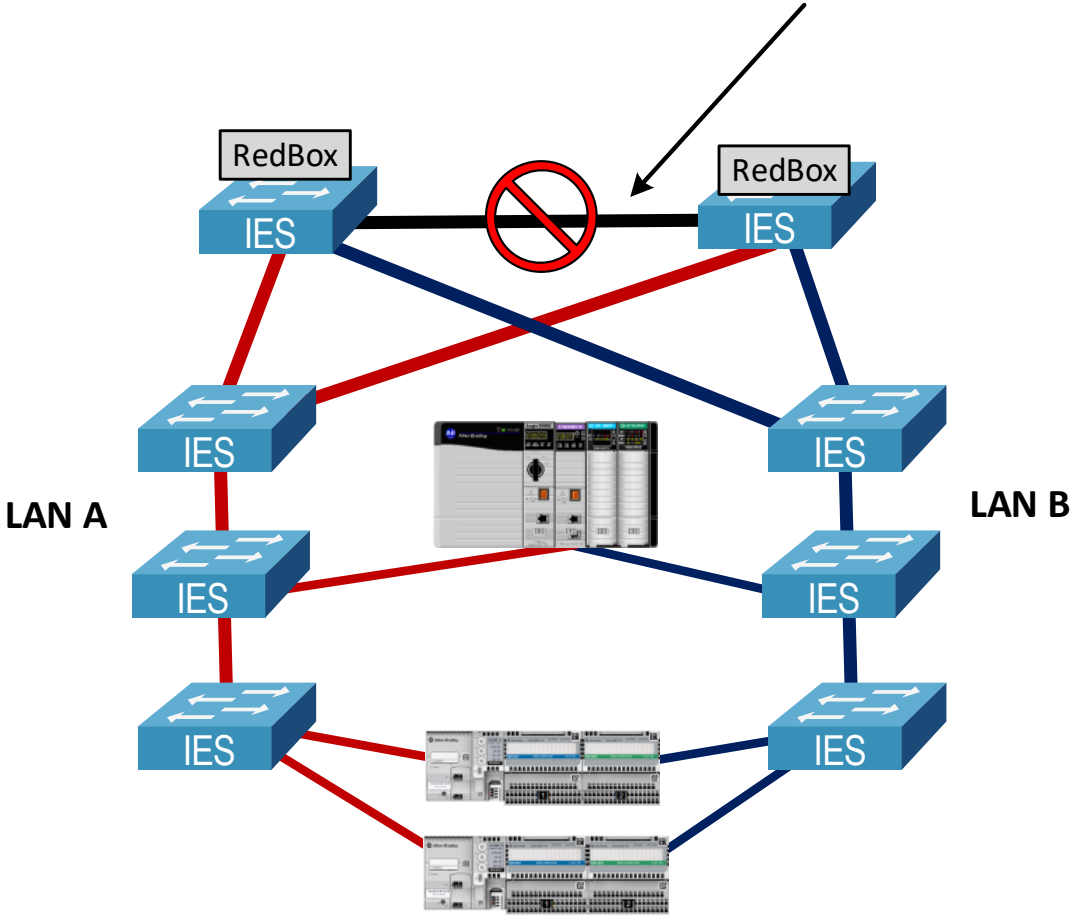


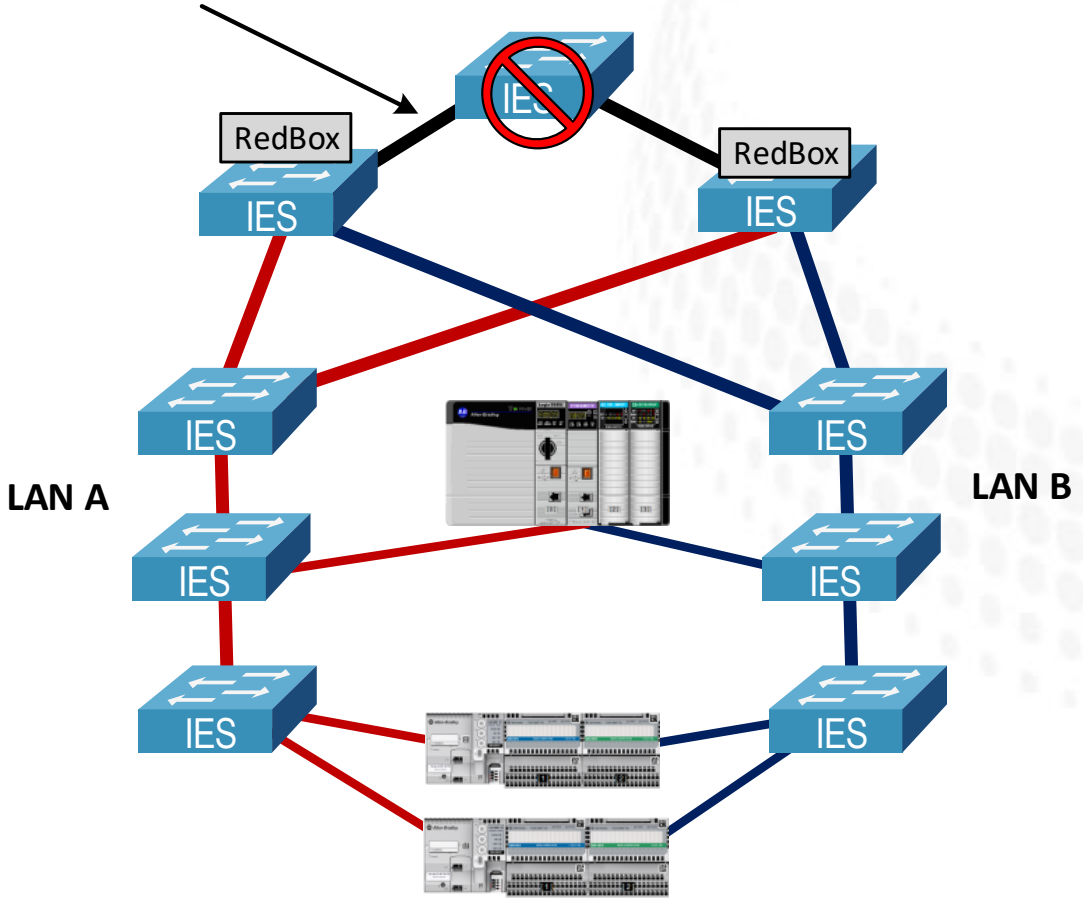
Invalid Topologies

Bridging a PRP VLAN with RedBoxes

Not allowed between RedBoxes:

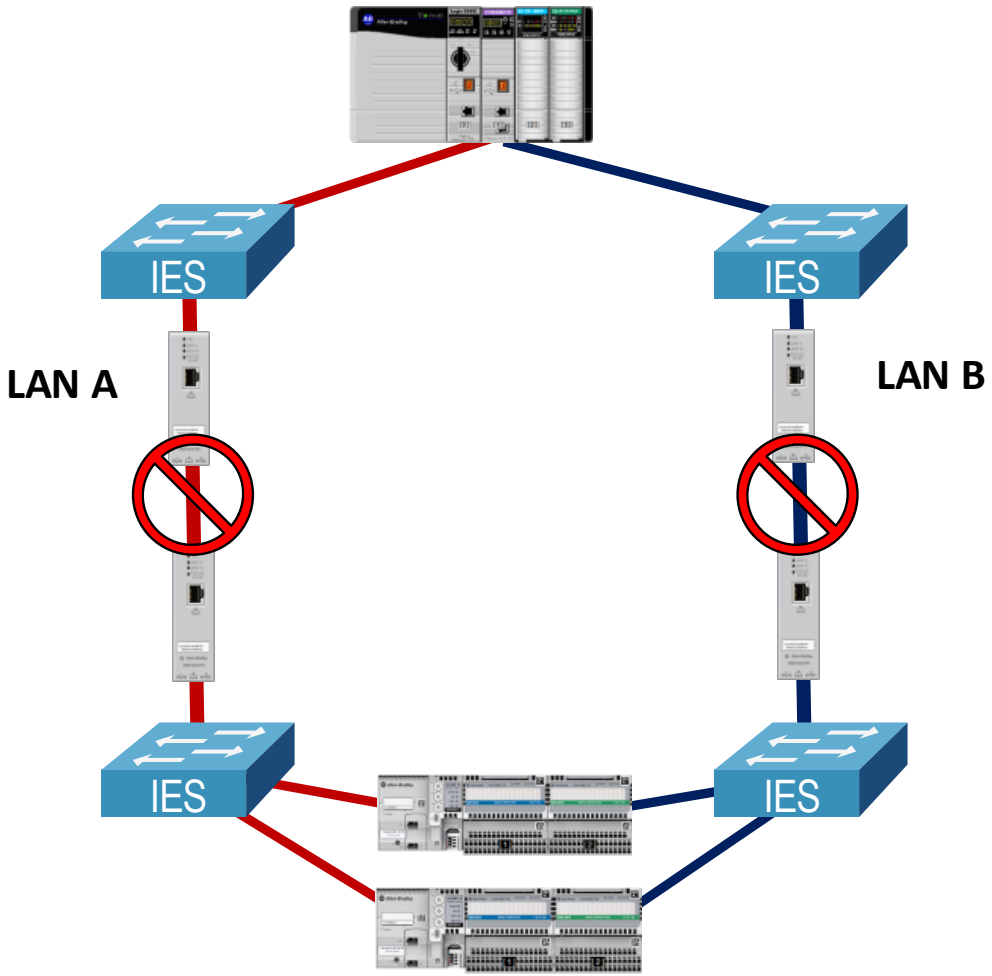
- Layer 2 links with any of the PRP VLANs

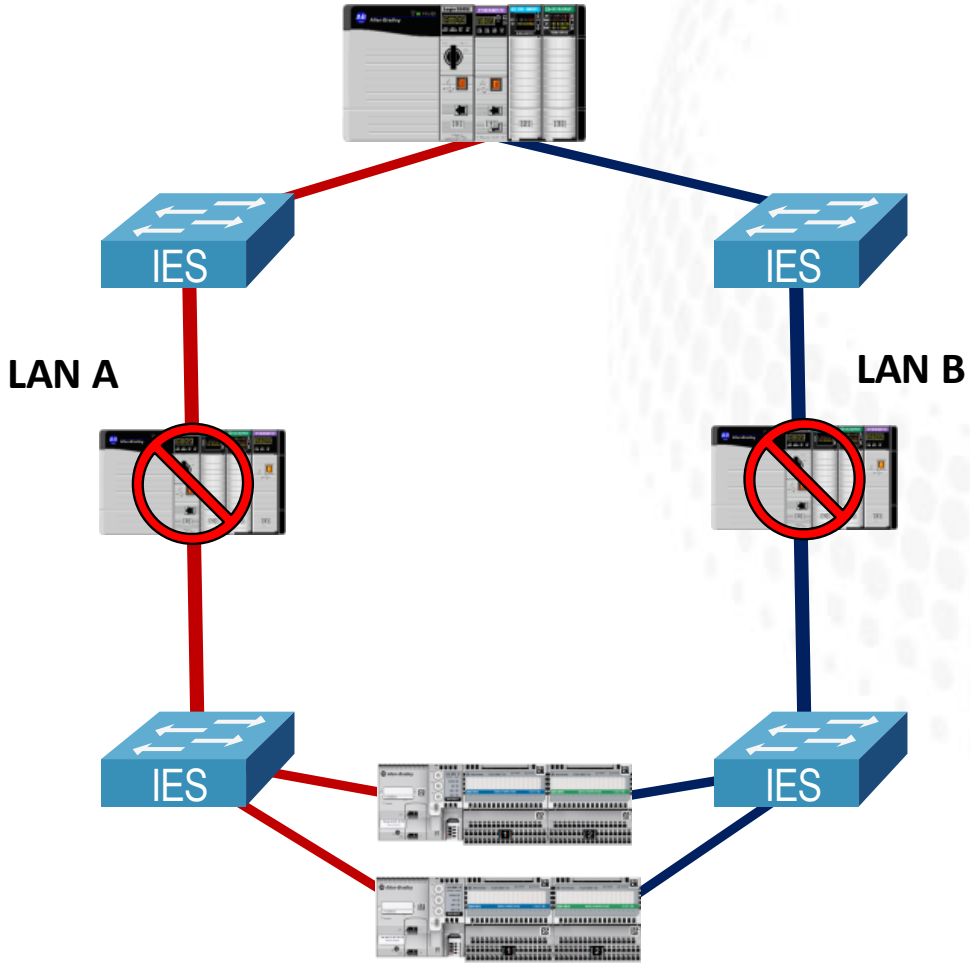




Unsupported Topologies

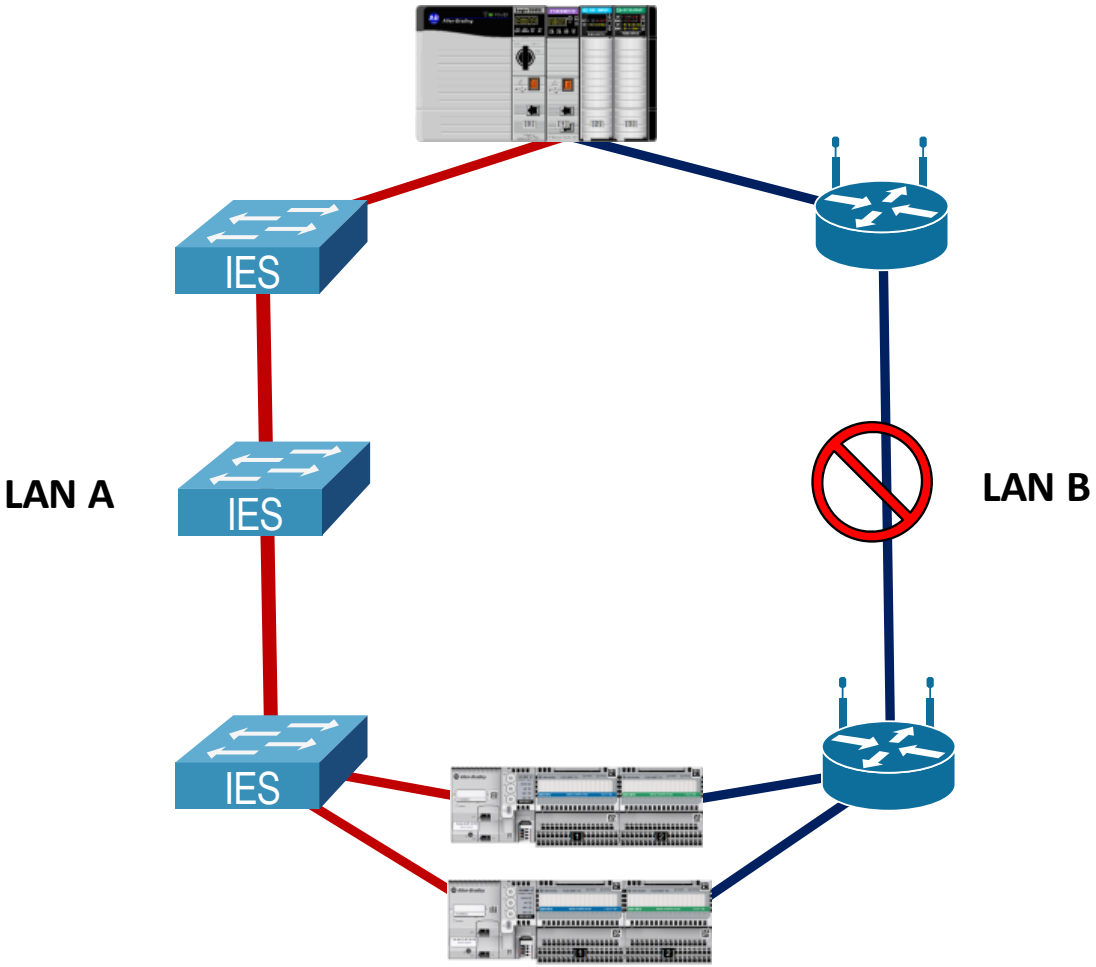
Traffic traverses embedded switch devices





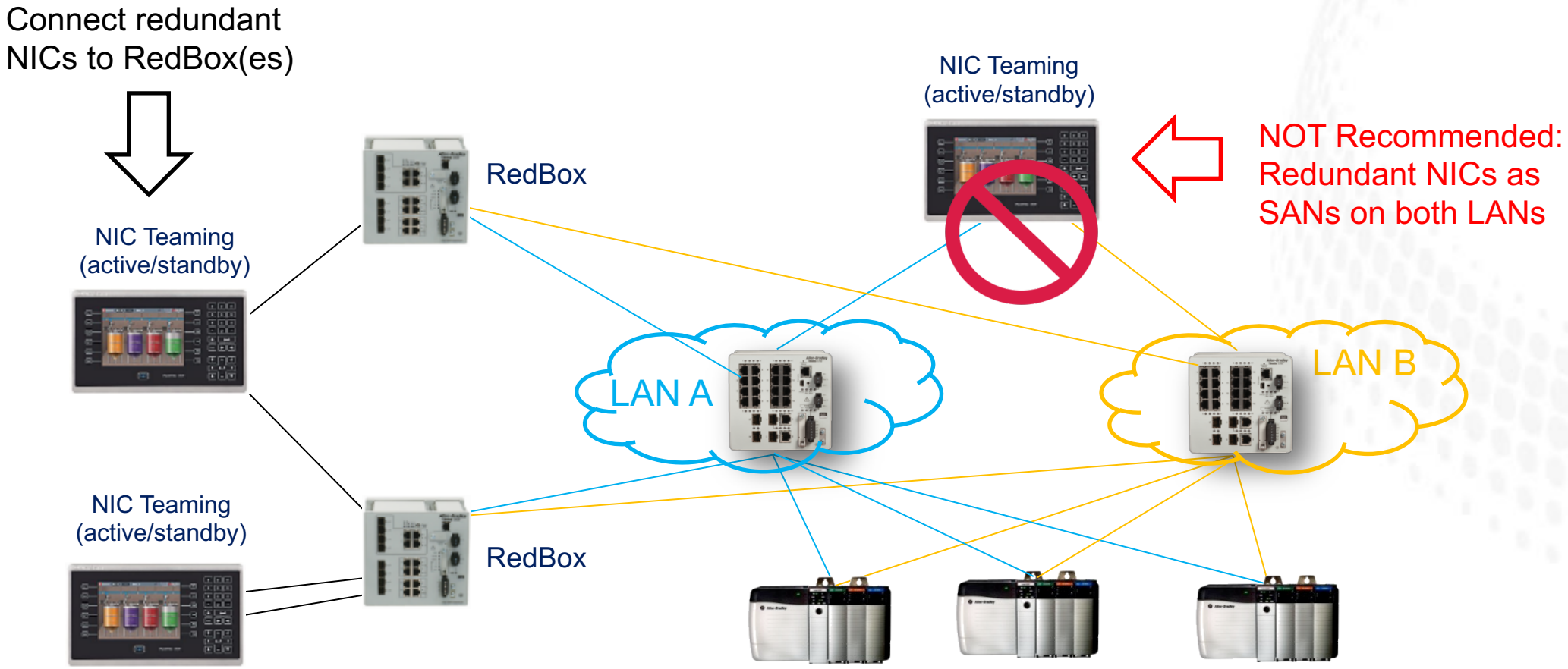
Unsupported Topologies

Combining low latency and high latency LANs



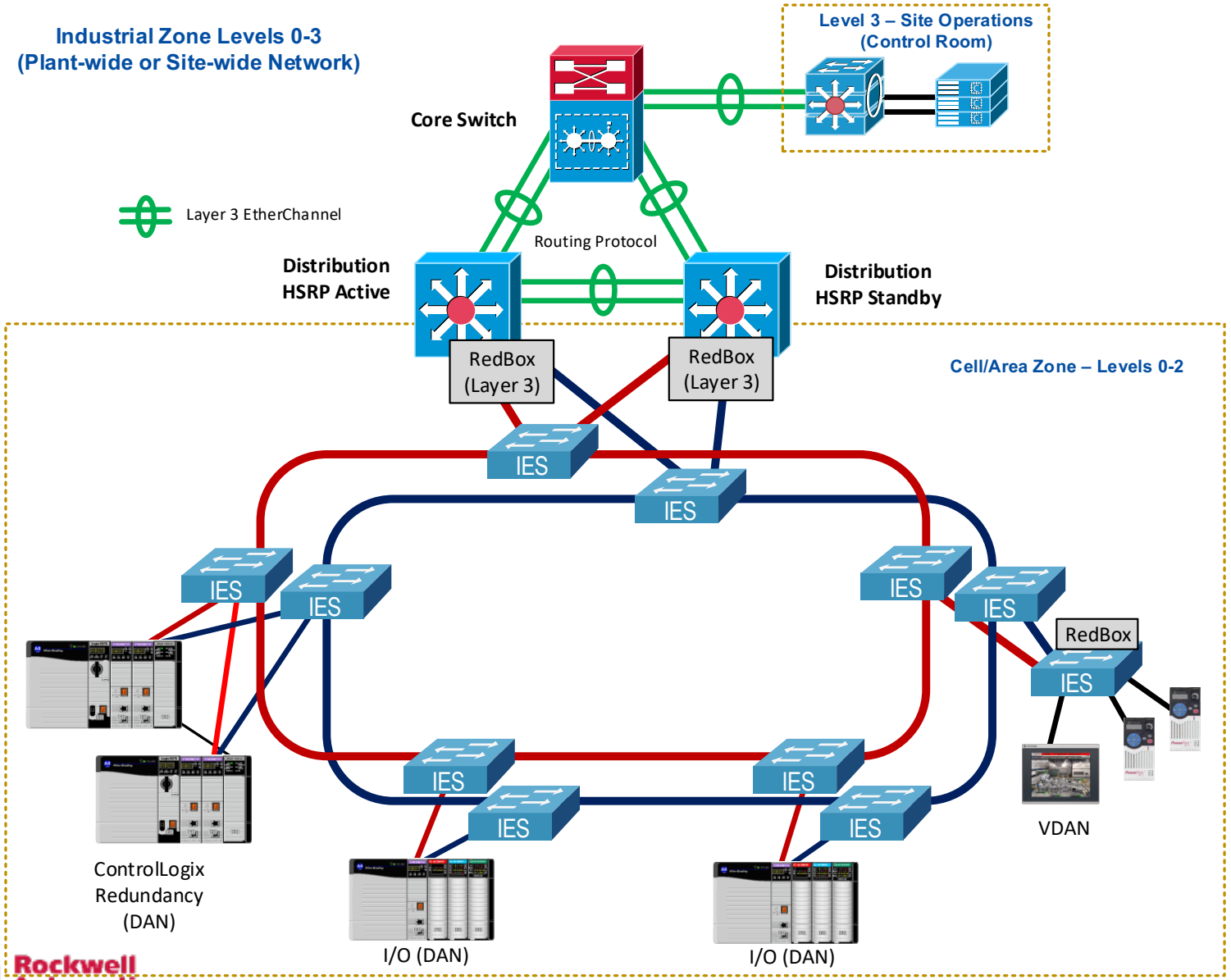
- Concerns about increased chance of duplicate frames arriving late and being wrongly accepted as non-duplicate
- Examples: WAN cellular, Wi-Fi, satellite connections as a secondary LAN

NIC Teaming


Connect redundant NICs to RedBox(es)
NIC Teaming (active/standby)
NIC Teaming (active/standby)
RedBox
RedBox
NIC Teaming (active/standby)
NOT Recommended: Redundant NICs as SANs on both LANs
LAN A
LAN B

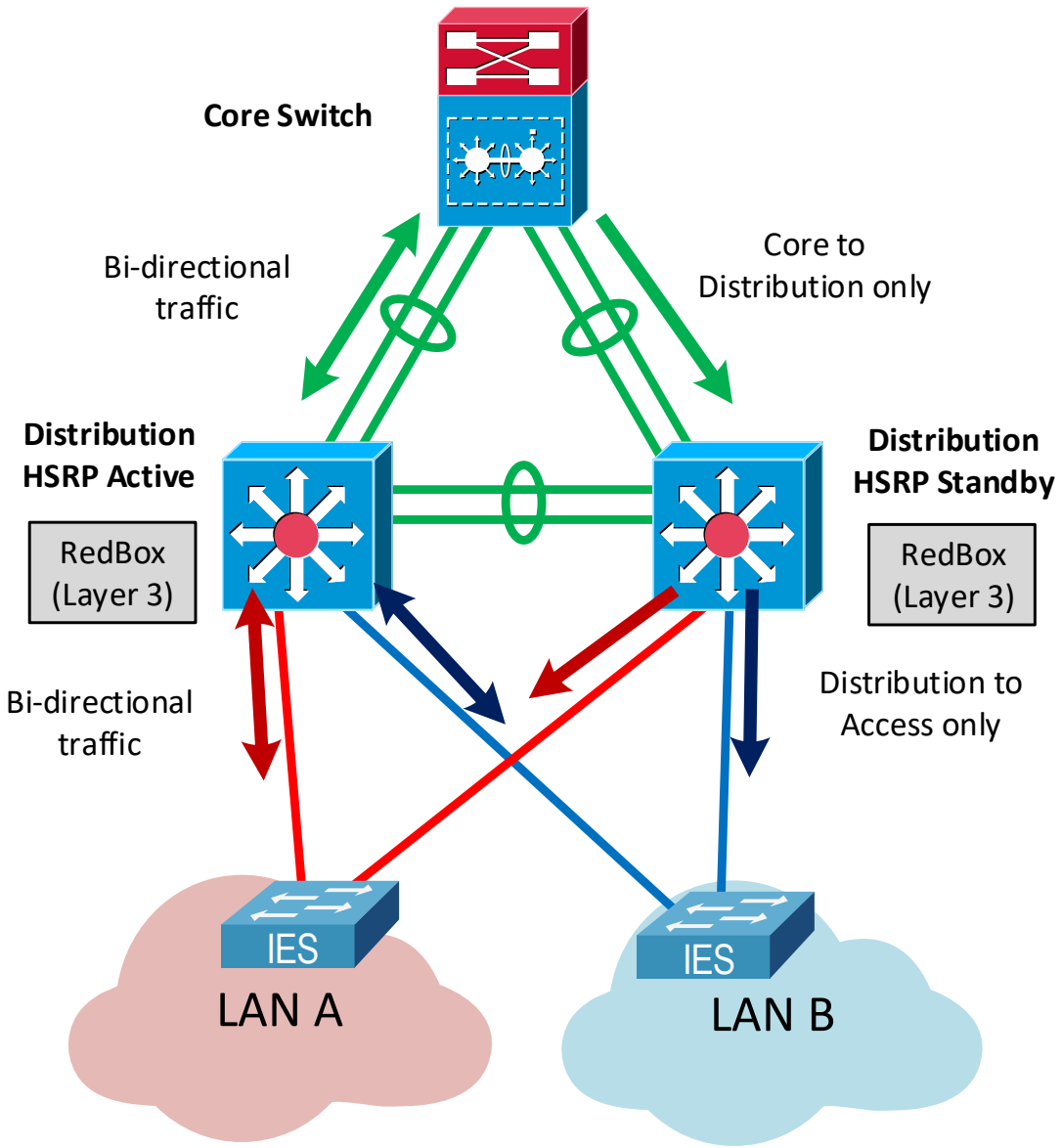
PRP Design for CPwE Architecture

Connectivity to the Industrial Zone



- Redundant Layer 3 RedBoxes (HSRP active/standby gateways)
  - Layer 3 Stratix 5400/5410 catalog numbers (-R)
- Layer 3 links on RedBoxes (except PRP channel ports)
  - Dynamic or static routing

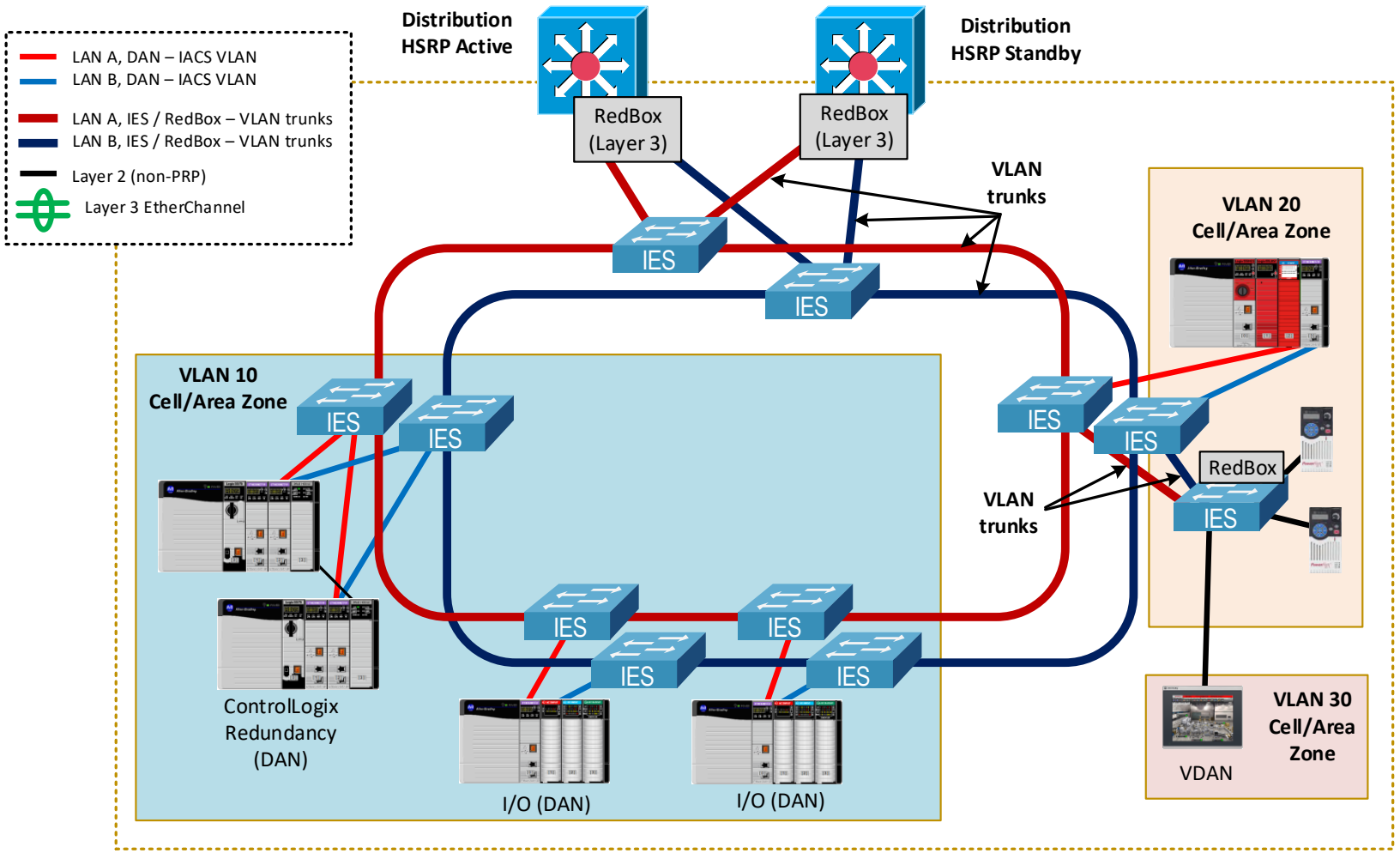
Routed Traffic Flow



- PRP redundancy protects data flows up to the PRP channel ports
- HSRP gateway faults impacts routed traffic
- Routed traffic convergence depends on HSRP parameters
  - See CPwE guide for details
- Return traffic can flow through either active or standby RedBox gateway

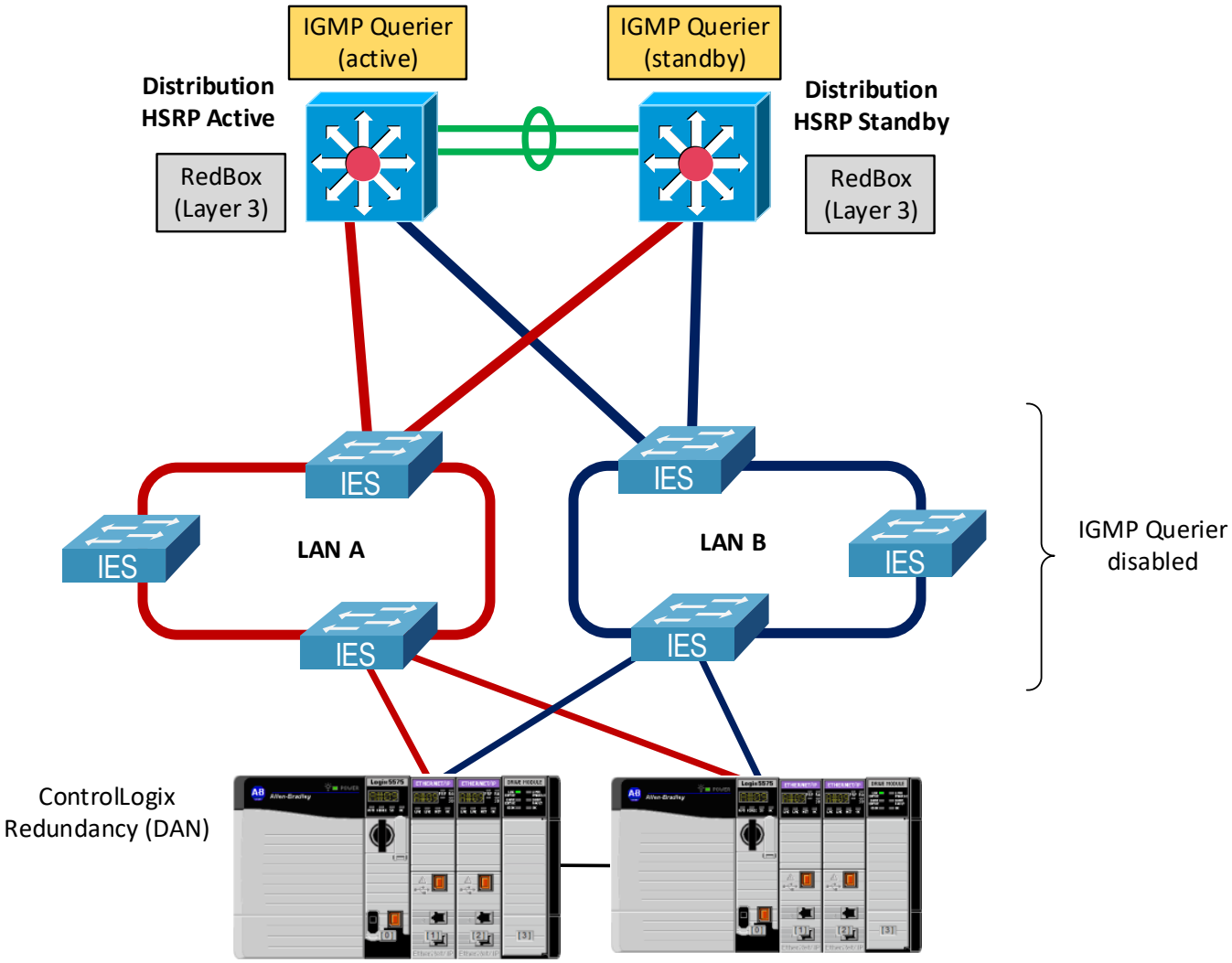
PRP Considerations for Network Services and Protocols

VLAN Segmentation with PRP



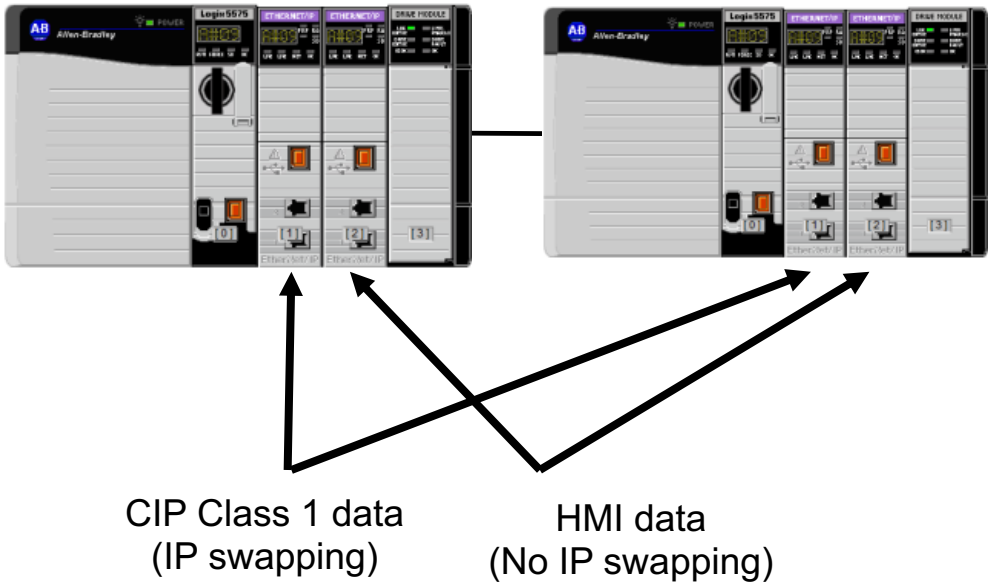
- VLAN trunking is supported on PRP channels and between LAN A/B switches
- HSRP gateway faults will impact inter-VLAN traffic (not covered by PRP redundancy)
- PRP diagnostics on each DAN is limited to its own VLAN

Multicast with PRP

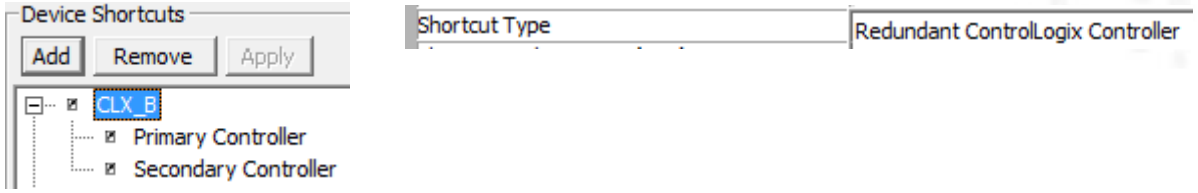


- Enable IGMP querier on HSRP gateways (default)
- Disable IGMP querier on infrastructure switches
- See CPwE guide for details

ControlLogix Redundancy with PRP



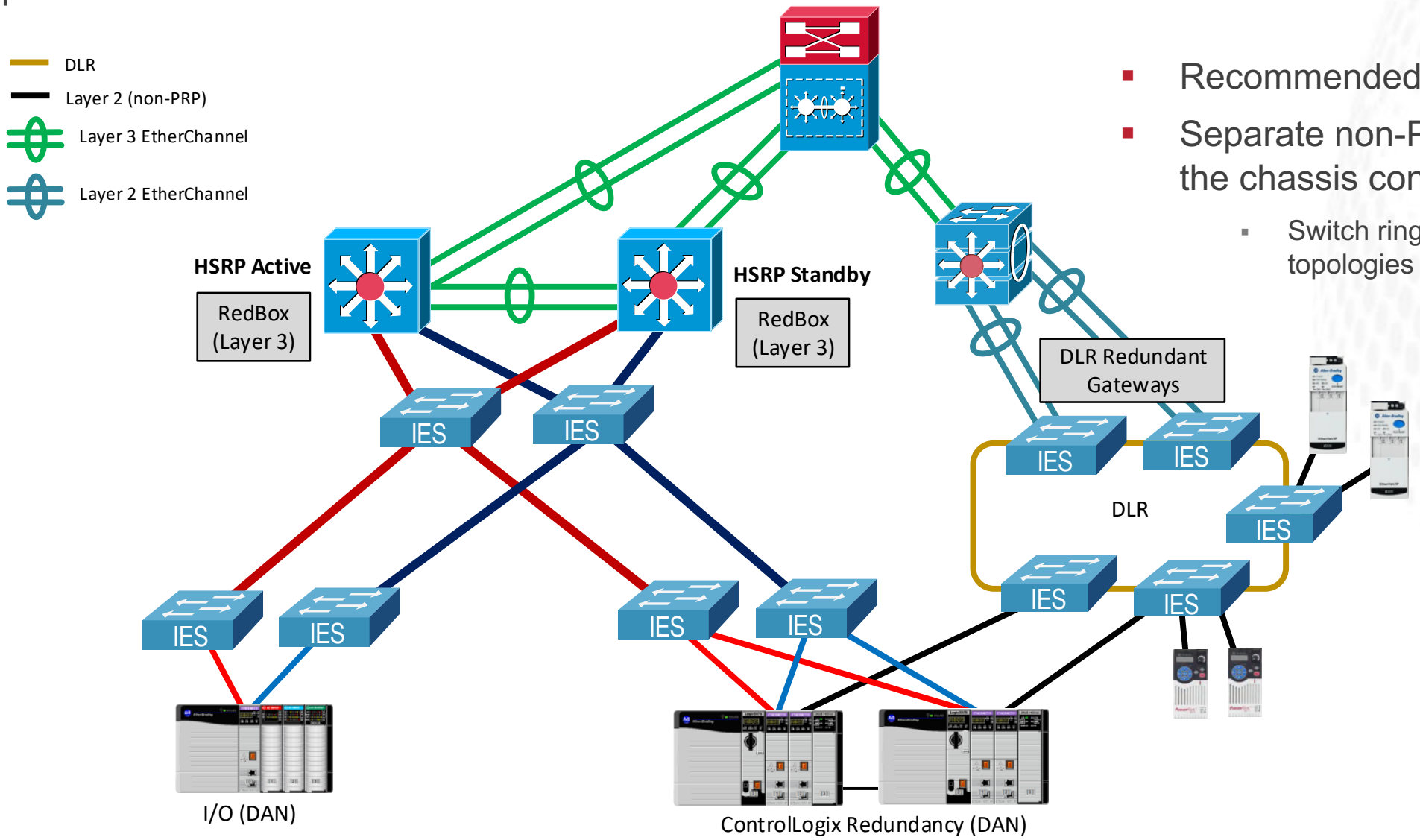
- 1756-EN2TP modules for I/O and Produced Consumed data (IP address swapping)
- 1756-EN2TP modules for HMI data (no IP swapping)
- “Redundant ControlLogix Controller” shortcut type in FactoryTalk Linx
  - See FactoryTalk Linx Getting Results Guide
- ControlLogix Redundancy firmware revision 31.052 or later, FactoryTalk Linx 6.11 or later
- Infrastructure and RedBox switches are configured for multicast per CPwE guide



CLX Redundancy

Connectivity to DLR

Separate Cell/Area Zone

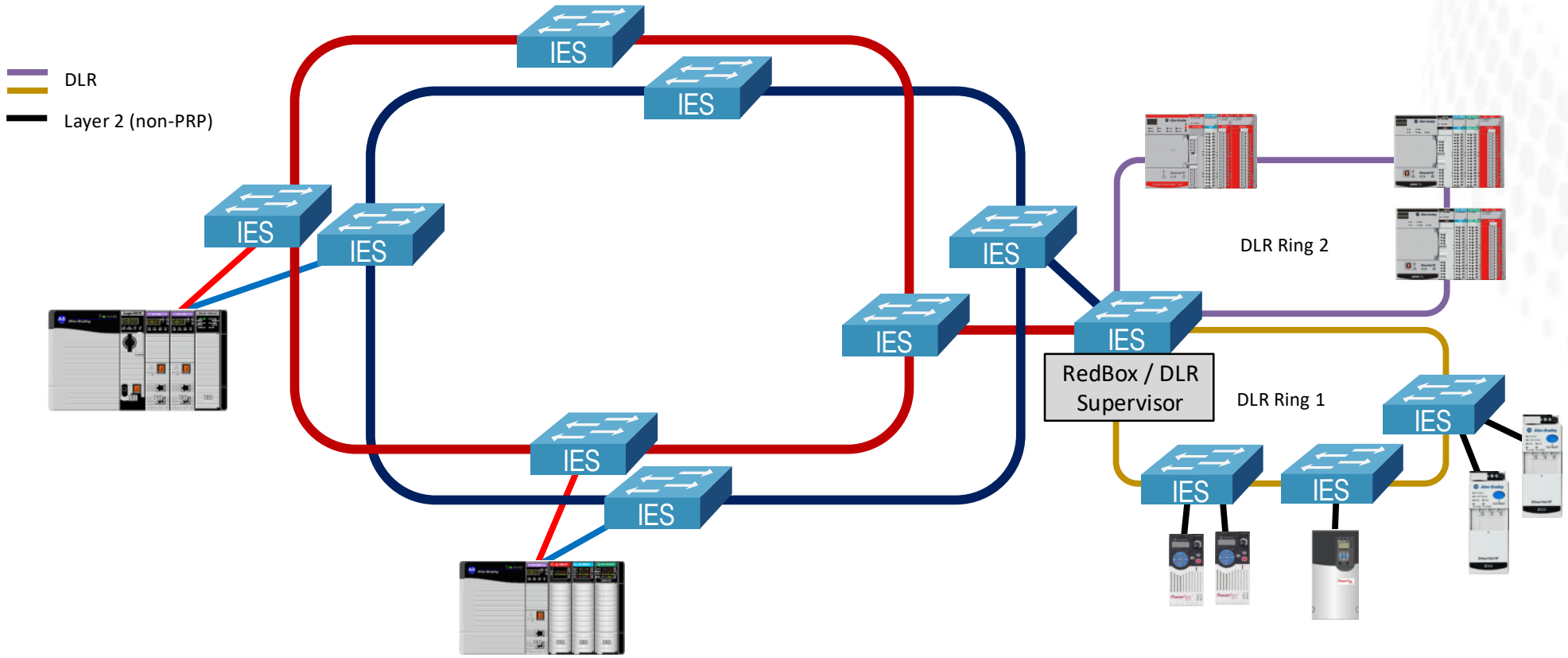


- Recommended for CPwE
- Separate non-PRP modules in the chassis connecting to DLR
  - Switch ring or device ring topologies

Connectivity to DLR

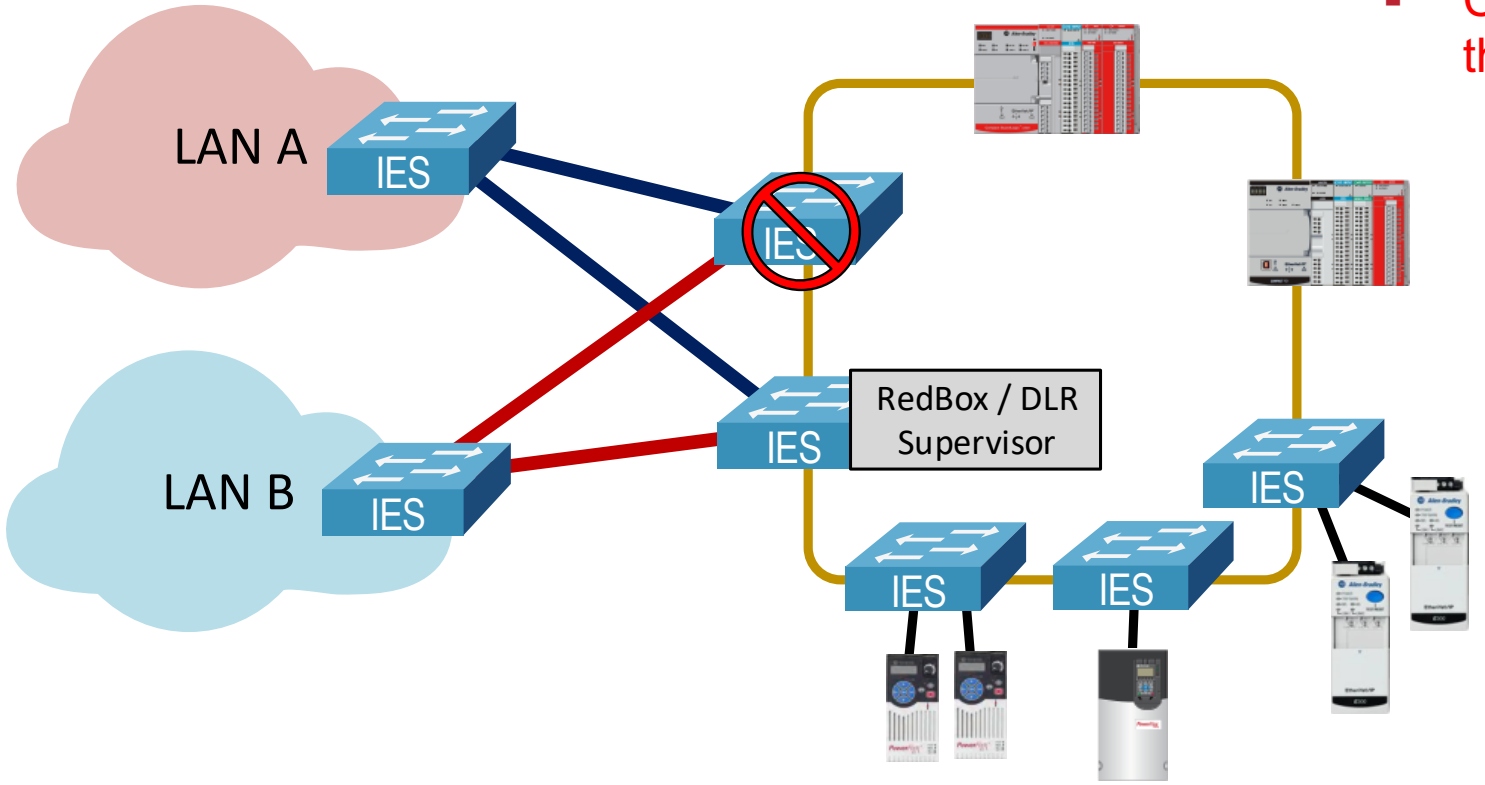
DLR on a RedBox

- Non-redundant RedBox with DLR
- Allowed but not fully validated for performance or scalability



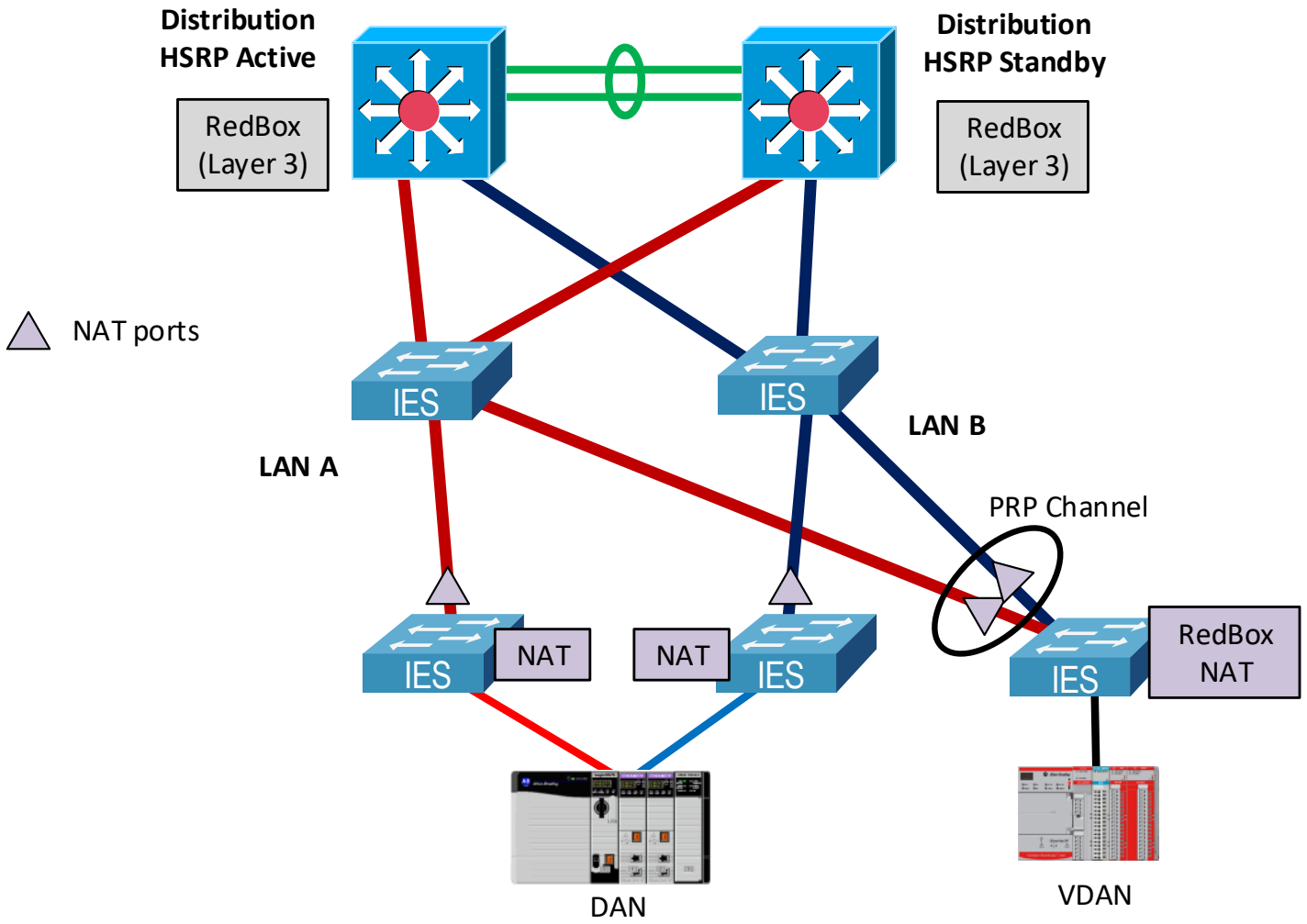
Connectivity to DLR

Unsupported Topology



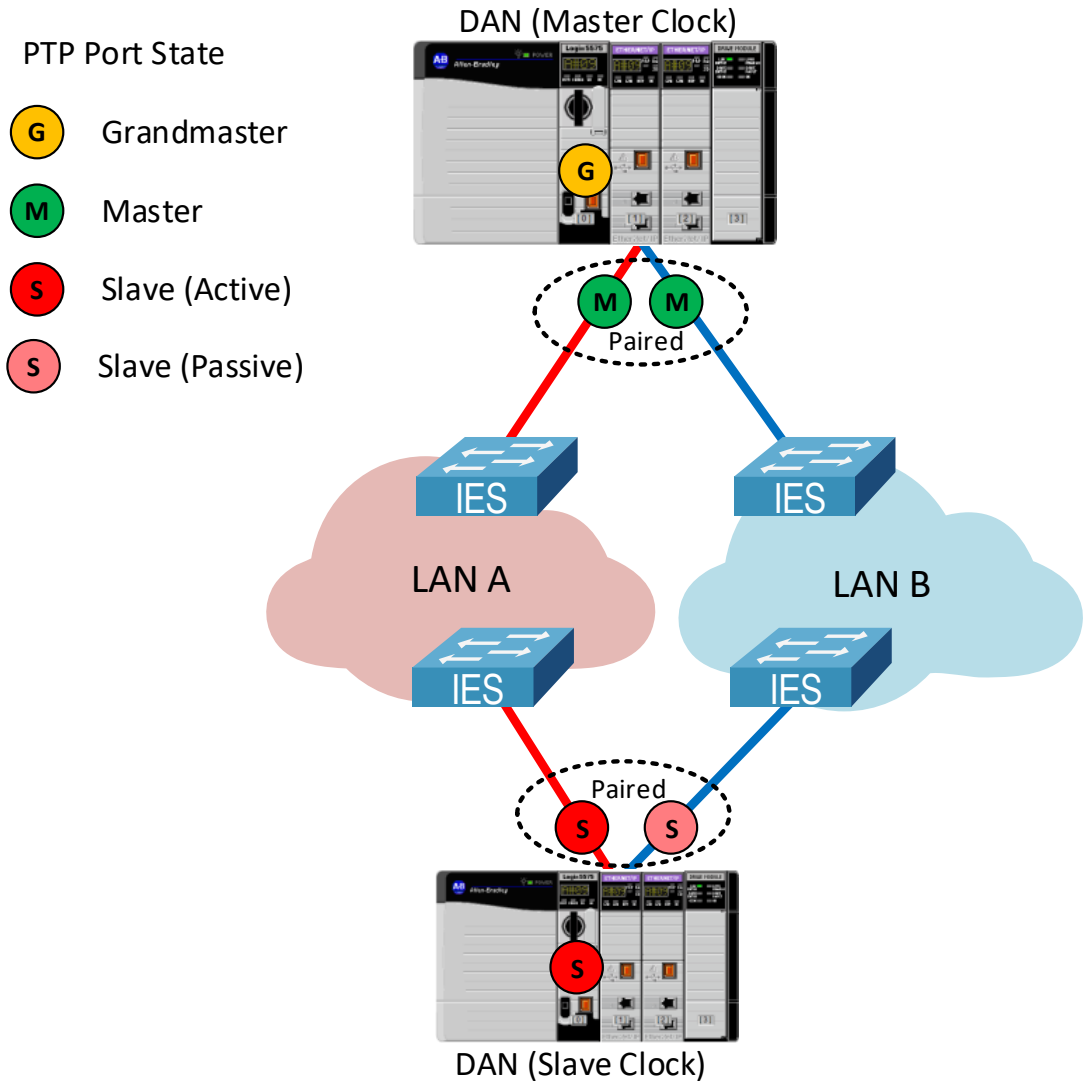
- DLR Redundant Gateway with RedBoxes is not supported
- Connections may be dropped on the gateway recovery

Network Address Translation (NAT) with PRP



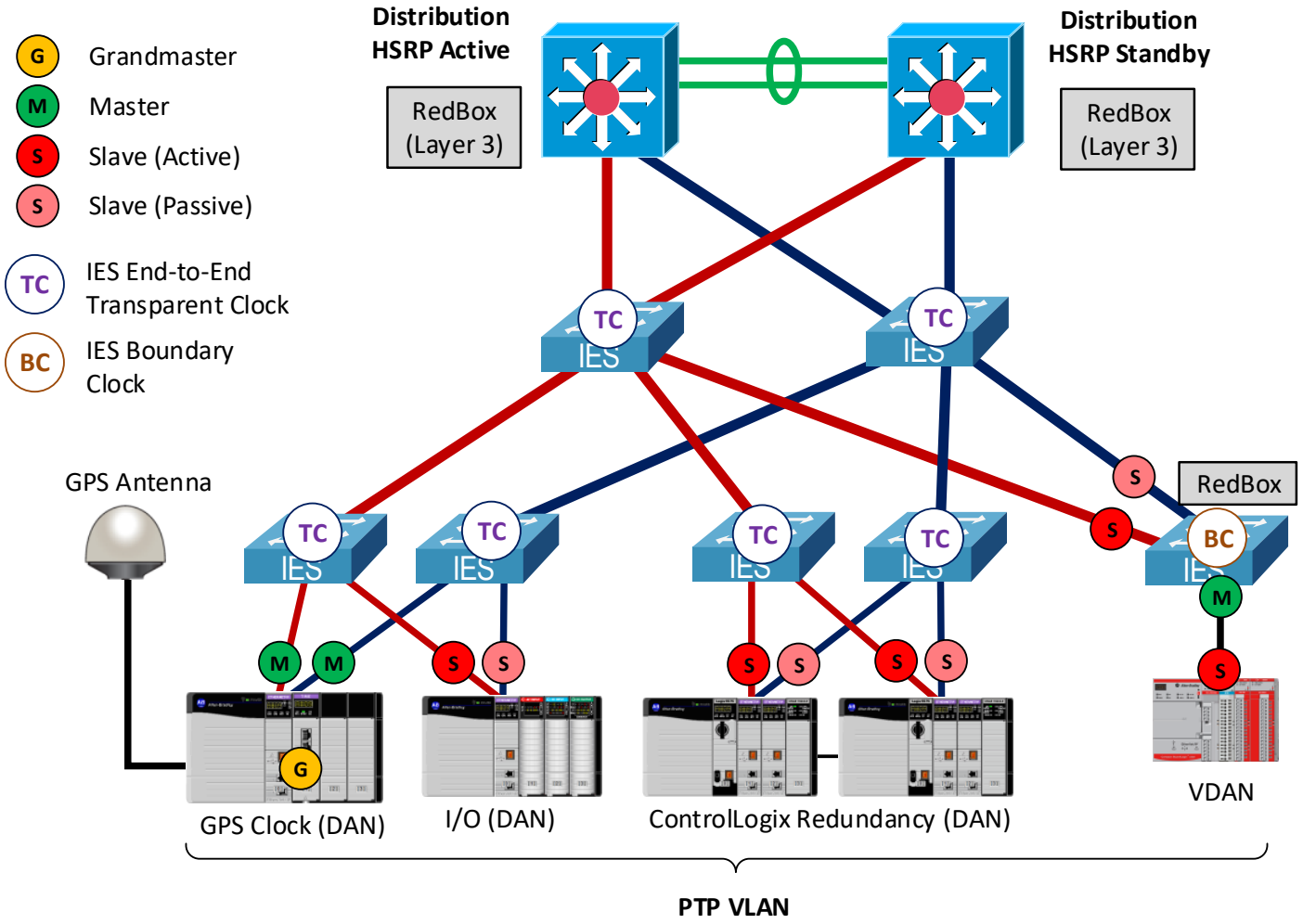
- Use case 1: NAT on LAN A/B switches – configuration must be identical
- Use case 2: NAT on RedBox switch
- Translations for HSRP addresses
  - Gateway translation for the virtual IP address
  - Public-to-Private translations for the physical IP addresses of both HSRP gateways

Precision Time Protocol (PTP) with PRP



- Each PRP port sends and receives PTP packets independently
- No duplication of PTP data
- Both ports can have PTP master or active/passive slave status

Precision Time Protocol (PTP) with PRP



- RedBox switch: Boundary clock (BC) or NTP/PTP hybrid mode
- Infrastructure switches: Transparent clock (TC)
- Place Grandmaster in a DAN chassis or on a RedBox
  - Redundant GMs are recommended
- Single PTP VLAN with TC switches
- See CPwE guide for details

Questions

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