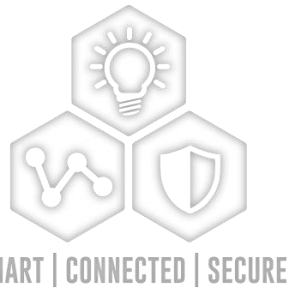
Application of PTP for Power Utility Automation over Parallel Redundancy Protocol (PRP) Networks

A Leading Provider of Smart, Connected and Secure Embedded Control Solutions



Gregg Watson

November 2021

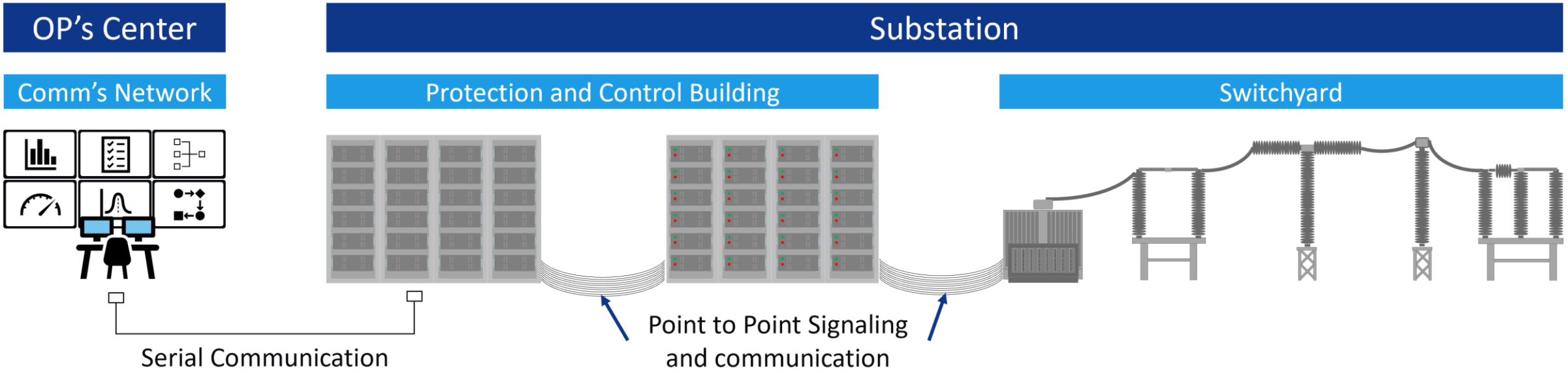
Agenda

- **Migration to Digital Substation with Process Bus**
- **Seamless Redundancy**
  - Parallel Redundancy Protocol **(PRP)**
  - High-availability Seamless Redundancy **(HSR)**
- **PRP and HSR Comparison**

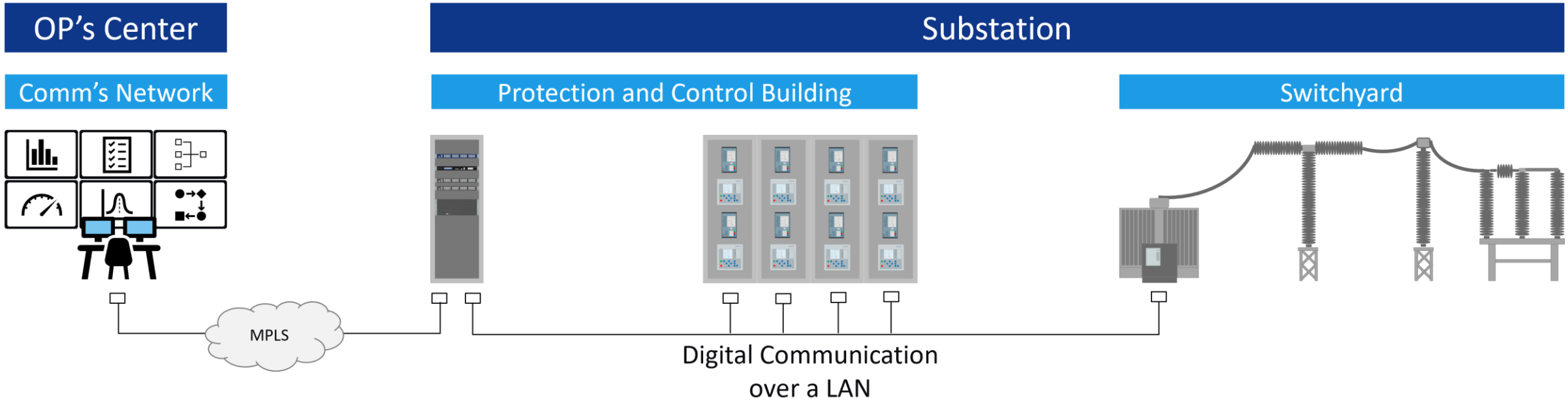
Migration to Digital Substation with Process Bus

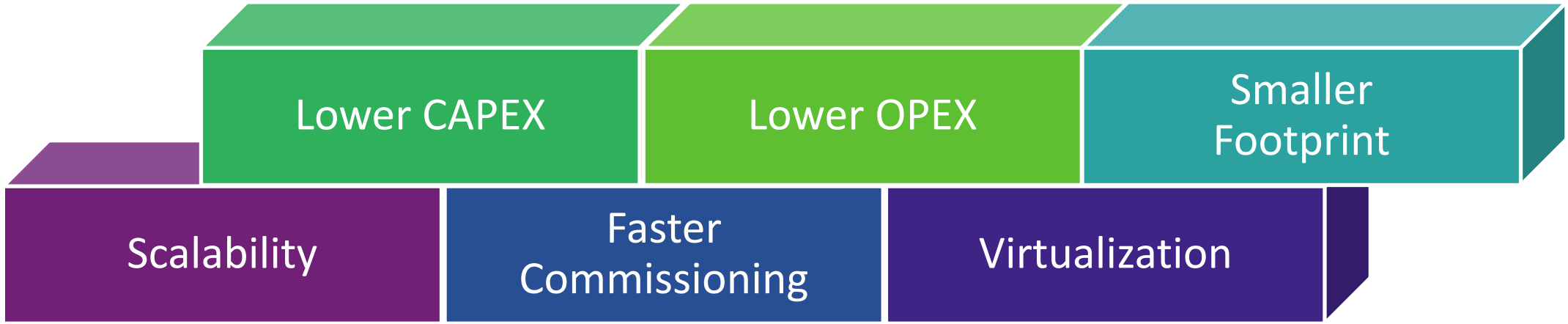
Migration to Digital Substation with Process Bus

Legacy Substation



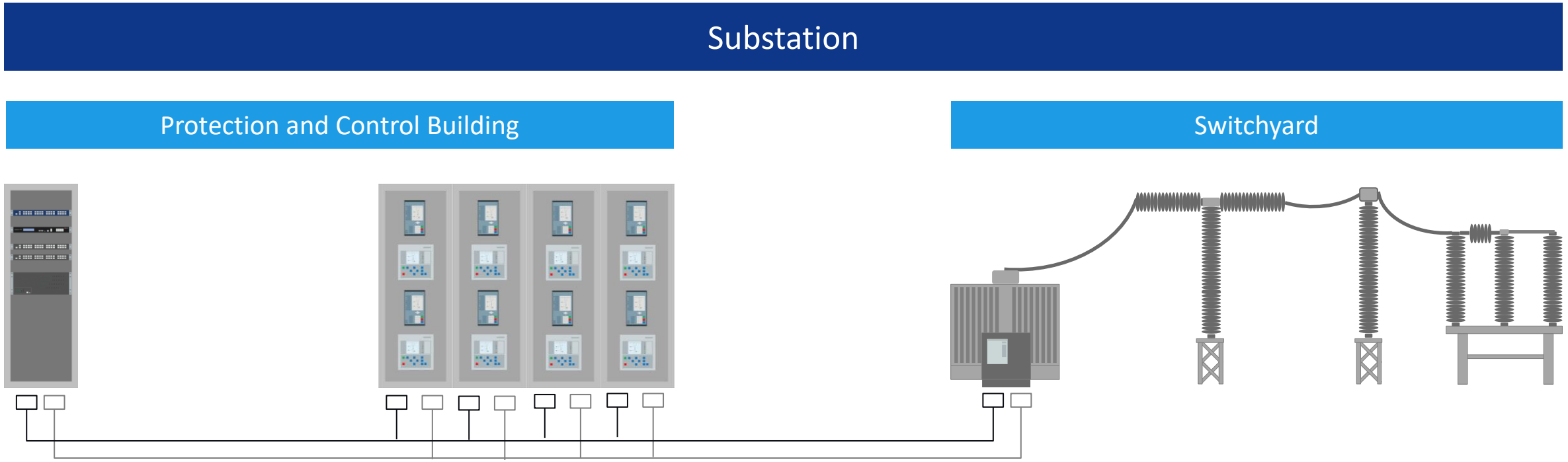
Migration to Digital Substation with Process Bus





System Protection

- **Implement main and back-up protection**
- **Communication redundancy**



Seamless Redundancy

Parallel Redundancy Protocol **(PRP)**

and High-availability Seamless Redundancy **(HSR)**

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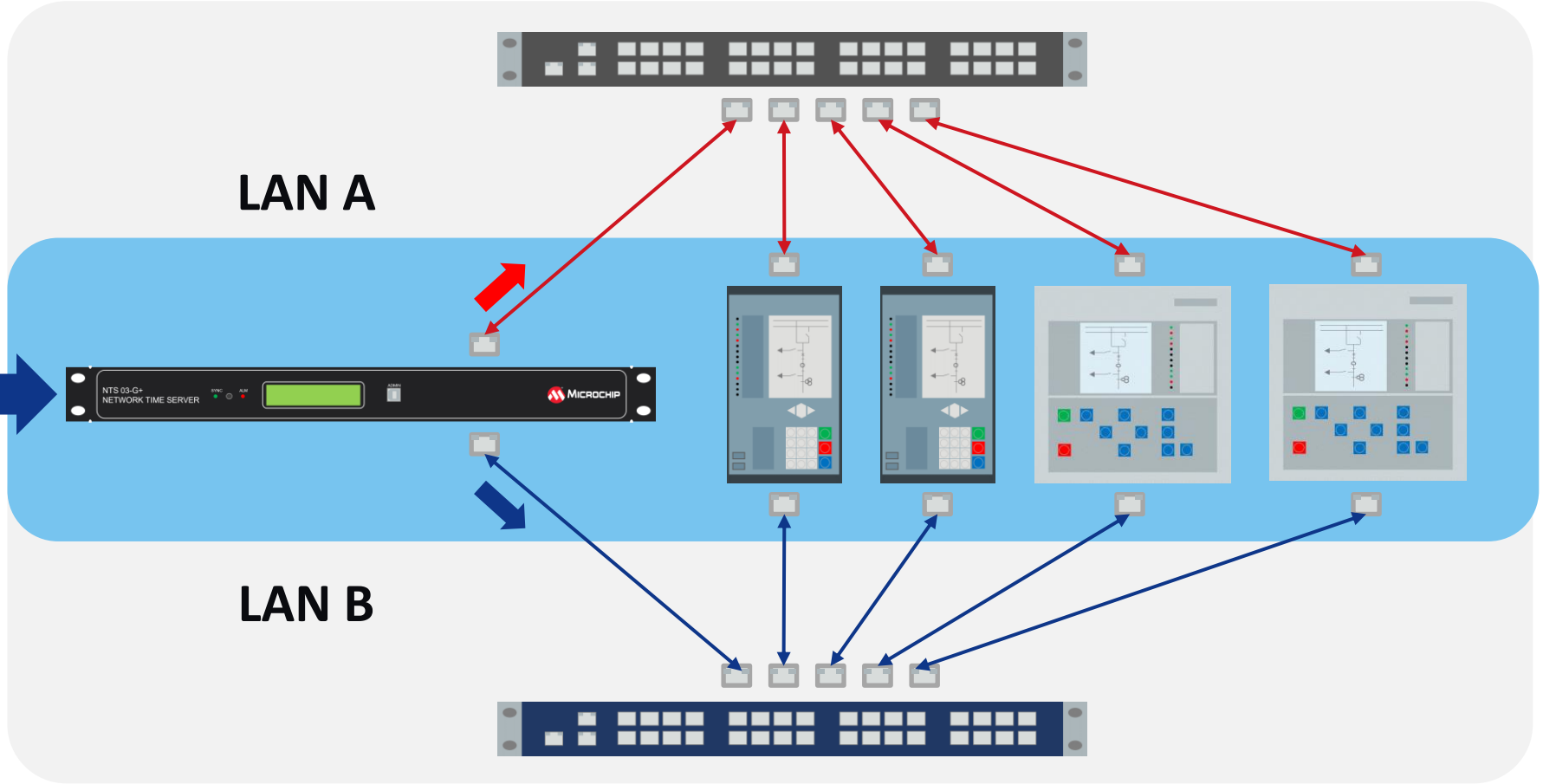
Types of Nodes

- **DAN: Doubly Attached Node**
  - DANP: Doubly Attached Node implementing PRP
  - DANH: Doubly Attached Node implementing HSR
- **SAN: Singly Attached Node**
- **RedBox: Redundancy Box which attaches a SAN to a redundant network**
- **QuadBox: 4-port device connecting two HSR rings, which filters the traffic and forwards it from ring to ring**

Parallel Redundancy Protocol (PRP)

Doubly Attached Nodes (DANs)

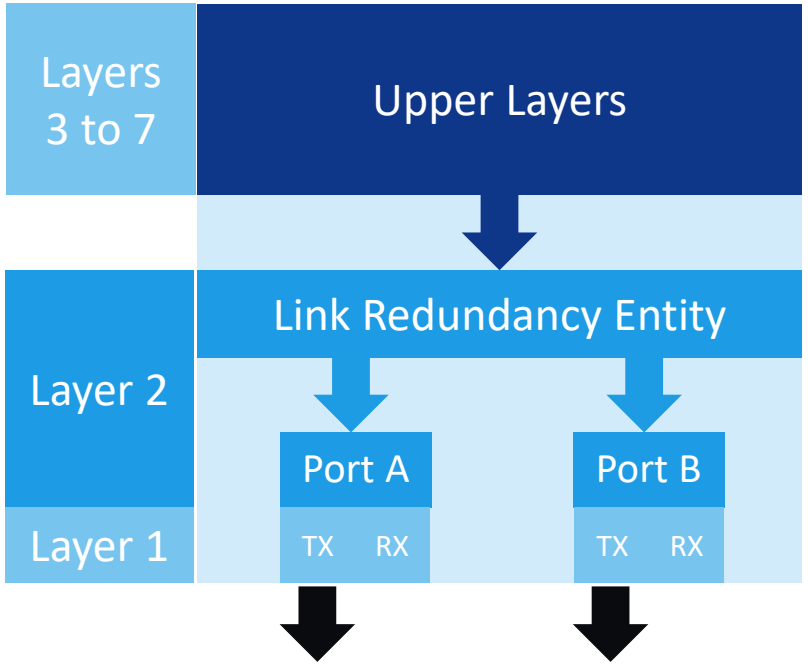


Parallel Redundancy Protocol (PRP)

General Frames

Transmitting Frames

- **The frame passes through the upper layers and the Link Redundancy Entity duplicates the frame, appends a Redundancy Check Trailer (RCT) containing the sequence number, LAN ID, frame size and PRP Suffix, and forwards it on to transmit.**



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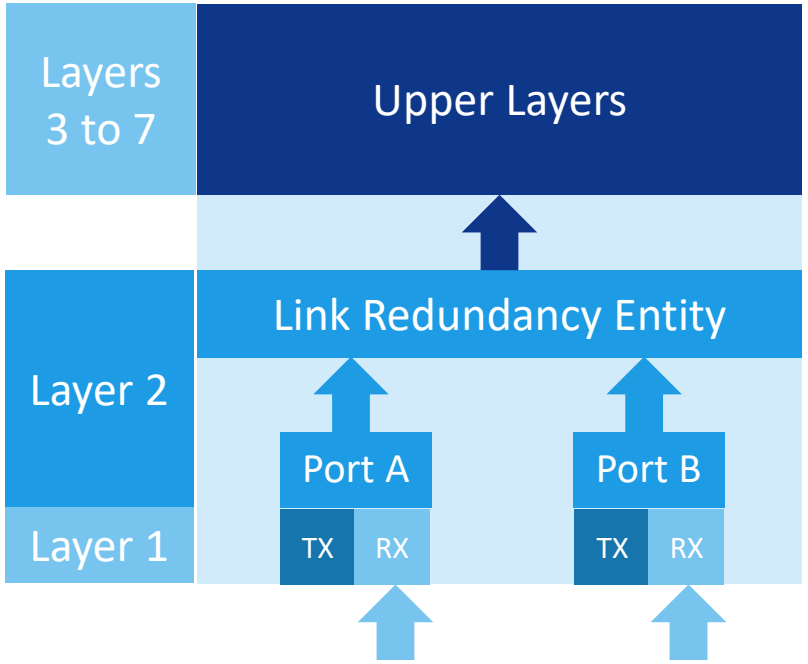
Parallel Redundancy Protocol (PRP)

General Frames

Receiving Frames

- The frame passes through the receiver and the Link Redundancy Entity checks the MAC address of the sender, RCT sequence number, and frame length.
- It passes on the first frame it receives and discards the duplicate before forwarding it on to the upper layers.



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Parallel Redundancy Protocol (PRP)

PTP Frames

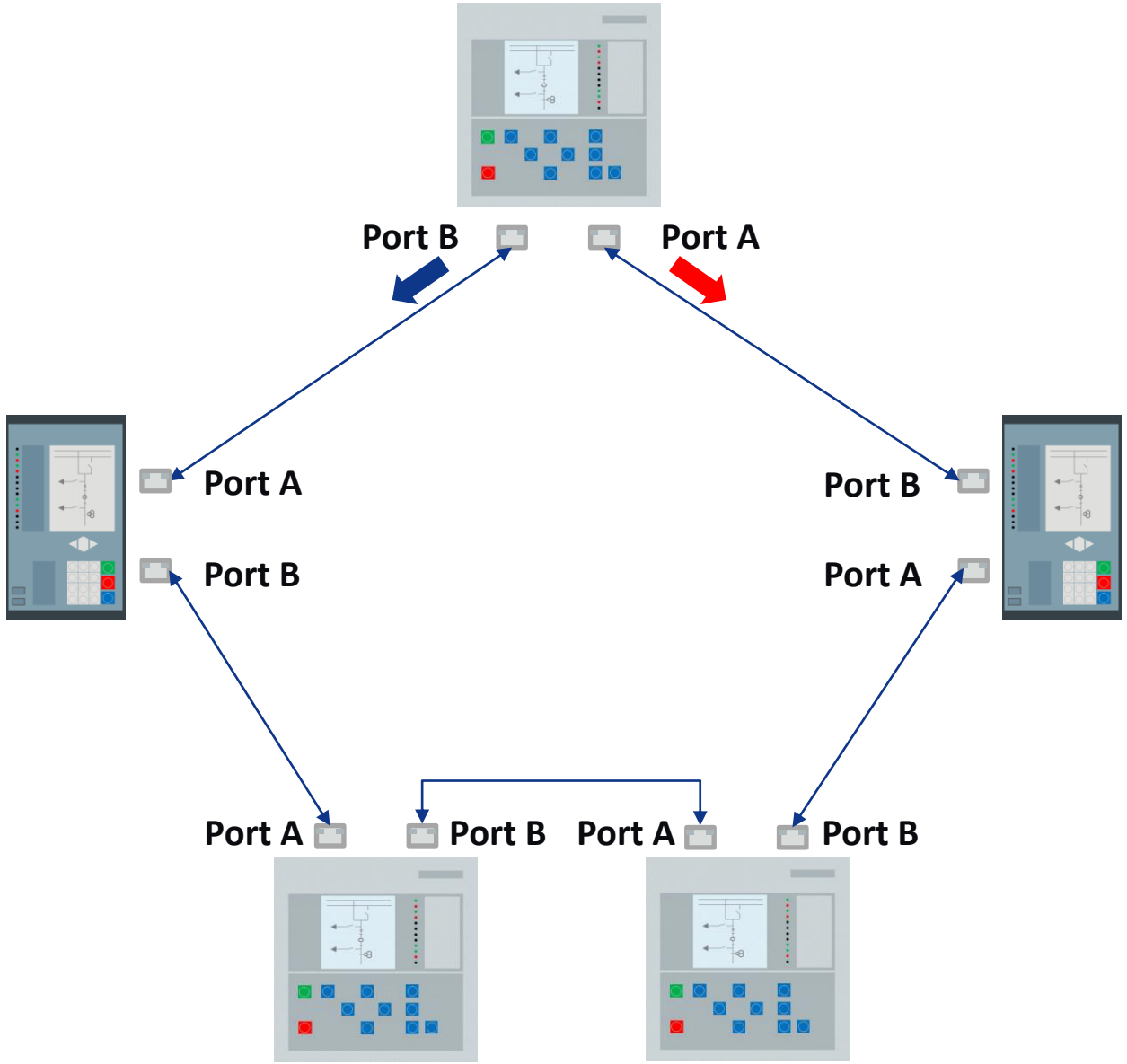
- The duplicate and discard method used for General Frames cannot be applied to PTP messages
- PTP Sync messages packet delay variation is different between LAN A and LAN B
- The correction field is updated by intermediary nodes and is different on each LAN
- Transparent Clocks are not PRP aware and are not required to forward the RCT's
- RCT's are not used in PTP messages

Parallel Redundancy Protocol (PRP)

PTP Frames

- Following BMCA selection as the Server, Port A and B go into the “Server” state
- Clients on the network will determine which port has the most accurate source, and that port will enter “Client” state, while its peer will enter “Passive Client” state
- If a better “Server” is identified via BMCA selection, then the preceding server will enter the Client/ Passive Client, or Passive Server/ Passive Server state.

High-availability Seamless Redundancy (HSR)

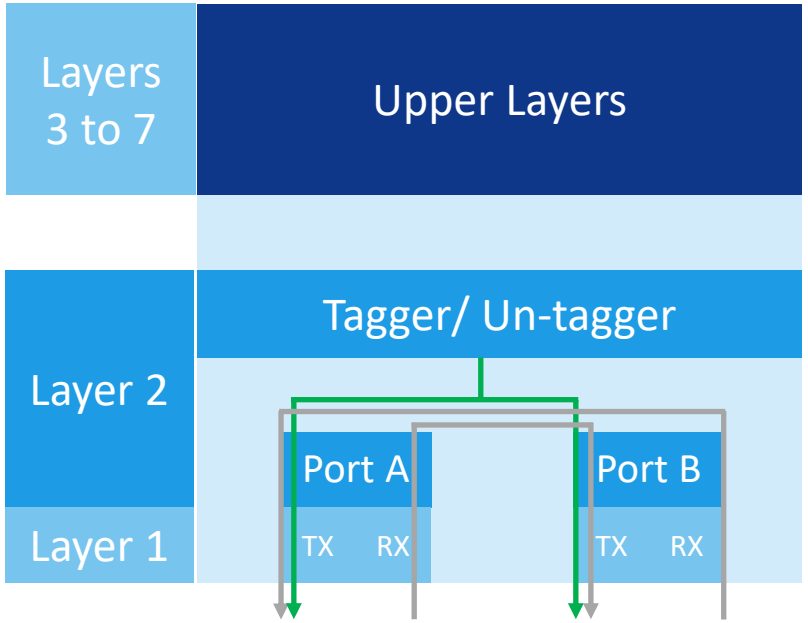


High-availability Seamless Redundancy (HSR)

General Frames

Transmitting Originating Frames

- **DANHs sends all messages with a HSR Tag**
- **The frame passes through the upper layers and the Link Redundancy Entity duplicates the frame, appends a HSR Tag containing the Ethertype, Path ID, frame size and sequence number and forwards it on to transmit.**

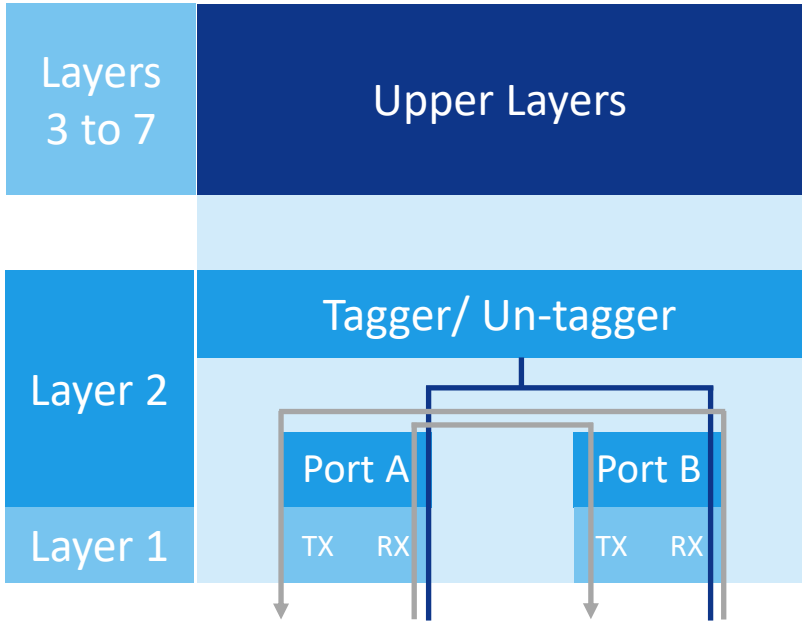


High-availability Seamless Redundancy (HSR)

General Frames

Receiving Frames

- The frame passes through the receiver and the Link Redundancy Entity checks the HSR Tag
- If the DANH is the intended recipient, the frame is passed on to the upper layers and not passed on to its pair (unless it is part of a group)
- If the same tagged frame has already been received on a port from the opposite direction, the frame is not passed on and discarded (with some exceptions)
- If the frame received originated from the DANH (therefore has traversed the ring), then the frame is not passed on and is discarded



High-availability Seamless Redundancy (HSR)

PTP Frames

- DANHs sends all PTP messages with a HSR Tag
- PTP Sync messages packet delay variation is different for clockwise and anticlockwise directions
- Port state is communicated to its peer to ensure that one port does not go to the “Server” state when the other is in the “Client” state
- Syncs messages are modified by HSR nodes to adjust the correction field

PRP and HSR Comparison

	PRP	HSR
Benefit	• Transparent Clocks do not need to be PRP aware • Non-PRP devices can be attached to a PRP LAN (A or B) if redundancy is not required for that specific device • **If a node fails or is removed from service for maintenance, redundancy remains intact (except for a Switch/ Transparent Clock where some redundancy may be lost)** • Each LAN (A and/or B) may implement different architectures and other forms of redundancy	• **Does not require Switches (Transparent Clocks) to distribute Ethernet frames through the network, therefore is typically lower cost**
Cons-traints	• **~Doubles the number of switches/ transparent clocks required** • Requires software support • Non-PRP nodes which require redundancy can only be connected to a network through a Redundancy Box (Red Box)	• Limited vendor support • Requires hardware and software support • Every node must support HSR. Non-HSR nodes can only be connected to a network through a Redundancy Box (Red Box) • **If a network node fails or is removed from service for maintenance, redundancy is effectively broken** • Doubles the Ethernet traffic on the network • Under non-fault conditions, nodes are exposed to all frames even when the node is not the intended destination

Thank You!