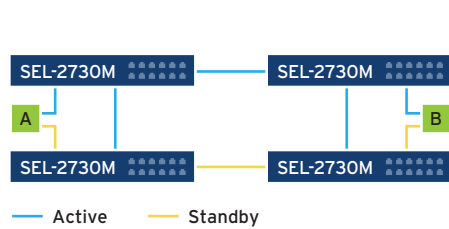


# SEL Ethernet Reference Sheet

## STA

### Spanning Tree Algorithm



### TRAFFIC PATH HEALING

Switches decide how to forward communications based on an algorithm that converges to a tree topology by designating or blocking links. Performance is very topology-dependent, and healing calculations don't start until a failure happens.

The Rapid Spanning Tree Protocol (RSTP) and Multiple Spanning Tree Protocol (MSTP) are specific implementations of STA.

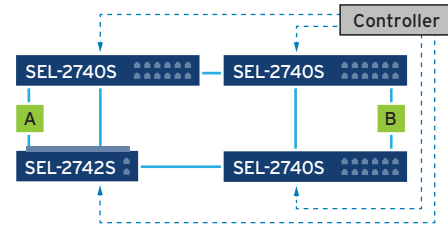
- Adds recoverability to the network. Widely supported by vendors.
- Cost-effective.
- Failover times of 20–50 ms for most scenarios.
- Failover times are dependent on topology and switch count.

#### Designed for ease of use and multivendor environments.

- Is not a zero-packet-loss protocol.
- Blocked-port technology reduces system bandwidth.
- Some vendors add proprietary features to their STA.
- Network disruptions during any topology changes.

## SEL SDN

### Software-Defined Networking



### TRAFFIC PATH HEALING

Standard 802.3 Ethernet with spanning tree removed from switches. All primary and backup network paths are configured by a software flow controller.

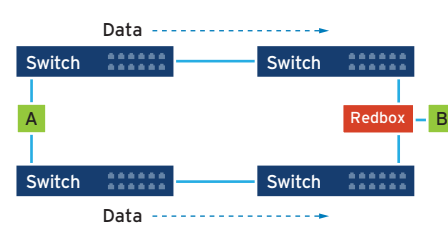
- Provides faster failover in <100 μs.
- Adds recoverability to the network in any topology.
- No network disruptions with topology changes.
- Cost-effective.

#### Offers other advantages for OT networks.

- Deny-by-default architecture improves cybersecurity.
- Elimination of STA blocked ports allows 100 percent of system bandwidth to be used.
- Automated data collection for cyber audits.

## PRP

### Parallel Redundancy Protocol



### TRAFFIC DUPLICATION

PRP utilizes STA or SDN switches. Splits communications across two completely separate (redundant) networks. Designed to create a zero-packet-loss communications network with 0 ms failover for a single point of failure (N+1).

Adds a redundancy control trailer (RCT) to the data payload that allows the packet to traverse traditional networking equipment.

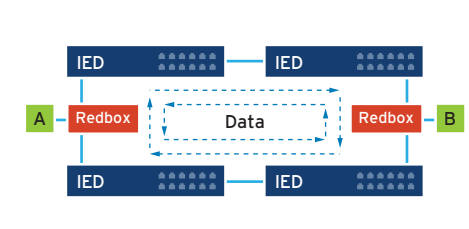
- Creates fully redundant Ethernet packets.
- No “dark” period for failovers.

#### Suited for applications where zero packet loss is required for single-point-of-failure (N+1) conditions.

- Requires doubling of all networking equipment.
- Requires a redundancy box for non-PRP “traditional” hosts.
- Relies on additional STA/SDN on each redundant network for recoverability.
- Recoverability for single-point-of-failure (N+1) conditions.

## HSR

### High-Availability Seamless Redundancy



### TRAFFIC DUPLICATION

Required ring architecture splits communications both ways around its topology. Adds a redundancy control field as a header in the packet, thereby requiring HSR-aware network appliances and not interoperable with traditional Ethernet appliances.

- STA or SDN switches are not used in HSR rings.
- Slightly more cost-effective than PRP.
- Creates fully redundant Ethernet packets.
- No “dark” period for failovers.

#### Suited for homogeneous environments that are monitored by personnel.

- Requires specialized hardware to reduce delays, much like EtherCAT®.
- Not compatible with traditional networking equipment (requires an additional redundancy box).
- Recoverability for single-point-of-failure (N+1) conditions.

## Terms

### **MRP (IEC 62439-2)**

Media Redundancy Protocol

### **CoS (IEEE 802.1p)**

Class of Service

### **QoS**

Quality of Service

### **CIDR**

Classless Inter-Domain Routing

### **CRP (IEC 62439-4)**

Coupled Redundancy Protocol

### **BRP (IEC 62439-5)**

Beacon Redundancy Protocol

### **DRP (IEC 62439-6)**

Distributed Redundancy Protocol

### **FRP**

Fieldbus Redundancy Protocol

### **RRP (IEC 62439-7)**

Ring Redundancy Protocol

### **OSPF**

Open Shorted Path First

### **NTP**

Network Time Protocol

### **PTP**

Precision Time Protocol

### **RIP**

Routing Information Protocol

### **VRRP**

Virtual Router Redundancy Protocol

### **HSRP**

Hot Standby Router Protocol

### **EIGRP**

Enhanced Interior Gateway Routing Protocol

### **BGP**

Border Gateway Protocol

### **MPLS-TP**

Multiprotocol Label Switching—Transport Profile

### **Recoverability**

The ability to return a system to a working state after a failure, with the ability to continue to recover from more failures.

### **Redundancy**

Extra always-active elements that allow a system to continue normal operation even during failure scenarios.

## Things You Should Know

(Explanation, customer reason, SEL response)

### **OpenFlow Proactive Vs. Reactive (OpenFlow 1.3)**

- Reactive flows require continual controller connectivity, while proactive flows are preconfigured and do not require continual connectivity.
- Customers will want proactive flow support for critical networks.
- SEL's implementation of SDN supports proactive flows.

### **IPv4 Vs. IPv6**

- IPv4 supports 4.2 billion unique addresses; IPv6 supports trillions.
- Customers want to eventually migrate to IPv6, but it is not a priority.
- SEL will support IPv6 in the future.

### **Unicast Vs. Multicast Vs. Broadcast Communications**

- Unicast is meant for a single device, multicast (like IEC 61850 GOOSE) is meant for groups of devices, and broadcast is meant for all devices on a LAN.
- Customers want to limit broadcast and use SCADA unicast and GOOSE multicast.
- SEL supports filtering unicast via the SEL-3620/3622 and supports multicast and broadcast using the SEL-2730M. The SEL-2740S/2742S can filter both unicast and multicast. SDN keeps the configuration simple and offers flexibility for IEC 61850 deployments.

### **Port-VLAN (PVID) Vs. Tagged VLAN (VID, IEEE 802.1Q)**

- PVIDs are generally added to nontagged traffic, whereas VIDs are used by VLAN-aware devices (like IEDs using GOOSE).
- Customers use VLANs to separate traffic on LANs.
- SEL-2730M and SEL-2740S/2742S switches support both PVIDs and VIDs.

### **RSTP Vs. MSTP (both IEEE 802.1D)**

- RSTP converges a single physical topology.
- MSTP converges virtual topologies and is VLAN-aware.
- Customers like RSTP for better performance and simpler configuration.

### **IRIG-B Vs. NTP Vs. PTP (IEEE 1588v2)**

- IRIG-B is the most accurate (tens of nanoseconds), followed by PTP (hundreds of nanoseconds), followed by NTP (milliseconds).
- NTP and PTP offer time sync over Ethernet (one less cable).
- SEL supports IRIG-B on IEDs; PTP on the SEL-2488 Satellite-Synchronized Network Clock, SEL-2740S/2742S SDN switches, and SEL-400 series relays; and NTP on other communications devices.



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