APPLICATION NOTE - HSR/RSTP

High Availability Seamless Redundancy (HSR) and Rapid Spanning Tree Protocol (RSTP/IEEE802.1W) Interoperability through the iS5Com's iRBX6GF HSR/PRP Switch (RedBox)

There has been an existing problem with integrating HSR and RSTP directly in electric substation networks and similar applications. Many legacy substations are running networks based upon RSTP for redundancy. However, recently more substations are migrating towards HSR/ PRP protocol. There is always a challenge in integrating this legacy architecture which is based on RSTP with newer IED/ Relays that supports HSR/ PRP protocols.

While RSTP has been adequate for many applications, it adds significant convergence times for network recovery due to the nature of the RSTP protocol (5 m/s convergence per switch). Second and more importantly, it is not possible to scale existing RSTP networks by connecting HSR enabled devices such as a relay or other Intelligent Electronic Device (IED) in the same RSTP network. The reason is that these redundancy protocols operate in opposition to each other. HSR requires rings to operate and RSTP break rings by design. RSTP allows redundant connections but these connections are placed in standby mode until needed in order to provide a loop free network.

iS5 Communications developed and patented the HSR/RSTP domain separation technology incorporated in the iRBX6GF. iS5Com's patent allows HSR and RSTP domains to interoperate on a network. With this technology, the user can eliminate the requirement to have a ring of IP Layer 3 routers doing the same function for connectivity but at a much slower speed for network failover.

PROTOCOL OVERVIEW

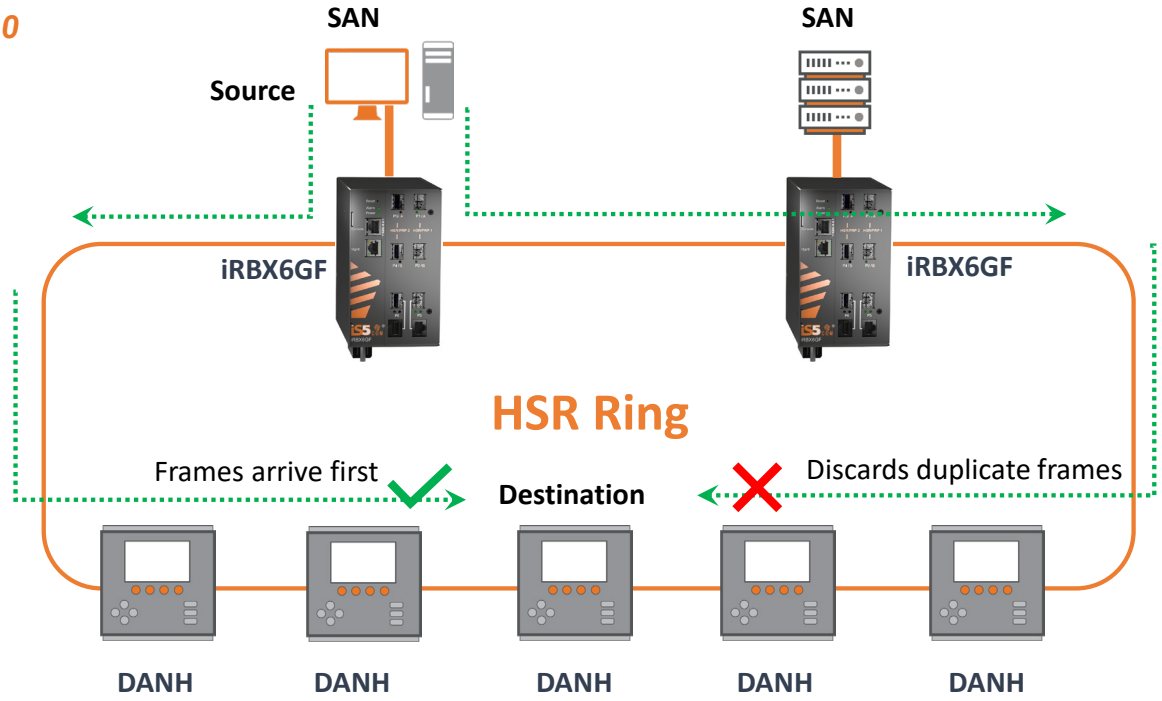
HIGH-AVAILABILITY SEAMLESS REDUNDANCY (HSR) IEC 62439-3

The High-availability Seamless Redundancy protocol delivers zero recovery time in case of a network element failure by utilizing a ring of network nodes and end devices. An HSR network node has two ports operating in parallel; typically, referred to as a Doubly Attached Node with HSR protocol (DANH).

A typical HSR is a ring topology that consist of doubly attached devices where each device has two ring ports which helps to minimize the connection counts and cabling. The connections between the devices are full duplex in configuration. *See figure 1*.

Messages sent from the publishing device is duplicated into an “A” frame and a “B” frame, and sent out both ports in opposite directions around the ring. The receiving device accepts the first frame received and discards the second. If a network link fails, the copy of the message traveling the other direction around the ring will be received and used. This creates a “lossless” network that deals with link failure without losing any frames.

Figure 1.0



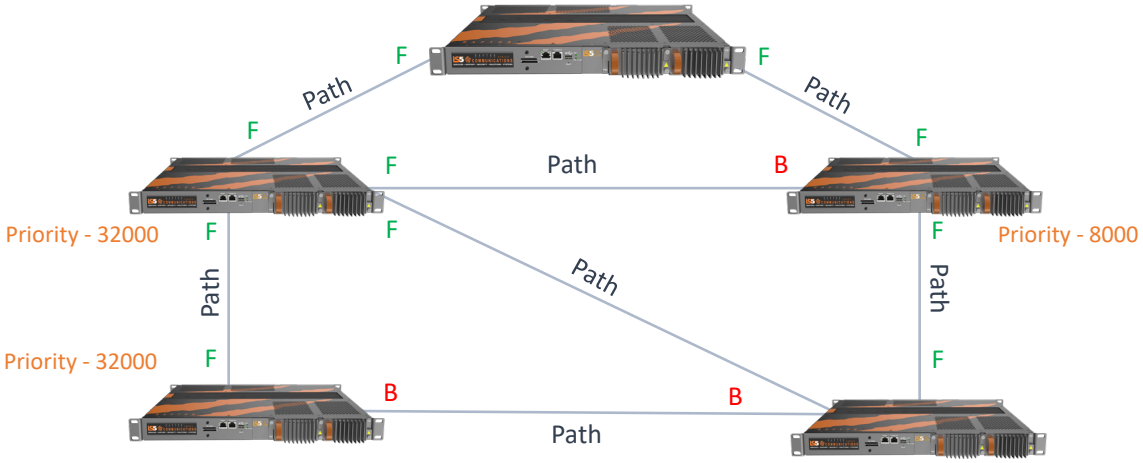
RAPID SPANNING TREE PROTOCOL

Spanning Tree Protocol (STP) manages redundant paths in Ethernet networks, resulting in loop-free logical topologies. The basic functions of STP are to prevent bridge loops and their resulting broadcast storms. Spanning tree allows backup links to be designed into networks to provide fault tolerance if an active link fails. STP detects the physical connections between switches and manages which links are active and which are standby. There are no network loops allowed to operate in real-time.

Rapid Spanning Tree Protocol (IEEE802.1D 2004) is the most recent version of Spanning Tree Protocol. RSTP breaks network loops, however it does not offer a zero-packet loss guarantee. When there is a link failure, RSTP takes time to detect the failure and send the traffic on a different path. During this time, data will be lost.

Figure 2.0

F – Port in forwarding state
B – Port in blocking state



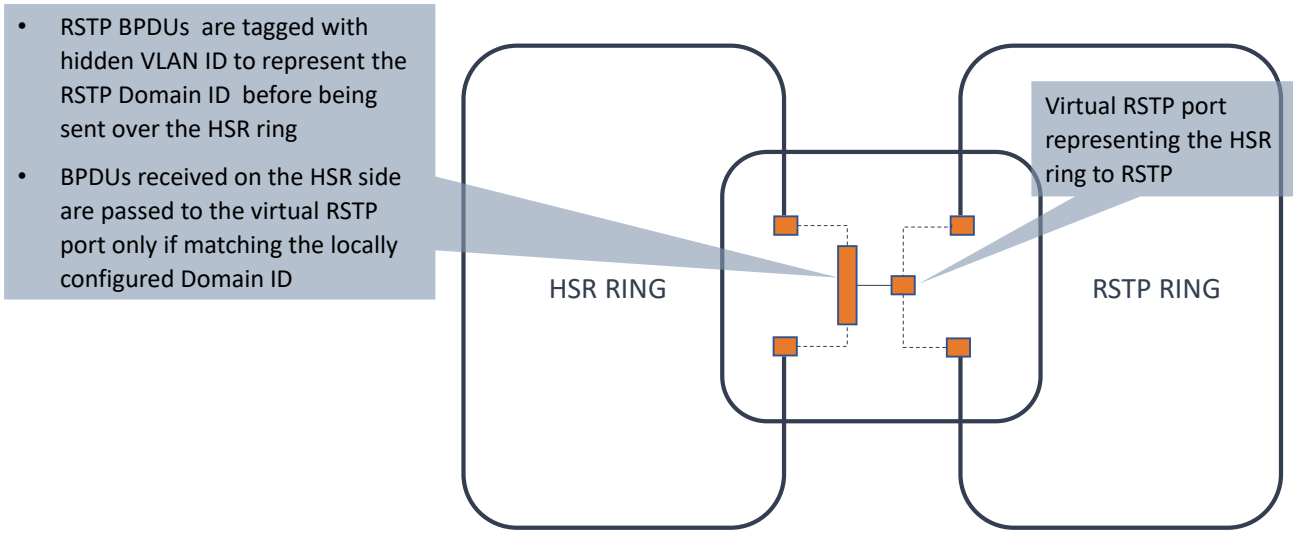
HSR-RSTP PROTOCOL INTEROPERABILITY

The iRBX6GF contains proprietary technology that allows the entire HSR ring to appear to the RSTP networks as a single switch hop. Consequently, for the RSTP protocol, the ring appears as a single connection, not as a loop to be broken.

The Resilient (or reliable) HSR ring provides a lossless environment for the RSTP networks to connect to. As a result of this interoperability, a robust network can be built that incorporates multiple RSTP networks connected to one big HSR Ring.

The below diagram illustrates how the iRBX6GF functions to directly connect HSR and RSTP.

Figure 3.0



Guidelines for the iRBX6GF configuration implementation

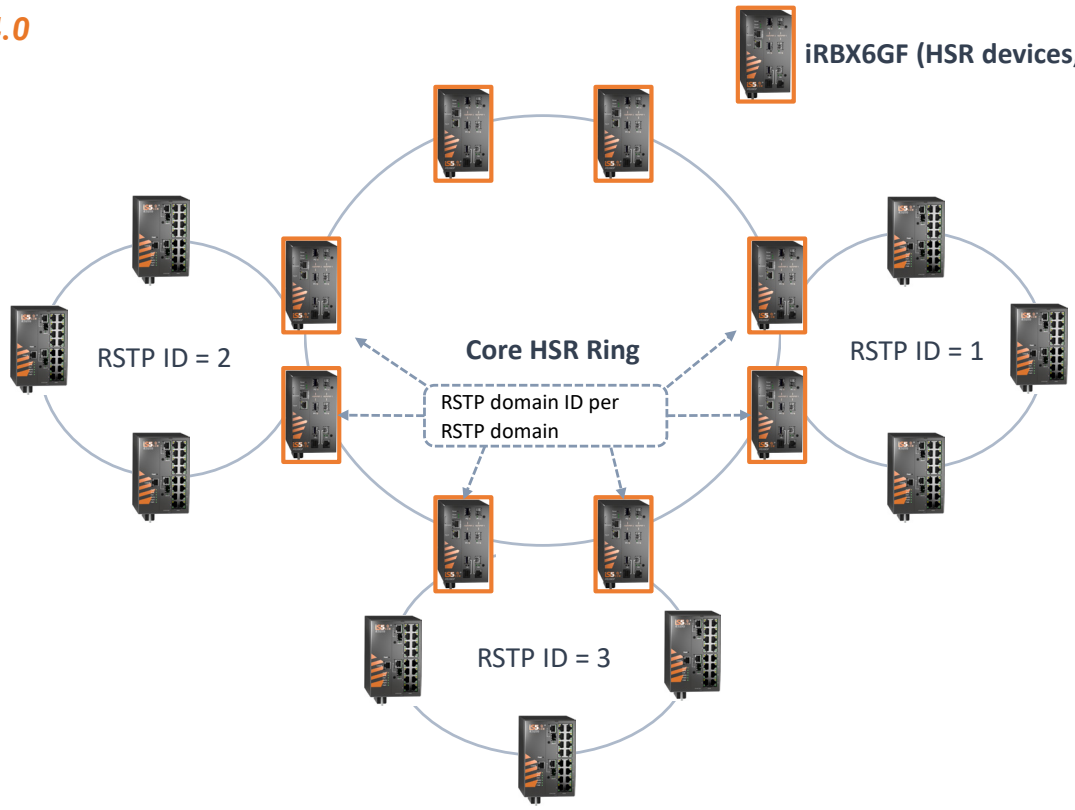
Below are the guidelines to consider when designing an RSTP network that would interoperate with the HSR protocol.

- RSTP Domain ID should be configured on the iRBX6GF (HSR Device)- It is necessary to identify the RSTP groups to the HSR network.
- If multiple RSTP groups would be connecting to an HSR ring, a different Domain ID must be configured for each of the RSTP rings, in order to distinguish the RSTP BPDUs for different groups.
- HSR Ring is represented to the RSTP state machine with a virtual RSTP port as per the diagram. The RSTP group sees this as another part of the existing RSTP domain.
- RSTP state machines can block the RSTP virtual port to prevent switch loops, yet does not impact HSR ring operation. The HSR ring is viewed as a single switch hop in the RSTP domain.
- RSTP BPDUs exiting an RSTP network side are tagged with a hidden VLAN ID to represent the RSTP Domain ID before being sent over the HSR Ring. This allows multiple RSTP groups to be used without interference on the HSR ring.
- BPDUs received on the HSR Side are passed to the virtual RSTP switch port only if matching the locally configured Domain ID. RSTP domains must be identified with the iRBX6GF in order to be accepted/used.
- All BPDUs received on the HSR side not matching the locally configured RSTP Domain ID are ignored and not passed to the virtual RSTP switch port. This prevents RSTP from interrupting HSR ring operation and disallows any RSTP BPDUs that are not configured in the iRBX6GF.

When these settings are met, and the necessary connections are configured on each iRBX6GF, the network looks like the diagram below.
Note that RSTP also counts switch hops from the source of the data to the destination of it. Even though the HSR rings have multiple nodes, the RSTP network views the HSR rings as a single RSTP switch connection while going from one side of the HSR ring to the other.

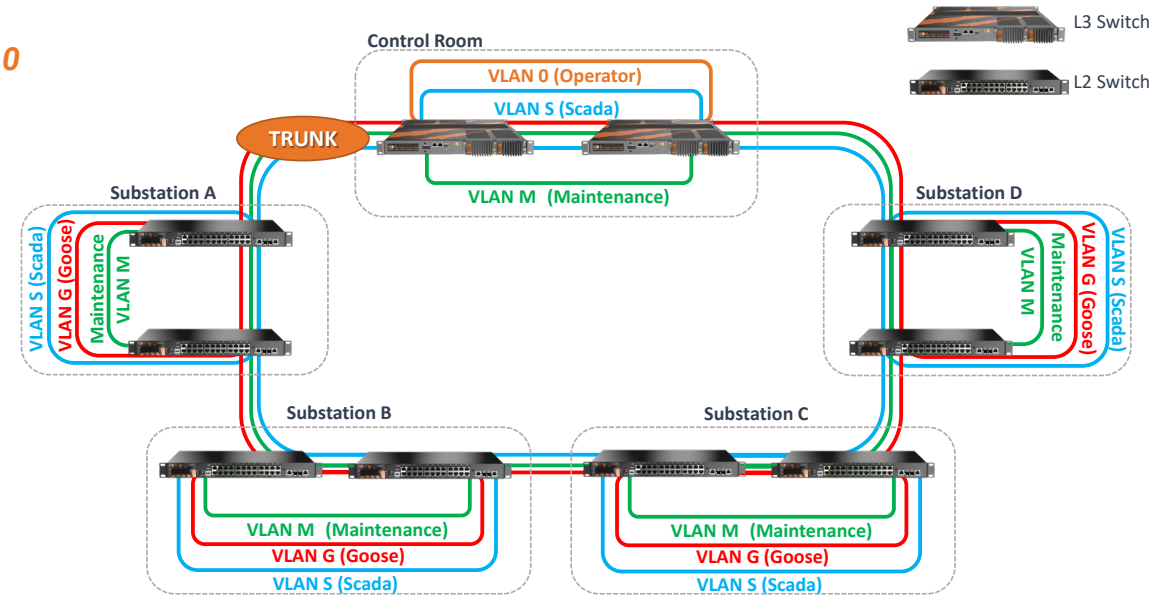
See Figure 4 on next page

Figure 4.0



As we add VLANs into the mix, the HSR ring becomes the high availability backbone for multiple RSTP networks. It allows for creating a very flexible, low cost, high availability network environment that is easy to deploy and maintain. Utilities widely use private IP addressing as they own the networks and the connectivity to the Control Centers.
Using the iS5Com technology, the user can eliminate the requirement to have a ring of IP Layer 3 routers doing the same function for connectivity with a much slower speed for network failover.
HSR based rings that connect seamlessly to multiple RSTP based networks can be created in the substations. This would create a network that reacts extremely fast to connectivity issues (ie. cut in the fiber optic cable) and minimizes data loss during these events until the damaged connections are re-established.

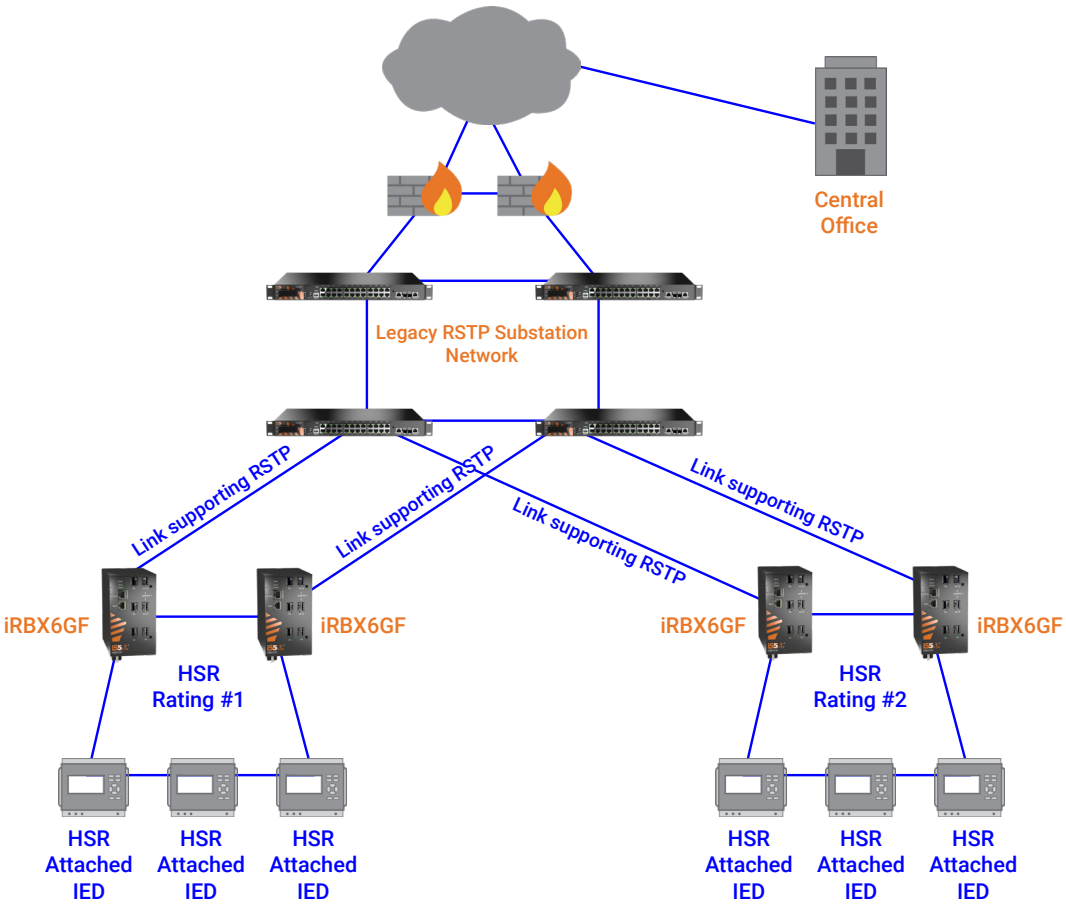
Figure 5.0



HSR/RSTP EXAMPLE (CUSTOMER USE CASE)

THE CHALLENGE

A customer was expanding an existing large substation with new HSR capable IED's supporting IEC 61850 protocols and had an existing RSTP based network supporting Ethernet-enabled IED's and legacy relays that use RS232 serial communications. The Ethernet attached relays were connected to Ethernet switches, and the legacy serial relays were attached to serial device servers that were connected to the RSTP based Ethernet network. The customer wanted to expand the control network without adding a separate IP subnet and having to purchase and install routers that also had to support HSR.



THE SOLUTION

The iRBX6GFs are used to create HSR rings in the newly installed IEC81850 based electric relay system as well as use RSTP connections to connect to the existing RSTP network using redundant links. The entire substation now uses a single set of IP address to communicate within the substation. As IEC61850 GOOSE (Generic Object Oriented Substation Event) messaging is not IP routable, this new Layer 2 network moves the high-speed GOOSE data without the use of an IP router, by running GRE tunneling to move the GOOSE data throughout the substation at wire-speed.

ABOUT iS5 COMMUNICATIONS INC.

iS5 Communications Inc. (“iS5Com”) is a global provider of integrated services and solutions, and manufacturer of intelligent Industrial Ethernet products. Our products are designed to meet the stringent demand requirements of utility sub-stations, roadside transportation, rail, and industrial applications. iS5Com’s services and products are key enablers of advanced technology implementation such as the Smart Grid, Intelligent Transportation Systems, Intelligent Oil Field, and Internet of Things. All products have the ability to transmit data efficiently without the loss of any packets under harsh environments and EMI conditions.

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