Application Note NAP169

RSTP in Nexto CPUs

List of Contents

1. Introduction

This application note addresses the RSTP protocol available in the following Nexto CPUs:

- NX3008: ports NET2 and NET3

The RSTP protocol allows the creation of fault-tolerant network topologies with these CPUs while avoiding the formation of network loops.

The following figures show some examples of possible topologies using RSTP. In these topologies, the following color conventions are used:

- The devices in orange color have RSTP configured, while devices in blue color do not have it;
- The connections in red color are managed by RSTP, because they connect devices with RSTP configured. The connections in black color are not managed by RSTP.

1.1 Example 1 of RSTP Topology

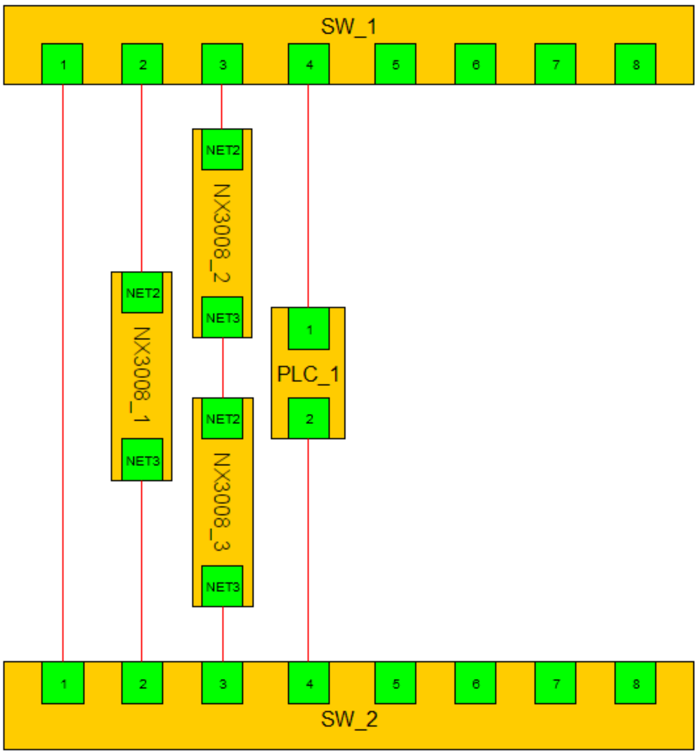

Figure 1 – Example 1 of RSTP topology

This topology contains only devices with RSTP configured. SW_1 and SW_2 are redundant central switches, where several PLCs with RSTP are connected.

This topology has very good fault tolerance against single failures:

- If a single connection fails, all the devices can still communicate;
- If a single device fails, like SW_1 or SW_2, the PLCs continue can still communicate.

In this example, it is recommended to configure SW_1 and SW_2 with the higher bridge priorities, so they become the preferred root bridges (in the section **Concepts about the RSTP Protocol** we define what are root bridges and their priorities).

1.2 Example 2 of RSTP Topology

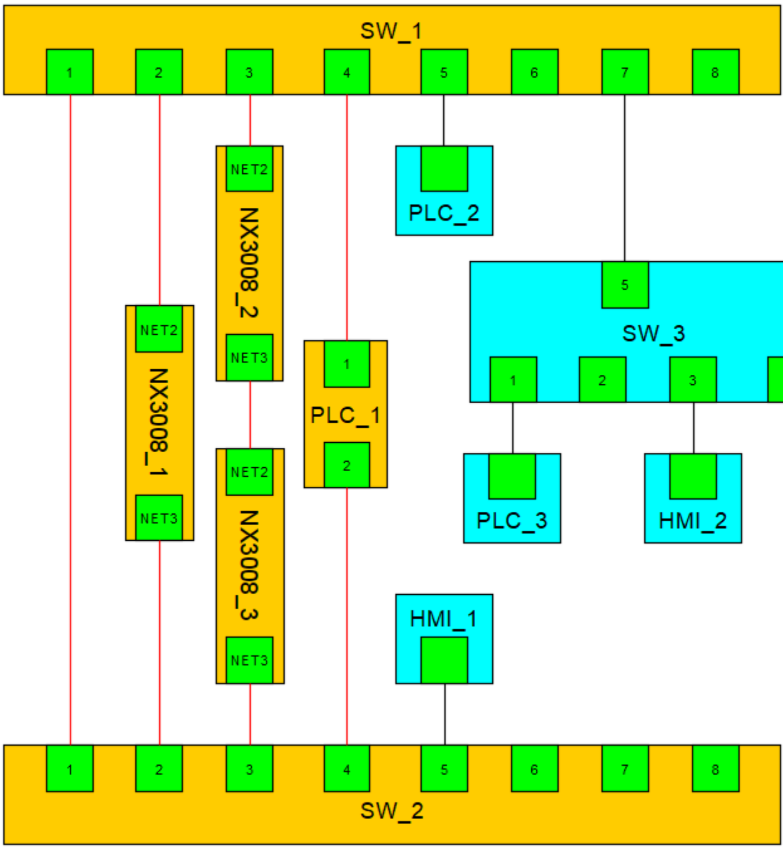

Figure 2 – Example 2 of RSTP topology

This example is an expansion of the previous example, where some non-RSTP-compliant devices must be used (in blue color).

The ports used to connect these devices to RSTP devices (SW_1.5, SW_1.7, and SW2.5) are called edge ports. In the section **Concepts about the RSTP Protocol** we define what are edge ports.

When using non-RSTP-compliant devices, take care to avoid the formation of loops in the network. The previous example is correct in this aspect.

1.3 Example 3 of RSTP Topology

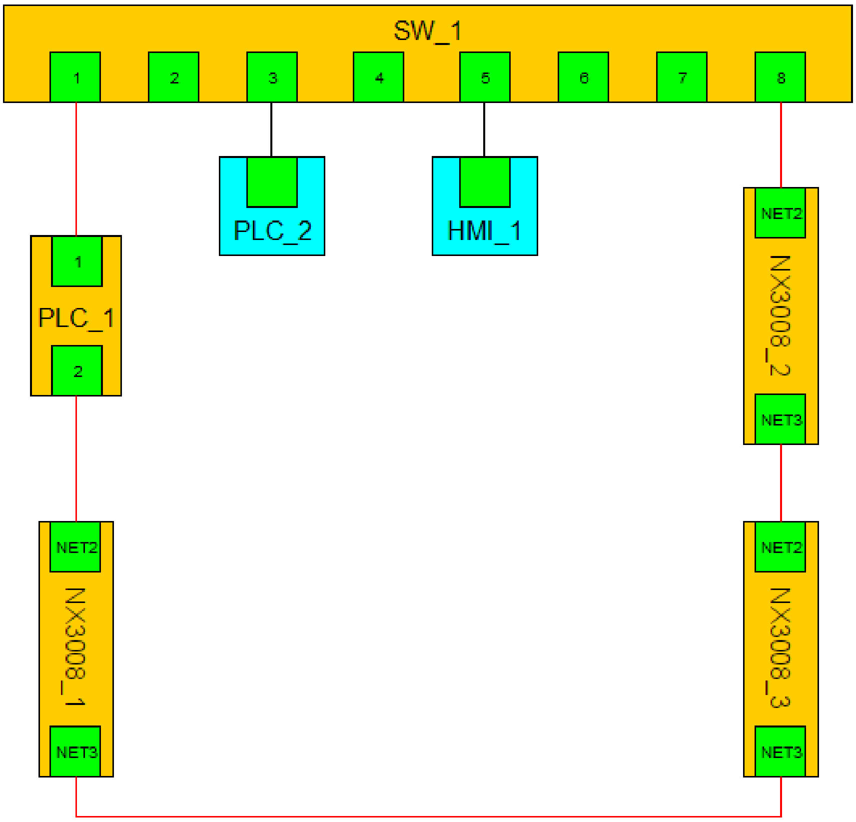

Figure 3 – Example 3 of RSTP topology

This example shows a ring topology between the RSTP-compliant devices. This topology is very common in industrial applications, and also has very good fault tolerance.

Some non-RSTP-compliant devices are connected to edge ports of SW_1.

2. Minimum Software and Firmware Revisions

The RSTP feature is available since the following software and firmware revisions:

- NX3008: 1.10.51.0
- Programmer Mastertool IEC XE (MT8500): V3.40

3. Concepts about the RSTP Protocol

Before using the RSTP protocol, it is useful to understand some concepts about it. Otherwise, the user may face some difficulties in configuring RSTP parameters and interpreting RSTP diagnostics for troubleshooting.

The Rapid Spanning Tree Protocol (RSTP, IEEE 802.1w) was a further evolution of the Spanning Tree Protocol (STP, IEEE 802.1D). It replaced the settling period with an active handshake between bridges that guarantees the rapid propagation of topology information throughout the network.

While providing much better performance than STP, IEEE 802.1w RSTP still required up to several seconds to restore network connectivity when a topology change occurred. A revised and highly optimized RSTP version was defined in the IEEE standard 802.1D-2004 edition. IEEE 802.1D-2004 RSTP reduces network recovery times to just milliseconds and optimizes RSTP operation for various scenarios.

Nexto CPUs support IEEE 802.1D-2004 RSTP.

3.1 Bridges

The RSTP-compliant devices are called bridges. Considering the topology examples in the section **Introduction**, these are all the devices with orange color.

3.2 RSTP Roles of Bridges

RSTP bridges have two possible roles to play:

- Root
- Designated

Only one bridge has the root role. It is the logical center of the network.

All other bridges in the network are designated bridges.

For deciding which is the root bridge, there is a configuration parameter called **Bridge Priority** (see section **Configuration of RSTP Parameters in Nexto CPUs**).

If the root bridge fails (power-off for instance), another bridge will assume as the new root, based on the bridge priority parameter.

3.3 RSTP States of Ports of Bridges

The RSTP state describes what is happening at the port in relation to address learning and frame forwarding.

There are three RSTP states for a port of a bridge:

- Discarding
- Learning
- Forwarding

The discarding state is entered when the port is first put into service, but can also be reached later on. The port does not learn addresses in this state and does not participate in normal frame transfer. The port only looks for RSTP traffic to determine its role in the network. When it is determined that the port will play an active part in the network, the state will change to learning.

The learning state is entered when the port is preparing to play an active part in the network. The port learns addresses in this state but does not participate in frame transfer. In a network of RSTP bridges, the time spent in this state is usually quite short.

After learning, the bridge will place the port in the forwarding state. The port both learns addresses and participates in frame transfer while in this state.

The following section gives examples of the RSTP states of ports together with the RSTP roles of ports.

3.4 RSTP Roles of Ports of Bridges

There are four RSTP roles for a port of a bridge:

- Root
- Designated
- Alternate
- Backup

Besides these four port roles defined by the RSTP standard, a fifth port role not defined by the RSTP standard exists for Nexto CPUs:

- Disabled (not standardized)

The "Disabled" port role is always combined with the "Discarding" port state and indicates that a link-down failure was detected in the port. Some other manufacturers also use this fifth port role called "Disabled" for indicating a link-down failure in the port.

The following figure helps to understand the port roles. The figure shows the steady roles and steady states of ports for the given topology. Note that the "Learning" state does not appear in the figure, because this state is not steady – it is temporary.

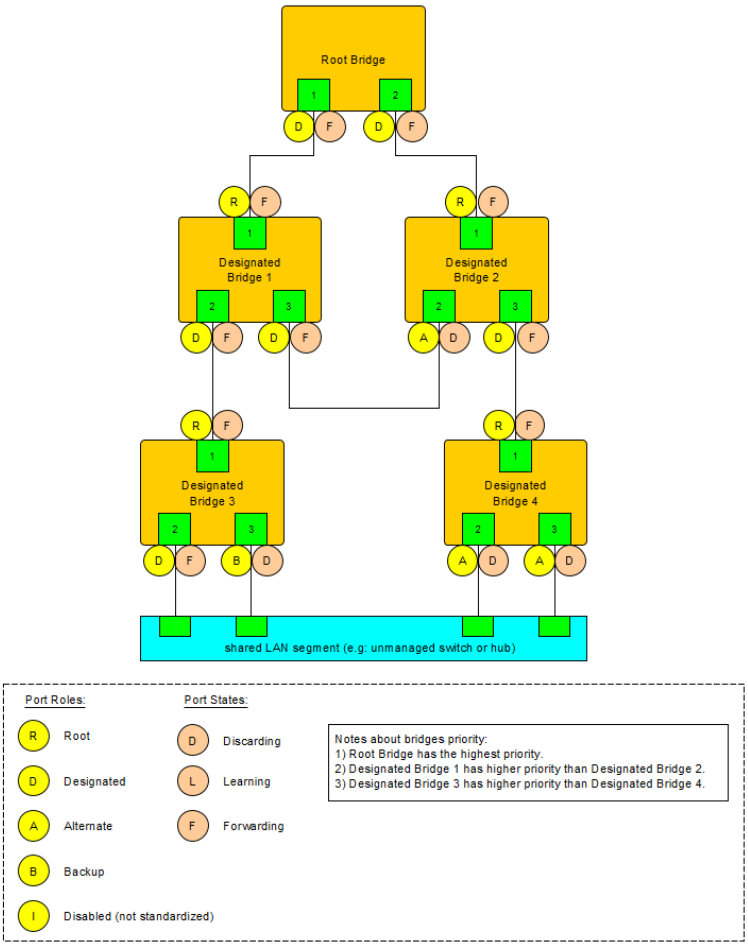

Figure 4 – RSTP roles and states of ports

If a bridge is not the root bridge, it must have a single Root Port. The Root Port is the quickest way to send traffic to the root bridge. This is the port closest to the root bridge in terms of path cost (see section **Path Cost to Root Bridge**).

A port is marked as Designated if it is the best port to serve the LAN segment it is connected to. All bridge ports on the same LAN segment listen to each others' messages and agree on which port is the Designated port. The other ports on the LAN segment must become either Root, Alternate, or Backup ports.

Nowadays, most LAN segments have only two ports connected to them (point-to-point connections, and typically full-duplex). In point-to-point LAN segments connecting different bridges, the Backup role never occurs for a port.

In the past, some shared LAN segments could have more than two ports connected to them. The previous figure shows an example of a shared LAN segment that can be implemented by using an unmanaged switch or a hub. Due to legacy reasons, the RSTP protocol must cover this unusual situation even currently. In shared LAN segments the Backup role can occur for a port.

Consider the following examples of point-to-point LAN segments in the previous figure:

- Designated Bridge 1 port 2 - Designated Bridge 3 port 1: because port 1 of Designated Bridge 3 is a root port, port 2 of Designated Bridge 1 will be a designated port.
- Designated Bridge 1 port 3 - Designated Bridge 2 port 2: because none of these ports is root, one must be designated and the other must be alternate. The designated port is selected in the bridge with higher priority (Designated Bridge 1 port 3).

A port is alternate when it receives a better message from another bridge on the LAN segment it is connected to. The message that an Alternate Port receives is better than the port itself would generate, but not good enough to convince it to become the Root Port. The port becomes the alternate to the current Root Port and will become the new Root Port should the current Root Port fail. The Alternate Port does not participate in the network (does not send data frames - only RSTP frames).

A port is a Backup Port when it receives a better message from the LAN segment it is connected to, originating from another port on the same bridge. The port is a backup for another port on the same bridge and will become active if that port fails. The Backup Port does not participate in the network (does not send data frames - only RSTP frames).

Normally, only a port connected to a shared LAN segment may assume the Backup role. In the previous figure, this situation happens in Designated Bridge 3, which have their ports 2 and 3 connected to a shared LAN segment (e.g.: an unmanaged switch or an old hub).

Considering that Designated Bridge 3 has higher priority than Designated Bridge 4, and ports 2 and 3 are not root ports:

- One of the two ports (2, 3) of Designated Bridge 3 will be designated and the other will be backup. Typically, the port with lower number (2) has higher priority and will be designated.
- Both ports (2, 3) of Designated Bridge 4 will be alternate.

Now let's see what happens after a link-down problem occurs between port 2 of Root Bridge and port 1 of Designated Bridge 2.

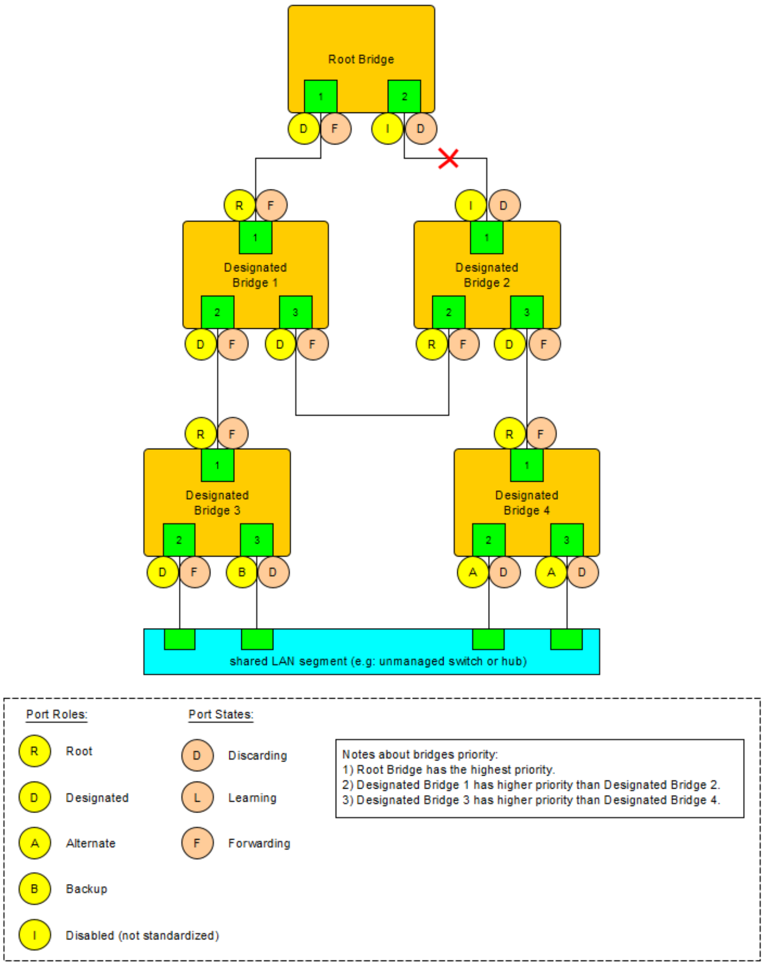

Figure 5 – RSTP roles and states after a link-down failure

In the ports affected by the link-down problem, in some bridges (e.g.: Nexto CPUs) the role may change to Disabled and the state may change to Discarding, but this is not standardized by RSTP.

In addition, port 2 of Designated Bridge 2 changes the role from Alternate to Root and changes the state from Discarding to Forwarding. Therefore, now this port starts to forward other data frames, besides RSTP messages.

3.5 Edge Ports

A port may be designated as an Edge Port if it is directly connected to an end station (like a PLC or HMI without RSTP). As such, it cannot create bridging loops in the network and can thus directly transition to forwarding, skipping the listening and learning stages.

An edge port must not receive RSTP configuration messages. If an edge port receives RSTP configuration messages it immediately loses its Edge Port status and becomes a normal spanning tree port. A loop created on an improperly connected edge port is thus quickly repaired.

In the following figure, port 5 of SW_1 and port 5 of SW_2 are examples of edge ports.

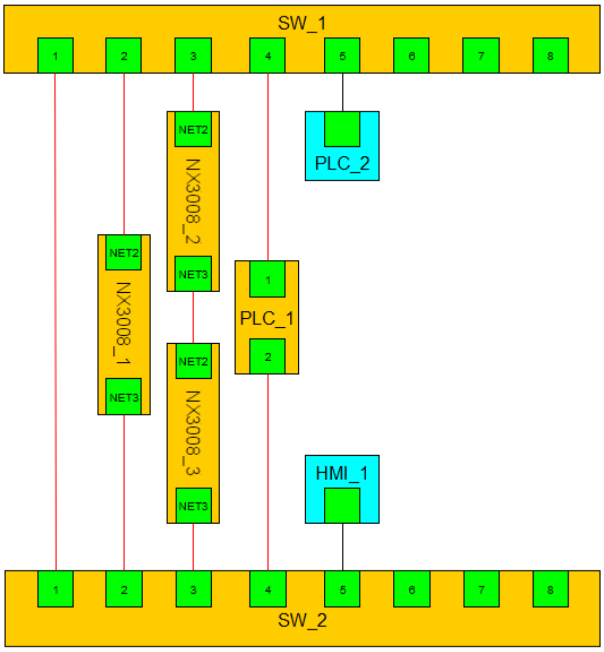

Figure 6 – Example for edge ports

Some bridges allow configuring a port explicitly as an Edge Port, while other bridges automatically detect if a port is an Edge Port. Nexto CPUs automatically detect if a port is an Edge Port.

3.6 Path Cost to Root Bridge

The path cost is the main metric by which root and designated ports are chosen. The path cost for a designated bridge is the sum of the individual port costs of the links between the root bridge and that designated bridge. The port with the lowest path cost is the best route to the root bridge and is chosen as the root port.

Most bridges calculate the individual port cost automatically, considering the link speed of this port, according to the following table (the slower the speed, the higher the cost).

Link Speed	Path Cost
10 Mbps	2,000,000
100 Mbps	200,000
1 Gbps	20,000
2 Gbps	10,000
10 Gbps	2,000

Table 1 – Path costs calculated automatically for ports

Some bridges also allow configuring manually the path cost for each port.

Nexto CPUs allow choosing between one of the following approaches:

- Automatic calculation based on port speed;
- Manual configuration. However, the same configuration is applied to all ports of the bridge.

The following figure shows which paths must be considered for calculating the path cost to Root Bridge for the Designated Bridge 3. These two paths are shown in red lines. If the link speed is 100 Mbps for these two paths, the path cost to root of Designated Bridge 3 is 400,000.

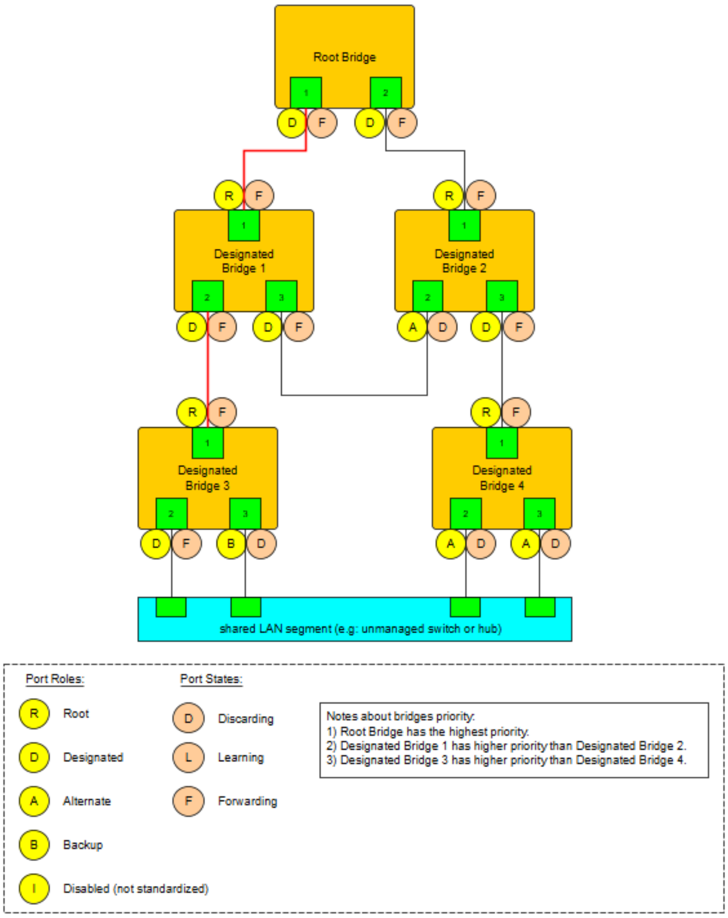

Figure 7 – Example for path cost to root

3.7 Bridge Diameter

The bridge diameter of a network with RSTP bridges is the maximum number of links (or hops) that can be traveled between any two bridges, then adding 1.

For instance, in the following ring topology with 5 bridges, the bridge diameter is 5.

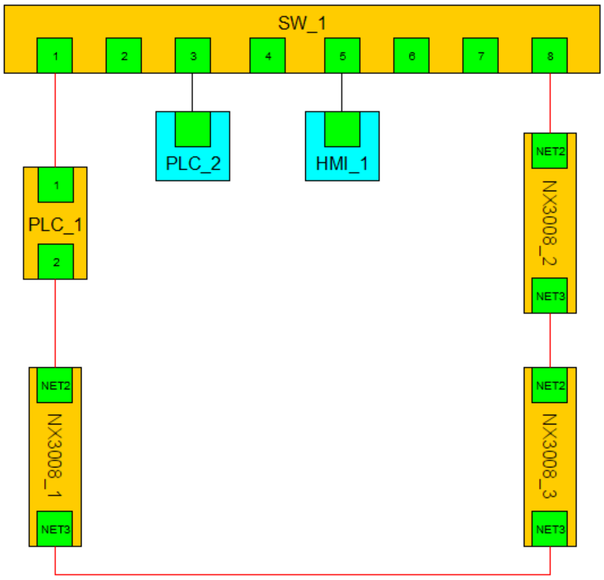

Figure 8 – Example where Bridge Diameter is 5

The bridge diameter reflects the realization that topology information requires time to propagate hop by hop through a network. If the RSTP messages take too long to propagate end-to-end through the network, the result will be an unstable network.

There is a relationship between the bridge diameter and the **Max Age** parameter (see section **Configuration of RSTP Parameters in Nexto CPUs**). The bridge diameter must not be bigger than the Max Age parameter. Because the maximum value of Max Age parameter is 40, the bridge diameter cannot be bigger than 40. This means, for instance, that a ring topology must not have more than 40 bridges.

4. Configuration of RSTP Parameters in Nexto CPUs

The configuration of RSTP Parameters in Nexto CPUs is accomplished using the Mastertool programming tool.

For instance, for configuring NET2 and NET3 as an RSTP bridge, after double-clicking over NET2 in the device tree, the following procedure must be followed:

1) Click the advanced button;
2) Select Mode as “Switch”;
3) Select the Loop Protection Mode as “RSTP”.

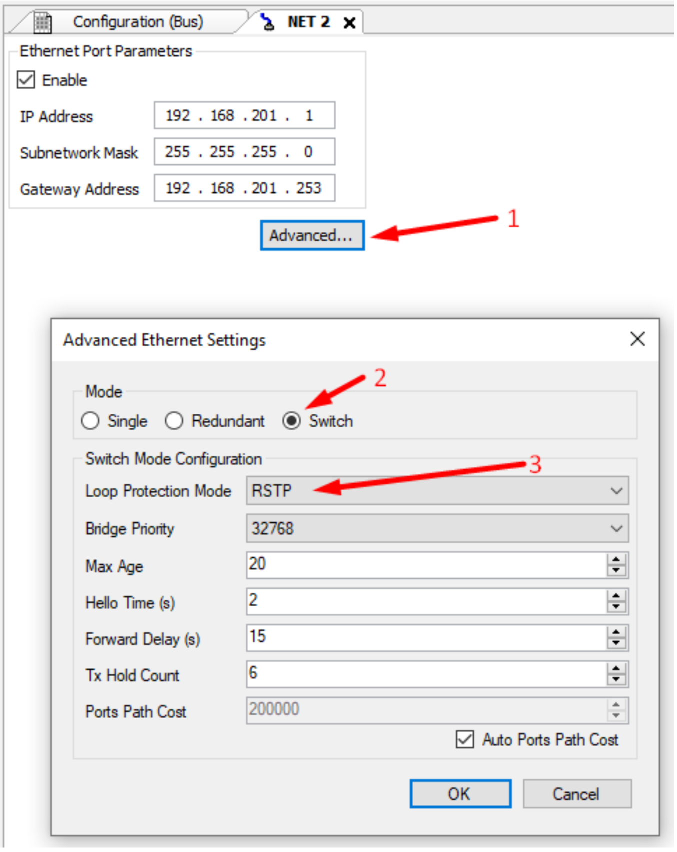

Figure 9 – Screen for configuring RSTP parameters in Nexto CPUs

The previous screen shows the RSTP parameters configurable in Nexto CPUs, and their default values.

Considering bridges from other manufacturers:

- Some of them may make additional parameters available for configuration;
- The default values for the parameters shown in the previous screen are usually the same used by Nexto CPUs.

4.1 Bridge Priority

The bridge priority is a number with the following possible values (multiples of 4096 between 0 and 61440), with a default equal to 32768.

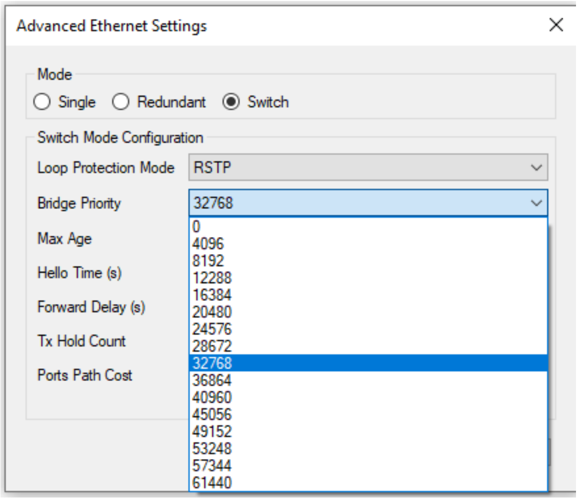

Figure 10 – Possible values of Bridge Priority

The bridge with the lowest priority number plays the root role. If two or more bridges have the same lowest priority, the one with the lowest MAC address plays the root role.

If the root bridge fails (power-off for instance), another bridge will play the root role, based on the priority parameter.

At configuration time, it is important to make a good choice about the bridges which have priority to assume the root role. Normally, these should be the bridges close to the center of the network, or the bridges with the highest reliabilities (lower failure rate). Selecting a bridge in the center of the network to be the root minimizes the number of hops between it and any other bridge. This is good for obtaining lower convergence times of the RSTP protocol and for obtaining a stable network.

For instance, in the example shown in section **Example 1 of RSTP Topology**, a good choice should be SW_1 as the primary root and SW_2 as the secondary root. This can be achieved using the following configurations:

- SW_1: bridge priority = 0
- SW_2: bridge priority = 4096
- All other bridges: bridge priority = 32768

4.2 Max Age

This parameter is an integer number that can be configured between 6 and 40, with a default value equal to 20.

Normally this parameter can be left with its default value. However, it must be equal to or bigger than the bridge diameter to avoid an unstable network (see section **Bridge Diameter**).

In addition, it is related to the configuration parameter **Forward Delay** by the following condition:

Max Age <= 2 * (Forward Delay – 1)

If this condition becomes false, the Mastertool programming tool shows an error message.

Notes:

- It is expected to configure the Max Age parameter with the same value in all bridges of the network.

- If a bridge is not the root bridge, then it will assume the Max Age parameter configured in the root bridge.

4.3 Hello Time (s)

This parameter is an integer number that can be configured between 1 and 10 seconds, with a default value equal to 2 seconds.

Normally this parameter can be left with its default value.

The lower the value, the faster should be the convergence time for some topology changes (see section **dwNumRxBPDU: this is the** number of RSTP protocol frames (BPDUs) received by this bridge since power-on or reset (BPDU = Bridge Protocol Data Unit).

Convergence Time of RSTP Protocol), but the traffic of RSTP messages and CPU consumption will increase.

Notes:

- It is expected to configure the Hello Time parameter with the same value in all bridges of the network.
- If a bridge is not the root bridge, then it will assume the Hello Time parameter configured in the root bridge.

4.4 Forward Delay (s)

This parameter is an integer number that can be configured between 4 and 30, with a default value equal to 15 seconds.

It is a delay between states Discarding and Forwarding, during which the state is Learning. However, this is only true when a neighbor bridge supports the legacy STP protocol instead of RSTP. If all devices support RSTP, the time in the Learning state will be quite short and is not related to Forward Delay.

Normally this parameter can be left with its default value.

However, it is related to the configuration parameter **Max Age** by the following condition:

Max Age <= 2 * (Forward Delay – 1)

Therefore, if you need to increase Max Age because of bridge diameter, it may be necessary to increase Forward Delay to keep the previous condition true. Otherwise, the Mastertool programming system will issue an error message.

Notes:

- It is expected to configure the Forward Delay parameter with the same value in all bridges of the network.
- If a bridge is not the root bridge, then it will assume the Forward Delay parameter configured in the root bridge.

4.5 Tx Hold Count

This parameter is an integer number that can be configured between 1 and 10, with a default value equal to 6.

The number of RSTP messages that can be transmitted by a bridge during every Hello Time period ranges from a minimum of one and a maximum of not more than Tx Hold Count value. The higher the value of Tx Hold Count, the faster is the convergence time of the RSTP protocol.

Normally this parameter can be left with its default value.

4.6 Ports Path Cost

This parameter allows configuring manually the cost of the two ports of the bridge (for instance, NET2 and NET3 for CPU NX3008). See section **Path Cost to Root Bridge**.

The cost is a number configurable between 1 and 200,000,000, with a default value equal to 200,000, which corresponds to a speed of 100 Mbps. Note that the same cost applies to both ports of the bridge (for instance, NET2 and NET3 for CPU NX3008).

This parameter has no effect and cannot be edited when the checkbox “Auto Ports Path Cost” is marked.

4.7 Auto Ports Path Cost

This parameter is a checkbox, which by default is marked.

Normally this parameter can be left with its default value.

When not marked, the parameter “Ports Path Cost” determines the cost of both ports of the bridge (for instance, NET2 and NET3 for CPU NX3008).

When marked, the cost is automatically calculated from the link speed of each port, using the table shown in the section **Path Cost to Root Bridge**. In this case, the two ports of the bridge can have different costs (for instance, NET2 and NET3 for CPU NX3008).

5. RSTP Diagnostics in Nexto CPUs

The RSTP diagnostics can be found in the GVL System_Diagnostics as shown in the following figure:

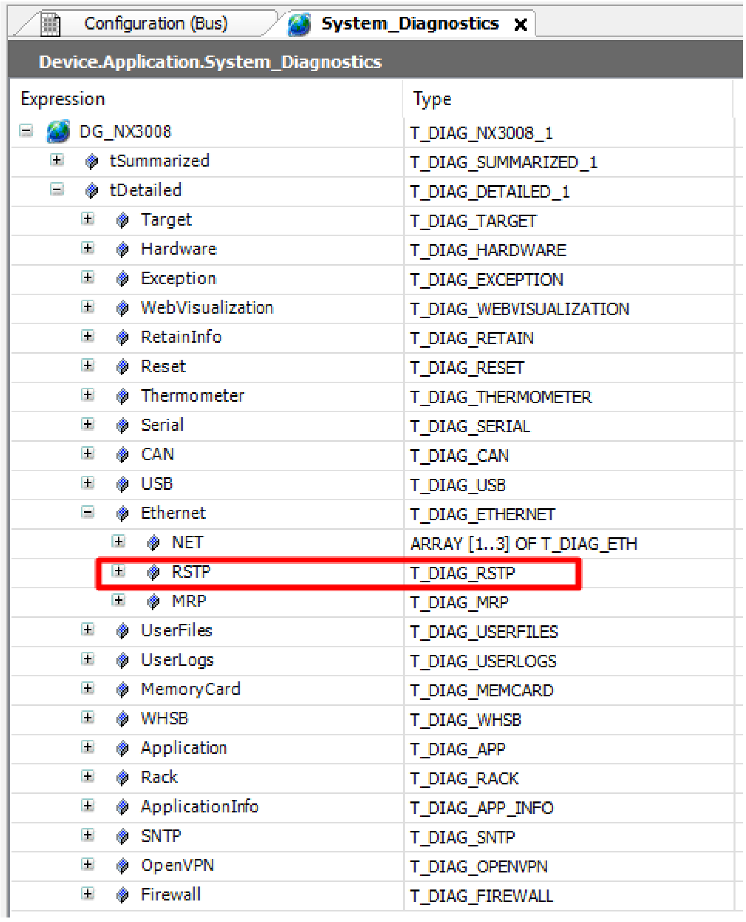

Figure 11 – Location of RSTP diagnostics

The following figure shows a detailed view of all RSTP diagnostics for the CPU NX3008.

RSTP	T_DIAG_RSTP		...
aBridge	ARRAY [0..0] OF T_DIAG_RSTP_BRIDGE		...
aBridge[0]	T_DIAG_RSTP_BRIDGE		
bProtocolEnabled	BIT	TRUE	RSTP protcol status
bBridgeIsRoot	BIT	TRUE	Shows if this bridge is the root bridge
eProtocol	ENUM_RSTP_PROTOCOL	RSTP	Shows the protocol version
sBridgeId	STRING(22)	'0000.00:01:01:37:4C:19'	Local Bridge Id <Priority.MAC>
sRootId	STRING(22)	'0000.00:01:01:37:4C:19'	Root Bridge Id <Priority.MAC>
eRootPort	ENUM_ETH_PORT_NAME	NONE	Which port is the Root Port
dwRootPathCost	DWORD	0	Path Cost to Root Bridge
byBridgeHelloTime	BYTE	2	Configured Hello Time
byRootHelloTime	BYTE	2	Learned Hello Time
byBridgeMaxAge	BYTE	20	Configured Max Age
byRootMaxAge	BYTE	20	Learned Max Age
byBridgeForwDelay	BYTE	15	Configured Forward Delay
byRootForwDelay	BYTE	15	Learned Forward Delay
dwTxHoldCount	DWORD	6	Limit of BPDU's transmitted per cycle
dwTimeSinceTC	DWORD	5	Time Since Topology Change
dwTCCount	DWORD	5	Number of times that the Topology Change occours
aPort	ARRAY [0..1] OF T_DIAG_RSTP_PORT		
aPort[0]	T_DIAG_RSTP_PORT		
eName	ENUM_ETH_PORT_NAME	NET2	Name of the port
eRole	ENUM_RSTP_PORT_ROLE	DESIGNATED	Role of the port
eState	ENUM_RSTP_PORT_STATE	FORWARDING	State of the port
wIdentity	WORD	16#8001	ID of the port
dwPathCost	DWORD	200000	Cost of the port
bOperEdge	BIT	FALSE	Show if the port is working as Edge Port
bOperP2P	BIT	TRUE	Show if the port is working as Point-to-Point Port
dwNumTxBPDU	DWORD	1305	Number of BPDU's frames transmitted
dwNumRxBPDU	DWORD	17	Number of BPDU's frames received
aPort[1]	T_DIAG_RSTP_PORT		
eName	ENUM_ETH_PORT_NAME	NET3	Name of the port
eRole	ENUM_RSTP_PORT_ROLE	DISABLED	Role of the port
eState	ENUM_RSTP_PORT_STATE	DISCARDING	State of the port
wIdentity	WORD	16#8002	ID of the port
dwPathCost	DWORD	200000	Cost of the port
bOperEdge	BIT	FALSE	Show if the port is working as Edge Port
bOperP2P	BIT	TRUE	Show if the port is working as Point-to-Point Port
dwNumTxBPDU	DWORD	9	Number of BPDU's frames transmitted
dwNumRxBPDU	DWORD	2	Number of BPDU's frames received

Figure 12 –RSTP diagnostics for CPU NX3008

The RSTP diagnostics as a whole have the type T_DIAG_RSTP, which is formed by an array of several bridge diagnostics (aBridge, with type T_DIAG_RSTP_BRIDGE).

The CPU NX3008 has a single bridge with two ports (NET2 and NET3).

No matter which CPU model, the bridge diagnostics are the same (type T_DIAG_RSTP_BRIDGE). These diagnostics will be described in the following paragraphs.

- **bProtocolEnabled**: this bit is TRUE if the RSTP protocol is enabled for the bridge.
- **bBridgeIsRoot**: this bit is TRUE if this bridge plays the root role.
- **eProtocol**: this enumeration informs the protocol used, and can have the following values:
  - RSTP: the RSTP protocol is enabled for this bridge;
  - NONE: the RSTP protocol is disabled for this bridge.
- **sBridgeId**: this string identifies this bridge. It has the format 'PPPP.MM:MM:MM:MM:MM:MM', where 'PPPP' is the priority configured for this bridge in

hexadecimal, and ‘MM:MM:MM:MM:MM:MM’ is the MAC address of this bridge in hexadecimal. The big number as a whole indicates the priority of the bridge. The lower the number, the bigger the priority used to define which bridge will play the role of the root bridge.

- **sRootId**: this string identifies the bridge currently playing the role of the root bridge. It has the same format ‘PPPP.MM:MM:MM:MM:MM:MM’ previously described for the diagnostic sBridgeId.
- **eRootPort**: this enumeration indicates which is the root port of this bridge. It can have the following values:
  - NET2
  - NET3
  - NONE: there is no root port in this bridge because it is playing the role of the root bridge, or the RSTP protocol is not configured for this bridge.
- **dwRootPathCost**: this double-word indicates the path cost to the root bridge (see section **Path Cost to Root Bridge**).
- **byBridgeHelloTime:** this byte informs the value of the parameter “Hello Time” configured in this bridge.
- **byRootHelloTime:** this byte informs the value of the parameter “Hello Time” configured in the root bridge. It overrides the parameter “Hello Time” configured in this bridge.
- **byBridgeMaxAge:** this byte informs the value of the parameter “Max Age” configured in this bridge.
- **byRootMaxAge:** this byte informs the value of the parameter “Max Age” configured in the root bridge. It overrides the parameter “Max Age” configured in this bridge.
- **byBridgeForwDelay:** this byte informs the value of the parameter “Forward Delay” configured in this bridge.
- **byRootForwDelay:** this byte informs the value of the parameter “Forward Delay” configured in the root bridge. It overrides the parameter “Forward Delay” configured in this bridge.
- **dwTxHoldCount**: this double-word informs the value of the parameter “Tx Hold Count” configured in this bridge.
- **dwTimeSinceTC**: this double-word informs the time (seconds) since the last topology change.
- **dwTCCount**: this double-word informs the number of topology changes since power-on or reset.

After the previous diagnostics related to the bridge as a whole, there is an array of diagnostics for the two ports of the bridge (aPort with type T_DIAG_RSTP_PORT). The diagnostics for each port are described in the following paragraphs:

- **eName**: name of the port that can be:
  - NET2
  - NET3
- **eRole**: role of the port, as defined in section **RSTP Roles of Ports of Bridges**:
  - ROOT
  - DESIGNATED

    - ALTERNATE
    - BACKUP
    - DISABLED
- **eState**: state of the port, as defined in section **RSTP States of Ports of Bridges**:
    - DISCARDING
    - LEARNING
    - FORWARDING
- **wIdentity**: this is the ID of the port inside the bridge. The first port of the bridge has ID = 16#8001, the second has ID = 16#8002, and so on. The smaller the number, the bigger the port priority. For instance, port priorities are used to define which port is designated and which is backup when both are connected to a shared LAN segment. Ports priorities in Nexto CPUs are fixed:
    - NET2 = 16#8001
    - NET3 = 16#8002
- **dwPathCost**: indicates the cost calculated for this port. See the description of parameters "Ports Path Cost" and "Auto Ports Path Cost".
- **bOperEdge**: this bit indicates if the port is operating as an edge port (see section **Edge Ports**).
- **bOperP2P**: this bit indicates if the port is connected to a point-to-point LAN segment. LAN segments can be point-to-point or shared (see discussion about types of LAN segments in section **RSTP Roles of Ports of Bridges**).
- **dwNumTxBPDU**: this is the number of RSTP protocol frames (BPDUs) transmitted by this bridge since power-on or reset (BPDU = Bridge Protocol Data Unit).
- **dwNumRxBPDU**: this is the number of RSTP protocol frames (BPDUs) received by this bridge since power-on or reset (BPDU = Bridge Protocol Data Unit).

6. Convergence Time of RSTP Protocol

The convergence time of the RSTP protocol is the time needed for accomplishing a topology change after a failure appears or a failure is fixed. Examples of failures are:

- Link down in connections;
- Bridge failure, like power-down.

Most types of failures, like link downs, have convergence times below 1 second.

However, in some special conditions, the worst case can reach the value:

3 * "Hello Time"

It is important to notice that a communication failure can take some additional time to disappear after the topology change is completed. This may have several causes, like the following:

- Internal delays of communication partners, for instance, for opening a new connection or waiting for timeouts.

- Time spent by switches for refreshing their MAC address tables.

7. Recommendations for RSTP Networks

The following recommendations may help to configure the RSTP protocol efficiently.

7.1 Parameters with the Same Value and Default Values

Use the same value in all bridges for the following parameters:

- Max Age
- Hello Time
- Forward Delay

In addition, if possible, try to keep the default values for these parameters.

7.2 Parameter Bridge Priority

Bridges closer to the center of the network should have priority to get the root role, for minimizing the number of hops to the other bridges.

It is also recommended to select root bridges with higher reliability (i.e. lower failure rate).

A good solution should be using at least three values of Bridge Priority:

- The lowest number (e.g.: 0) for that bridge with priority for playing the root role.
- The second lowest number (e.g.: 4096) for that bridge with second priority for playing the root role.
- The default value (32768) for all other bridges.

7.3 Avoid Shared LAN Segments

Although the RSTP protocol can manage shared LAN segments, this may increase convergence time. Instead, use only point-to-point LAN segments.

These types of segments were explained in the section **RSTP Roles of Ports of Bridges**.

7.4 Avoid Using Legacy STP Bridges

Although the RSTP protocol can manage legacy STP bridges in the same network, this may increase convergence time. Try to use only RSTP bridges.

7.5 Take Care with non-RSTP and non-STP Devices

Avoid connecting devices like unmanaged switches between RSTP bridges.

However, it is possible to connect an unmanaged switch at an Edge port of an RSTP bridge, as shown in the example of section **Example 2 of RSTP Topology**.