Ethernet Ring Redundancy

Broadcast Storms in Ethernet Networks

Network loops can cause network storms if ring management is not employed. When an unmanaged switch receives a broadcast or multicast packet, it repeats these packets out every port except the one it was received on. In a looped or ring environment, the broadcasts and multicasts are continuously repeated creating a broadcast storm. The network throughput will quickly diminish until 100% of the bandwidth is used to circulate these packets.

Mission critical network applications frequently require redundant paths of communication (redundant media) in the event that one path is lost. If media redundancy is employed, only one path can be active at a time. One solution is to have a redundant cable left unplugged in case the primary cable is damaged, but that would take manual intervention to repair.
IEEE Spanning Tree and Rapid Spanning Tree Protocol (STP, RSTP)

The IEEE Spanning Tree Protocol (STP) was designed to discover network loops and break them before they can cause a broadcast storm. Spanning Tree (STP) will also automatically activate the redundant link if the primary link fails.

![Managed switches running Rapid Spanning Tree (RSTP) Protocol 1 to 2 second heal time](image)

Figure 2, Spanning Tree Protocol blocking one path

Figure 2, shows a network with spanning tree automatically blocking one of the redundant or ring path connections. Spanning Tree will set a port on one of the switches to a blocking state so that it will not forward or receive standard Ethernet frames. The exception is the Spanning Tree BPDU (bridge protocol data units) packet which is generated to determine the shortest path through the network and as a heartbeat to determine if the ring connections are intact. The time required to detect a break in the primary path and to unblock the blocked port to establish a path around the break is the ring “Heal Time”. The “Heal Time” of a failed network connection using the STP protocol is 30-120 seconds. In larger networks it can take as long as 5 minutes for spanning tree to recover.
Spanning Tree Protocol was standardized by IEEE in 1990 as 802.3d. In 1998 The IEEE standardized Rapid Spanning Tree Protocol (RSTP) 802.3w with a faster heal time of 2-3 seconds. STP & RSTP are open standards that many switch manufacturers, including N-Tron, implement in their managed switch products. The faster heal time of RSTP is very helpful in the enterprise network where a few seconds network delay is not a problem. However in an industrial controls network, one second of missed communications can cause serious problems. Factory automation applications typically involve machinery requiring much faster fail over times. This is required for safe operation of the processes being controlled and to prevent expensive plant down time. Programmable control products and process controllers both require high speed fail over networks in order to maintain control of the I/O, Drives, and other field devices being controlled by them.

**N-Tron N-Ring™ Protocol**

N-Ring is a high speed proprietary protocol developed by N-Tron to provide consistent healing times of ~30 milliseconds, many times faster than RSTP’s one to two second heal time. N-Ring will prevent disruptions in even the fastest control networks.

<table>
<thead>
<tr>
<th></th>
<th>N-Ring</th>
<th>RSTP</th>
<th>STP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heal Time</td>
<td>~30 ms</td>
<td>~1-3sec</td>
<td>&gt;30 sec</td>
</tr>
<tr>
<td>Fault Reporting</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Proprietary</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Sufficient for Automated Control</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

*Figure 3, Ring Management Comparison*

N-Ring requires an N-Tron managed switch (700,7000, and 9000 Series Switches) to be configured as a Ring Manager and can support up to 250 managed or 50 unmanaged N-Tron switches as ring members. The N-Tron 700, 7000, and 9000 Series managed switches can be configured as N-Ring Managers. The Ring Manager sends out Health Check Packets around the ring at a fast rate. When these packets make it back to the Ring Manager in the specified amount of time, the ring is intact and therefore healthy. However, if the ring is broken and the Ring Manager stops receiving the health check packets, the ring manager will remove the block and reroute the network traffic within ~30 Ms.
Figure 4, N-Tron N-Ring high speed ring management

Managed switches running N-Tron N-Ring Protocol ~30 Ms heal time
N-Ring Monitoring
When using all N-TRON fully managed switches (700, 7000 and 9000 Series Switches) in the N-Ring, a detailed Ring Map and Fault Location Chart will also be provided via the Ring Manager’s web interface. This provides an additional diagnostic tool to identify the status of the ring.

### N-Ring Status View
Switch is an N-Ring Manager.

<table>
<thead>
<tr>
<th>Switch No</th>
<th>MAC Address</th>
<th>IP Address</th>
<th>Subnet Mask</th>
<th>Name</th>
<th>Ports</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM</td>
<td>00:07:af:ff:f6:e0</td>
<td>192.168.1.136</td>
<td>255.255.255.0</td>
<td>N-TRON Switch</td>
<td>A2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A1</td>
</tr>
<tr>
<td>1</td>
<td>00:07:af:ff:f6:40</td>
<td>192.168.1.131</td>
<td>255.255.255.0</td>
<td>N-TRON Switch</td>
<td>A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A2</td>
</tr>
<tr>
<td>2</td>
<td>00:07:af:ff:f6:60</td>
<td>192.168.1.132</td>
<td>255.255.255.0</td>
<td>N-TRON Switch</td>
<td>A2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A1</td>
</tr>
<tr>
<td>3</td>
<td>00:07:af:ff:f6:80</td>
<td>192.168.1.133</td>
<td>255.255.255.0</td>
<td>N-TRON Switch</td>
<td>A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A2</td>
</tr>
<tr>
<td>4</td>
<td>00:07:af:ff:f6:a0</td>
<td>192.168.1.134</td>
<td>255.255.255.0</td>
<td>N-TRON Switch</td>
<td>A2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A1</td>
</tr>
<tr>
<td>5</td>
<td>00:07:af:ff:f6:c0</td>
<td>192.168.1.135</td>
<td>255.255.255.0</td>
<td>N-TRON Switch</td>
<td>A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A2</td>
</tr>
</tbody>
</table>

**Figure 5, N-Ring Manager Status (No Fault)**
### N-Ring Fault!!

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<th>Subnet Mask</th>
<th>Name</th>
<th>Ports</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM</td>
<td>00:07:af:ff:6e:80</td>
<td>192.168.1.136</td>
<td>255.255.255.0</td>
<td>N-TRON Switch</td>
<td>A2, A1</td>
</tr>
<tr>
<td>1</td>
<td>00:07:af:ff:6e:40</td>
<td>192.168.1.131</td>
<td>255.255.255.0</td>
<td>N-TRON Switch</td>
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</table>

**Figure 5, N-Ring Manager Status (Fault)**

Figure 5 shows an N-Ring fault status view indicating that a fault has been detected in the N-Ring network. This fault map shows a communication error has occurred between Switch 1, Port A2 and Switch 2, Port A2. In this case the Ring Manager declared a fault and re-mapped the ring within ~30ms, allowing communication to continue until the cable segments can be evaluated and repaired in the field.

### N-Ring Rules

- Only N-Tron switches are allowed on the N-Ring.
- Ring Manager runs N-Ring only. RSTP & Trunking, are disabled.
- Only one N-Ring Manager (700, 7000 and 9000 Series only) is allowed per N-Ring.
- N-Ring Auto-Members can run RSTP on non N-Ring ports.
- N-Ring switches can only participate in one N-Ring.
- N-Rings can be linked using N-Link (see N-Link Rules).
- *All* N-Ring ring nodes must be on the same VLAN when operating in tagged mode.
- Only *fully managed* N-Tron switches (700, 7000 and 9000 Series Switches) will appear in Ring Manager’s Fault Map.
N-Ring using process control switches (500-A Series) and unmanaged switches (900-N, 500-N and 300-N Series) as N-Ring Members

N-Ring health packets are multicast and can present problems when unmanaged switches are used in the ring. Unmanaged switches will treat these health packets as a broadcast and send them out all ports. Low bandwidth devices, such as wireless access points and older half duplex equipment, will be adversely affected by this unnecessary traffic. Managed N-Tron switches allow them to pass through the N-Ring ports but do not broadcast them out the other ports on the switch. The solution to this problem is to connect low bandwidth devices to the ring via a managed switch or use the 500-A (-A indicates Advanced Functionality) switch with port filtering enabled on both N-Ring ports to block the multicasts from being transmitted out the other ports on the switch. The N-Ring manager must be a 700, 7000 or 9000 Series managed switch with N-Ring enabled (see Figure 6).
Rapid Spanning Tree (RSTP) MESH Configurations
IEEE Rapid Spanning Tree can be used to configure very complicated MESH Networks as shown in Figure 7.

Figure 7, RSTP MESH Configuration
Multi Ring, N-Ring RSTP Mix Topology

Mesh networks can only be configured using RSTP. N-Tron N-Ring Protocol can be used with RSTP to form a multiple ring topology as in Figure 8.

Figure 8, N-Ring with Multi RSTP Ring Configuration
Redundant and Multiple N-Ring Topologies

N-Tron N-Ring can be configured into redundant multiple ring topologies using the N-Tron N-Link technology as demonstrated figure 9 and 10.

Figure 9, Redundant N-Rings using N-Link
Figure 10, Multiple N-Rings using N-Link

N-Link Rules

1) N-Link Master
   a) N-Link must be turned on and ports configured if default ports are not used.
   b) N-Ring Manager is automatically disabled (the N-Ring Manager and N-Link Master must be separate switches)
   c) RSTP is automatically disabled
2) N-Link Slave
   a) Standby N-Link coupler Port must be configured if defaults are not used
   b) N-Ring Manager is automatically disabled
   c) RSTP is automatically disabled
3) N-Link Primary Coupler
   a) No Configuration Required
   b) Can’t be an N-Ring Manager
4) N-Link Standby Coupler
   a) No Configuration Required
   b) Can’t be an N-Ring Manager
5) Control Link
a) N-Link Master, Control Link Port – Configuration (default port 3)
   b) N-Link Slave, Control Link Port – Detected Automatically

6) Partner Link
   a) N-Link Master, Partner Link Port – Detected Automatically
   b) N-Link Slave, Partner Link Port – Detected Automatically

7) Primary Coupler Link
   a) N-Link Master, Primary Coupler Port – Configuration (default port 4)
   b) N-Link Primary Coupler, Primary Link Port – Detected Automatically

8) Standby Coupler Link
   a) N-Link Slave, Standby Coupler Port – Configuration (default port 4)
   b) N-Link Standby Coupler, Standby Coupler Port – Detected Automatically

9) All N-Link Switches must be 708, 7016 and 7018 (7014 and 9000 may not be used to perform the N-Link function.)