



ODVA
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Use of RSTP to Cost Effectively Address Ring Recovery Applications In Industrial Networks

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Technical Track

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Ethernet Extending Into Fieldbus

Today: Information and control communications

- ▶ Control products can now be connected over the plant network
- ▶ Remote visibility of control and diagnostic information through web services

What's changing: Fieldbus penetration

- ▶ 27+% CAGR¹ in Ethernet devices
- ▶ Growing faster than legacy fieldbus network devices

Tomorrow: Complete solutions

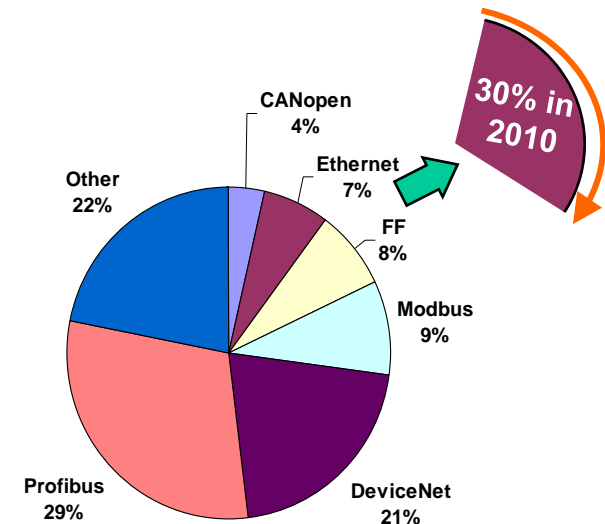
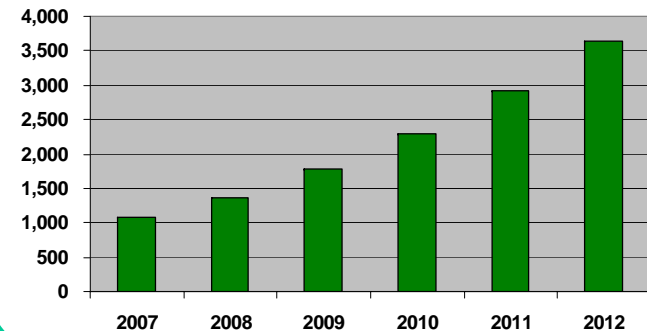
- ▶ Ethernet solves the most demanding applications such as process or motion control.

¹ ARC 2007 Study

² ARC 2008 Study

³ 2006 SE Study

Shipments of Ethernet Based Devices
(Thousands of nodes²)



Ethernet Fieldbus Growth ³

Industrial Applications Require High Availability Networks

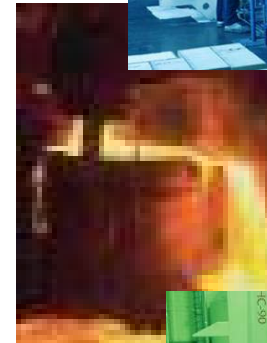
Examples of Key Segments Include

- ▶ Manufacturing
- ▶ Oil & Gas
- ▶ Power
- ▶ Food and Beverage
- ▶ Many others....



Network Recovery Times Vary Based on Application

- ▶ Some process control applications may require recovery times less than 20 ms.
- ▶ Other applications (mining, water/waste water) may allow recovery times of 500 ms.



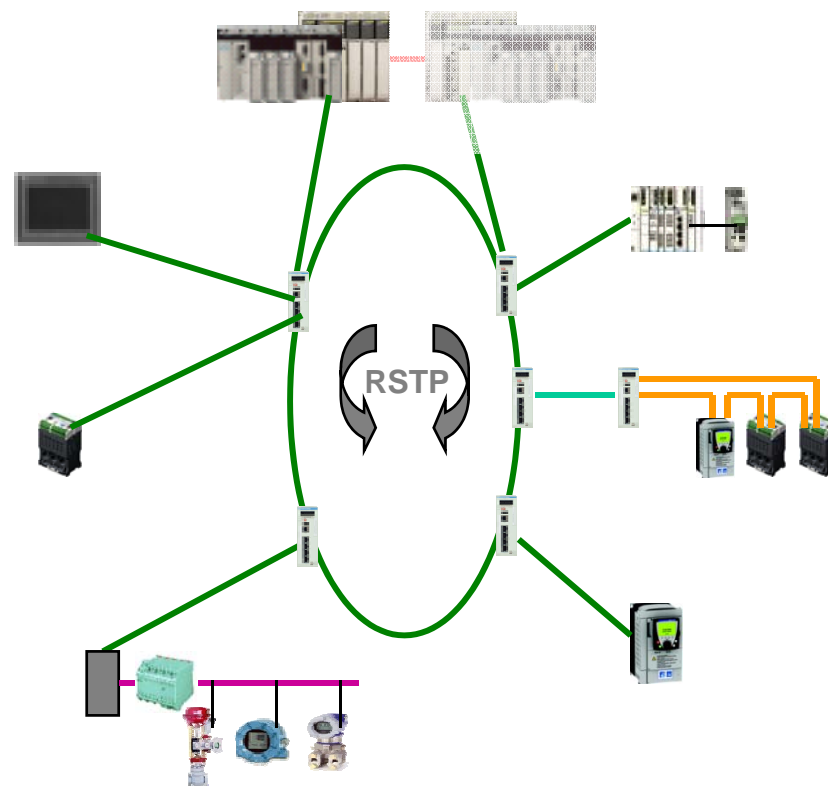
Ring Network Most Popular Redundant Configuration

Designed to withstand at least one failure

Variety of protocols designed to address ring recovery

- RSTP
- DLR
- MRP
- Proprietary Implementations

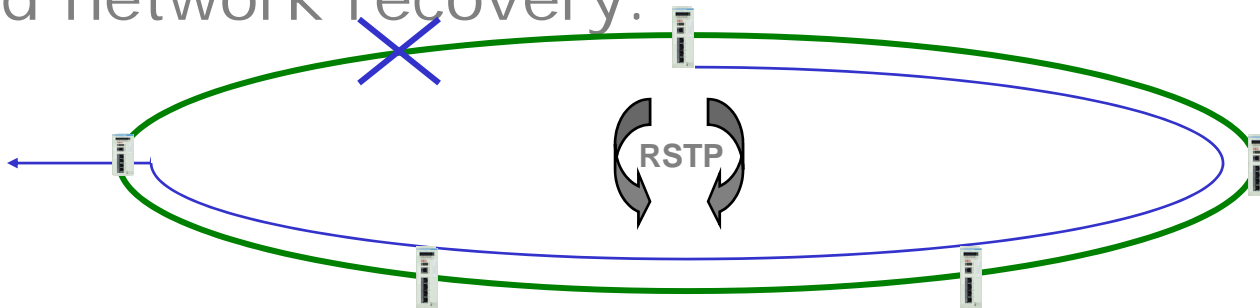
Each protocol offers advantages and disadvantages based on application



Ring Recovery Protocols

Rapid Spanning Tree Protocol (RSTP)

- Defined by IEEE 802.1D-2004
- Evolution of the Spanning Tree Protocol
- An exception based protocol – Uses minimal bandwidth and switch CPU cycles during normal operation. Loads go up during failure detection and network recovery.



Ring Failure Modes

Ring failures can be caused by:

- Equipment failures – Failure of switch component, failure of cable/connector
- Environmental failures – Cable cut, noise, corrosion

RSTP failures classified into three types

- Common failures – Physical network failure, like a cable cut.
- Root failure – Failure of the RSTP root, new root must be selected.
- Uncommon failure – As name implies, very infrequent. Includes:
 - Scenario where switch processor fails but packets are still passed.
 - Scenario where RSTP packets are lost.

Common Failure Recovery Time

Common Recovery Time Less Than:

$$T_L + (N * T_{PA})$$

Where:

- ▶ N - The number of switches in the ring
- ▶ T_L - The fault detection time. Many industrial vendors report detection times in the 5 ms range
- ▶ T_{PA} - The time it takes to perform RSTP proposal agreement handshaking. Many industrial vendors report times in the 5 ms range
- ▶ Note: T_{PA} is based on the ability of the switch to quickly process a incoming message and send the corresponding message to the next node. A high speed switch using an interrupt for this task can see times of 2 ms.



Root and Uncommon Recovery Times

Root Failure Recovery Time

- 2 x Common Recovery Time

Uncommon Failure Recovery Time

- Note that uncommon failures (as the name implies) occur infrequently
- Configuration can be performed to minimize the impact on ring recovery time
 - Set watchdog timer to 100 ms to respond to scenario where switch processor fails but switch continues to process packets. Recovery time equals common failure time + 100 ms.

Ring Recovery Time Summary

Failure Type	Recovery Time	Assumptions
Common	55 ms	
Root	110 ms	
Uncommon	150 ms	Watchdog timer set to 100 ms

Note: Assumes ring with 10 nodes and 5 ms T_L and T_{PA}

RSTP Configuration Rules

Ring size must be less than or equal to 40 nodes.

RSTP logistics packets should be configured with the highest priority class of service. If not possible, then 10% of highest priority class of service bandwidth should be reserved for RSTP logistics packets.

All links should be configured to be full duplex connections.

Enable RSTP on ring ports. Disable RSTP on all switch ports that are not used as part of the ring.

Conclusions

Equipment vendors are optimizing RSTP performance, achieving T_{PA} values of 2 ms.

- ▶ Results in recovery time of 25 ms for ring with 10 switches experiencing a common failure
- ▶ RSTP can be run on common off the shelf equipment

Industrial grade equipment is designed to minimize the likelihood of equipment failure. The great majority of ring failures are common failures.

RSTP is designed to minimize network bandwidth consumption and processor load when the network is operational.

Protocols that insure faster recovery times for all failure instances consume greater network bandwidth and hardware processing resources. Many require specialized hardware.

Applications that do not require aggressive recovery times should not have to pay the penalty to hardware cost and bandwidth utilization.