MOXA White Paper **Redundant Gigabit Backbone Adds Speed and Reliability to Industrial Networks**

by Harry Hsiao, Moxa Networking Product Manager
harry.hsiao@moxa.com

Introduction

Gigabit network applications are becoming more and more popular in the modern networking world. In fact, most PC motherboards now come standard with a built-in gigabit Ethernet port. In addition, the rapid growth in demand for high-bandwidth data, such as on-line video, is driving many network administrators to convert their existing network backbones to gigabit speeds and higher.

Industrial networks are also moving towards gigabit networks. To benefit the most from automatic, centralized monitoring and control, it is necessary to transmit larger amounts of data that include voice and video. The problem faced by industrial network administrators is how to build a redundant network backbone that is sufficiently reliable in harsh industrial environments. Before discussing possible solutions, let's first take a closer look at why redundancy and reliability are so important in industrial networks.

The importance of redundancy for industrial networks

Redundancy is one of the most important aspects of industrial networks since it helps ensures uninterruptible network communication for industrial settings. Redundancy is established by creating backup systems that duplicate the functions of key systems that are necessary for continued operation. In the following section, we briefly describe several different types of

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About MOXA

The MOXA Group manufactures one of the world's leading brands of device networking solutions. Products include serial boards, device servers, *ready-to-run* embedded computers, USB-to-serial Hubs, media converters, terminal servers, Modbus gateways, industrial switches, remote I/O servers, and Ethernet-to-fiber converters. Our products are key components of many networking applications, including industrial automation, manufacturing, POS, and medical treatment facilities.

How to Contact MOXA

Tel: 1-714-528-6777
Fax: 1-714-528-6778
Web: www.moxa.com
Email: info@moxa.com

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redundancy to help you understand which elements require backup systems.

Power redundancy

Since harsh industrial environments can cause power lines to go bad or be severed, backup power supplies are used for power redundancy. Industrial products should have at least two power inputs to accept power from a primary and a backup source, guaranteeing uninterrupted operation.

Media redundancy

A basic requirement for industrial networks is media redundancy, which involves forming backup paths for network access. Two protocols are standard for Ethernet ring topologies with backup paths: STP (IEEE 802.1D Spanning Tree Protocol) and RTSP (IEEE 802.1W Rapid Spanning Tree Protocol). The process is simple in theory. With the network in a ring topology, network communication will automatically recover from a break in the main path by using a backup path.

However, the time it takes for the network to recover with a backup path is critical for STP and RTSP. Even a few seconds of network downtime is unacceptable for industrial applications where system failure can cause enormous losses. For this reason, most industrial Ethernet switches that support network redundancy strive to provide near-instant recovery times. For example, MOXA's Turbo Ring technology allows network recovery in less than 0.3 seconds, while Turbo Ring II reduces that time to less than 0.03 seconds.

An important point to consider in addition to fast recovery times is the number of switches supported by the topology. Fast recovery times are meaningless to a large industrial network if only a few switches are allowed in each ring.

Node redundancy

In many industrial networks, certain devices must always be available and communication must not be interrupted at any

time, otherwise great losses are incurred. For this reason, critical devices can be backed up by setting up dual network nodes with a duplicate device and associated switch. Both network nodes should be connected to a dual-homing controller, which is able to select the most suitable homing path. To continue normal network communication even when a network disaster occurs, the dual-homing control must establish connections with certain critical end devices. In this case, the cost of redundant equipment would be less than buying an exact duplicate of the network switch, and part of the critical system would still be running if a network failure occurs.

Efficient installation of a replacement switch is an important consideration for establishing node redundancy. Switches must be able to migrate or restore switch configuration settings easily. A backup tool such as MOXA's Automatic Backup configurator can help reduce the time required to install a new switch.

Network and system redundancy

Some industrial networks may rely on two physical networks, even two complete systems, as a redundant solution. Once media and node redundancy have been implemented, advanced management of redundant systems must be taken into consideration, including the management of two completely independent networks with two communications ports on each connected devices. Network and system redundancy are more complete solutions, but involve greater cost and complexity.

Reliability of components

Reliability of equipment and media is essential for industrial networks due to the critical nature of the application environment. Every devices used for the network should be designed for rugged industrial use. Since environments can differ widely for each application, several points require evaluation when selecting products suitable for an industrial network.

EMI and surge protection

Most industrial environments are subject to more severe electricity and magnetic fields than other environments. Strong EMI and surge protection are essential to protect network devices for industrial applications.

Enclosure

A device's enclosure must provide good physical protection against unexpected damage from external factors. The IP (Ingress Protection) rating index (EN60529) is an international classification system that can be used to gauge an enclosure's suitability for a particular application. An enclosure's IP rating indicates its effectiveness in sealing electrical equipment against the intrusion of foreign bodies such as tools, dust, or fingers. For example, an IP 65 rating indicates complete protection again dust and low pressure jets of water from all directions.

MTBF (Mean Time Between Failure)

A device's MTBF represents how long on "average" the device can be expected to perform before failing. Higher MTBF values indicate longer and more reliable operation.

Wide operation temperature

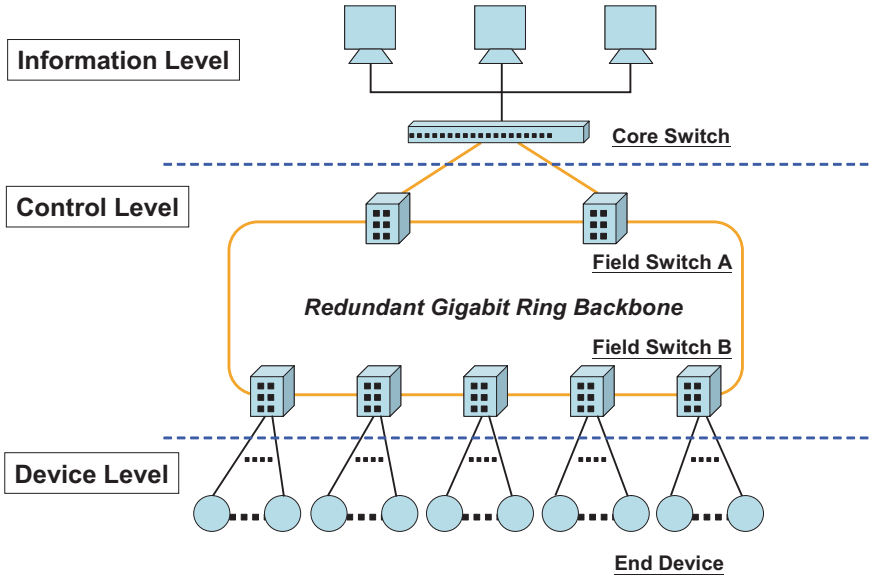
The operating temperature range is a key issue for industrial products. Some applications require reliable operation in environments where the temperature can range from -40 to 85°C. Relying on built-in fans to dissipate heat is not recommended due to the high probability of fan failure and dramatic reduction in MTBF.

How to build a redundant gigabit backbone

By discussing the essential requirements of redundancy and reliability, we have a clear picture of how to select appropriate products for industrial networks. Now, let's see how to build a redundant and reliable gigabit backbone solution.

If cost is not a factor, the simplest solution would be to use Ethernet switches with every Ethernet port supporting

10/100/1000 Mbps. For applications where cost is a concern, an evaluation is necessary to determine the number of gigabit ports and 10/100 Mbps ports required for each Ethernet switch. We can use the following basic industrial Ethernet infrastructure as a guide.



Core Switch

In the system control center, several servers or processing computers handle monitoring and control of devices in the field. The core switch establishes the communication channel for data transmission between the control center and the field site. The required bandwidth depends on how much data these system servers or computers need to receive. Ethernet ports that are connected with the uplink ports of Field Switch A should support gigabit transmission speeds to prevent network bottlenecks.

Usually, the core switch is located in a staffed room or other temperature-controlled facility, making rugged industrial-grade construction unnecessary. However, using industrial-grade switches is still preferable in harsh environments or for applications where reliability cannot be compromised.

Field Switch A

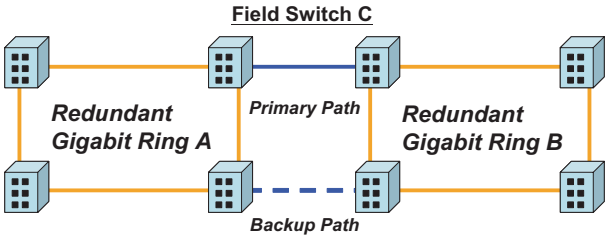
Field switches may be exposed to harsh environments full of dust, electromagnetic fields, moisture, or extreme temperatures. A field switch must be of rugged design in order to perform reliably under such conditions.

In the gigabit backbone of an industrial network, at least two gigabit Ethernet ports are required to build a redundant ring. Since Field Switch A is connected with the core switch, at least one more gigabit Ethernet port is required for uplink.

Field Switch B

Field Switch B is connected to the end devices. Ethernet port requirements depend on how many devices are connected and how much data each device needs to transmit. In general, 100Mbps is enough for each device.

It may not be convenient to connect every device in one large redundant ring, especially when some devices are at remote sites. Instead, devices can be grouped into smaller redundant rings that are connected using a "ring coupling" function.



In this figure, ring coupling is illustrated with two lines connecting Ring A and Ring B. One line is the primary path, and the other is a redundant backup path. Field Switch C needs an additional gigabit port to build these two paths, for a total of three gigabit ports for ring coupling, or four gigabit ports if an additional uplink port with the core switch is needed.

Case Study: Traffic monitoring system for desert highway

The following case study can provide a better understanding of how to build a redundant and reliable gigabit backbone solution in a harsh environment.

Scenario

A 300 km highway was being constructed in a desert and required both traffic and environmental monitoring. Video cameras, vehicle detectors, and weather stations were to be installed along the length of the highway. Data from these devices needed to be transmitted to a control center for immediate recording and analysis. It was essential that the Ethernet infrastructure be extremely rugged and reliable.

Requirements

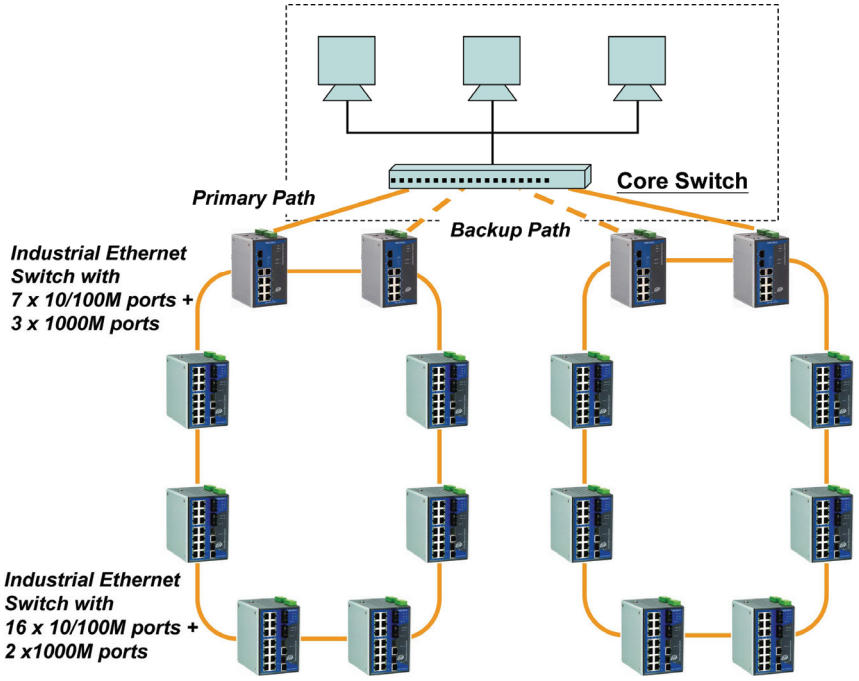
1. Field switches require tough construction to stand up to the harsh desert conditions. We can assume a temperature range of -40°C to 75°C.
2. Due to the bandwidth that is required for multiple video streams and other data, gigabit Ethernet speeds are required for the network backbone. Network and system redundancy are required to ensure the utmost reliability.
3. Fiber optics is the media of choice for the network backbone, due to the long transmission distances involved.

Solution

1. Network Structure: Since the control center is located about halfway down the length of the highway, two separate redundant gigabit rings with redundancy were used, one for each half.
2. Core Switch: Since the core switch is located in the control center, exceptional ruggedness was not required. A general 26-port gigabit Ethernet switch was used.
3. Field Switch: Two gigabit Ethernet ports were required on each switch to support the redundant ring topology. An industrial Ethernet switch with sixteen 10/100M ports and two 1000M ports was used for most field switches. Certain field switches required an additional gigabit port for connecting to the core

switch. For those switches, an industrial Ethernet switch with seven 10/100M ports and three 1000M ports was used. Both types of switch met the requirements for reliability and ruggedness in harsh environments.

Network Diagram



Summary

Reliability and redundancy are the key elements when building an industrial Ethernet network. In addition to choosing the right industrial Ethernet switches, it is important to establish an efficient and economical network infrastructure. The system planner must clearly determine the specific requirements of the system, such as bandwidth, port densities, network structure, etc. Improper design or inappropriate specifications results in wasted labor and expense. For guidance in building industrial Ethernet networks, you can consult with a system integrator in the industrial automation field or with a supplier who develops and provides industrial Ethernet switches.