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When Failure is NOT an Option

Redundant Serial-to-Ethernet Data Connections
for Mission-Critical Applications
Antaira's Industrial Redundancy Serial Device Servers

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White Paper

Abstract

This paper provides information about redundancy in serial-to-Ethernet communications. It describes Antaira Technologies' redundancy serial-to-Ethernet device servers and how they can eliminate single points of failure for networked devices while also assuring data redundancy to support data transmission with dual independent host connections simultaneously.

What is redundancy and why is it important?

Today, serial devices still play a major role in many applications worldwide to collect or report process data. No matter the industry, from Power/Utility, Water Wastewater or Treatment, Oil/Gas or Mining, Transportation, Factory or Process Control Automation, Medical, to Security, many applications are still equipped with legacy serial equipment, such as PLCs, sensors, meters, barcode scanners, display signs, security access controllers, and CNC controllers for processes, that are not yet Ethernet ready for a TCP/IP network.

Today, in these industries, it can be challenging to connect serial devices to an Ethernet network. Serial-to-Ethernet technology has been approved since the late 1990's, and represents a paradigm shift – data transmission which was previously tied to a 45-foot RS-232 serial cable can now be made available across TCP/IP Local Area Networks (LANs,) Wide Area Networks (WANs) and even the Internet. It benefits the limited transmission distance of serial-based connections and can be extended to essentially any distance with Ethernet. Serial-to-Ethernet can also benefit engineers in many applications to centralize remote management to easily and efficiently access, control, or monitor the status of field serial devices.

As engineers start to depend on access to these islands of information, issues such as the environment, connection reliability (uptime), and accessibility become top concerns. Thinking of redundancy as a design paradigm is important, especially, mission-critical applications that can not afford data to be lost by any network downtime. Building a reliable redundancy system with a primary and secondary remote host PC or Server will allow field devices to exchange data simultaneously through a dual-network infrastructure. With this setup, engineers will have no need to worry about any failures occurring because the primary and secondary hosts will continuously communicate with field devices.

Serial-to-Ethernet Redundancy

Typical Ethernet networks consist of many links between hosts and Ethernet switches, and form a tree topology with hundreds of point-to-point wired connections. Any link failure in the network could bring the entire operation to a critical halt. A redundant ring network allows a small portion of the network to be kept idle until another part of the network fails, at which point the "redundant" portion is activated to maintain the flow of data. However, building a reliable redundancy system can create other challenges to engineers, due to specific hardware and the costly software development.

Antaira Technologies chose to embrace the redundancy needs of users and responded with several new features in our industrial redundancy device servers: STE-6104C-T, and STE-700 series, including:

- LAN Bridge Mode Solutions
  - Provides a dual LAN port solution to allow engineers to perform daisy chaining
- LAN Redundancy Mode Solutions
  - Antaira's redundancy serial device series supports IEEE802.1D/W Spanning Tree or Rapid Spanning Tree Protocols, and an open standard ITU-T G.8032/Y.1344 ERPS (Ethernet Ring Protection Switching) Protocol to perform a single-ring redundancy network solution.
- LAN Dual Subnet Mode Solutions
  - Enabling this feature will allow engineers to setup the device servers to connect to two independent networks with different IP addresses for data redundancy solutions. It involves creating a complete backup to the Ethernet network.

Device Server Overview

Device servers represent the segment of product also known as Serial-to-Ethernet converters, which essentially allow any serial device with a serial port to communicate with an application across an Ethernet IP network. Antaira's serial device server series provides Virtual COM operation mode and TCP Socket connections to allow an application to communicate with a remote networked serial port as if it were attached locally.

Types of connections to device servers:
• Raw TCP Socket
• User Datagram Protocol (UDP)
• Serial Tunneling (a pair connection)
• Virtual COM

LAN Bridge Mode Solutions

Antaira's new STE-6104C-T and STE-700 series comes with dual 10/100Tx LAN ports that allow engineers to connect multiple serial devices in a single location through the Ethernet network. Engineers can enable LAN Bridge Mode to cascade multiple serial device servers through the 2nd LAN port. When enabling this feature, the built-in LAN 1 and LAN 2 will use the same IP address setup (Figure 1).

In many manufacturing automation applications, Ethernet-based devices are now being incorporated on the plant floor with a variety of legacy serial-based devices. By enabling LAN bridge mode, the device server can also allow engineers to apply the 2nd LAN port as a switching port to connect with the Ethernet-based device, instead of buying an additional Ethernet switch for the application. (Figure 2)

LAN Redundancy Mode Solutions

LAN redundancy mode, allows users to setup a single-ring redundancy network with all device servers. This feature uses a physical link in the network as a backup path, and the built-in software allows devices within the ring network to transmit data to the next connection link in one direction. The data transmission will be routed to the backup path direction if the built-in software does not detect data transmission in an uplink port, eliminating any network downtime concerns. Antaira's redundancy serial device server series provides two types of open standard network recovery protocols to support a redundant ring network: IEEE 802.1D/W and ITU-G.8032 ERPS.

IEEE 802.1D Spanning Tree and IEEE 802.1W Rapid Spanning Tree Protocols

IEEE 802.1D, Spanning Tree Protocol (STP) was introduced in 1990 to protect the network from broadcast storms caused by unintended loops, and to reduce network crashes caused by failure of a single link in the network. IEEE 802.1w, Rapid Spanning Tree Protocol (RSTP) is an enhanced version of STP released in 1998. Both STP and RSTP detect duplicate paths in the network and then block data from being transmitted across those duplicate paths. (Figure 3)
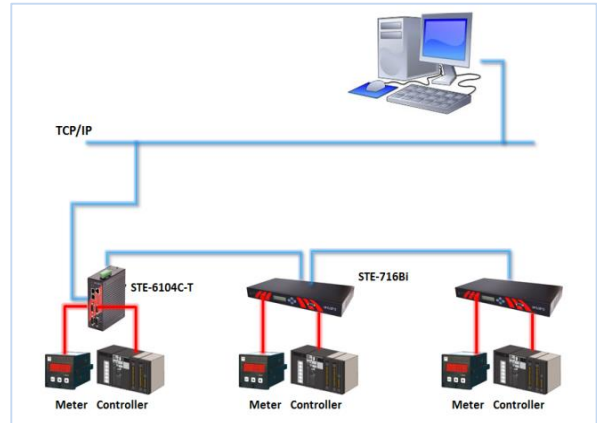

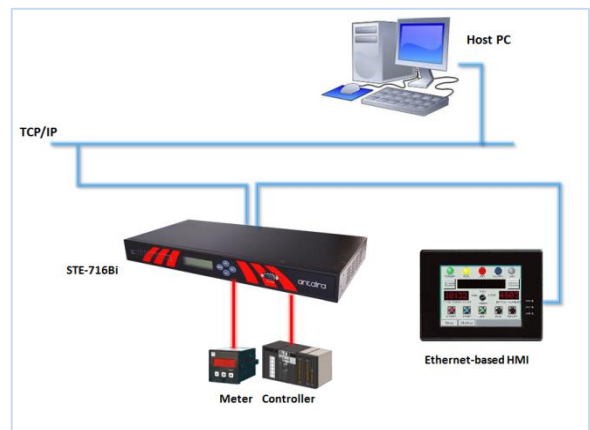Figure 1: Daisy Chain solution for LAN Bridge mode

Figure 2: Ethernet Switching solution for LAN Bridge mode
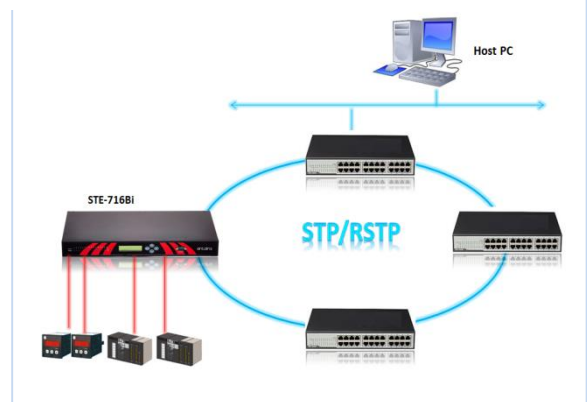

Figure 3: Daisy Chain Solution for LAN Bridge Mode

The STP/RSTP protocol is a typical setup for a tree or star topology network and can be used with complicated mesh-type networks. The advantage of setting up mesh-type networks is that there is no need to worry about loops. The STP/RSTP algorithm analyzes the network automatically to determine if any loops exist. If loops are discovered, the algorithm determines which links in the loops should be blocked, and the blocked loops are then reserved for use in the event that an active link is broken. Meanwhile, the STP/RSTP algorithm springs into action by activating one of the redundant links in the network. However, there is also a drawback to using STP/RSTP within an industrial network; slow recovery time. The STP protocol can take up to 30 seconds for network recovery, and RSTP can take up to 3~5 seconds. Since data transmission from device to device is in a matter of milliseconds, the slow recovery time of STP or RSTP protocol can run a potential risk of losing data between 3~5 seconds.

ERPS (Ethernet Ring Protection Switching)

ITU-T G.8032/Y.1344 ERPS (Ethernet Ring Protection Switching) was introduced in 2008 by the International Telecommunication Union (ITU). ERPS defines the automatic protection switching (APS) protocol and protection switching mechanisms for ETH layer Ethernet ring topologies. It was defined to protect the point-to-point, point-to-multi-point and multipoint-to multipoint connectivity within a ring network topology.

Antaira's STE-6104C-T and STE-700 series supports an Ethernet Ring Protection Switching (ERPS) protocol for Ethernet layer ring networks without requiring extra managed Ethernet switches. By enabling the ERPS function, users can connect all serial device servers to a ring topology network. In a ring topology, each ring node is connected to an adjacent ring node participating in the same ring using two independent links (i.e. two ways). Loops can be avoided by guaranteeing that traffic may flow on all but one of the ring links at any given time. This particular link is called a Ring Protection Link (RPL). A control message called an R-APS coordinates the activities of switching on/off the RPL. Under normal conditions, this link is blocked by the owner node, which is referred to as the blocking state. In case of a network failure, the RPL owner node will be responsible for unblocking the RPL to allow it to be used for forwarding, hence why it's called the protection state. Therefore, the RPL becomes the backup link when a link failure occurs. Ethernet Ring Protection Switching (ERPS) provides a highly reliable and stable protection within the ring topology, and supports a network recovery time <50ms (Figure 4).
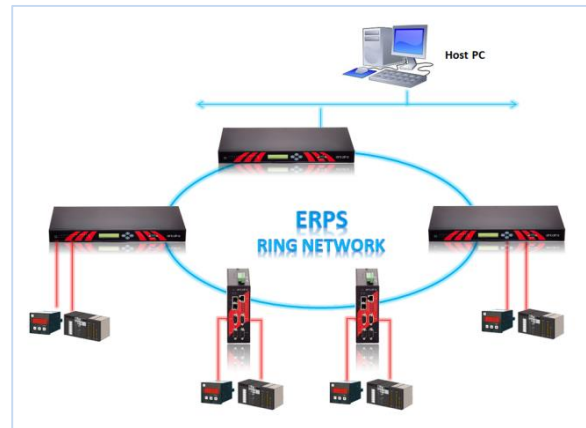
Figure 4: ERPS Protocol for LAN Redundancy mode

LAN Dual Subnet Mode Solutions

Antaira's STE-6104C-T and STE-700 series redundancy serial device servers provide dual independent LAN ports to setup dual-network redundancy architectures, in order to perform data redundancy for mission-critical applications. LAN dual subnet mode can be used to set up a redundant LAN between serial devices connected to the device server and the host computer. The redundant structure involves using the device server's two LAN ports to set up two independent LANs that connect the device server to the host computer. If any LAN port link fails, the other LAN link will continue transmitting packets between the serial devices and the host, with the packets passing through the device server. As a result, LAN dual subnet mode performs a zero data loss mechanism to support data redundancy applications (Figure 5).
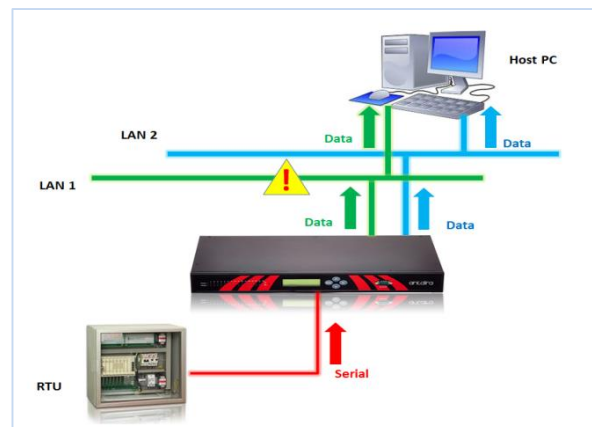
Figure 5: Dual-Network Redundancy

Multi-host Redundancy

In a multi-host setup (Figure 6), serial device servers can establish TCP connections to the serial port at the same time, duplicate the serial data, and transmit the data to all hosts at the same time. Ethernet data is sent on a first-in, first-out basis to the serial port when data comes into the device server from the Ethernet interface.
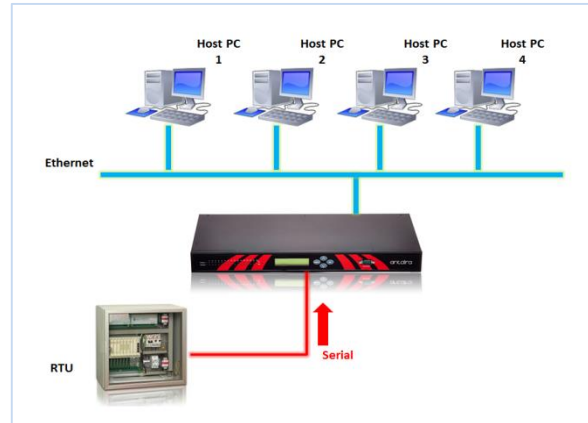
Dual Redundancy System

By setting up Antaira's STE-6104C-T and STE-700series' LAN dual subnet mode, the device server provides a highly redundant network structure that takes advantage of built-in dual LAN ports, dual IP

addresses, and dual MAC addresses. Engineers can setup two remote host PCs or servers with two independent networks to connect to the redundancy serial device server. The remote redundancy system sets one host PC up as a primary host and another PC as a secondary host as a backup system. When the primary IP fails, the backup IP will take over by using a switching library. However, this type of setup will only allow the primary host IP to transmit data bi-directionally to the device server, and the secondary IP to receive data from the device server.
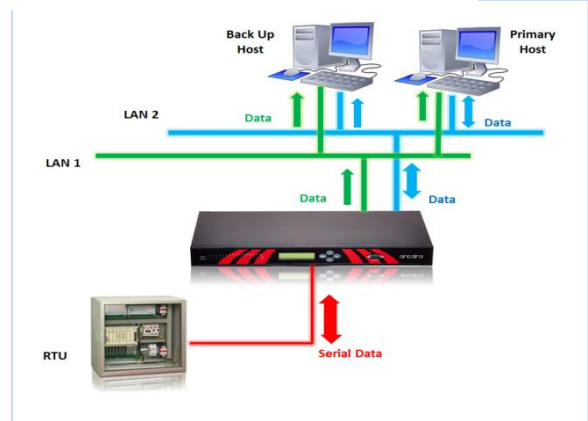
Application Notes: Data Redundancy Solutions in Power Substations

Within power substations, engineers cannot afford data loss from any piece of equipment. Building reliable systems and dual-network architectures for remote data acquisition and access control become mission-critical. There are so many serial-based devices, such as protection relays, controllers, switch gears, and RTUs that require integration with major redundancy systems and networks which can become a challenge because traditional redundancy systems and networks require costly software development and specialized hardware. Antaira's STE-6104C-T and STE-700 series provides LAN dual subnet mode to allow engineers to setup dual-network redundancy architectures without requiring a front-end redundancy system to connect all bay level legacy serial devices and exchange data simultaneously with remote dual-host servers.

Figure 6: Multi-Hosts Redundancy

Figure 7: Dual Redundancy System

Summary

Although there are a variety of Ethernet-based or USB-based devices in the market, they are more for consumer, commercial, or enterprise type equipment that thrive only in indoor or air conditioned environments. Most industrial application measurement devices are still being developed by device manufacturers which means serial is still prevalent in today's automation world and applications require real-time and accurate data exchange between field serial devices and remote control management maintenance system.

Antaira's industrial serial device server series provides high industrial grade, environmentally proven designs, plus new features that can assist in a number of mission-critical applications for data assurance and accuracy solutions.
- **LAN Bridge Mode –** applications can be applied as daisy chain connections, or Ethernet switching solutions.
- **LAN Redundancy Mode -** includes STP/RSTP protocols for mesh-type topologies, and the open standard TU-T G.8032/Y.1344 ERPS (Ethernet Ring Protection Switching) protocol for ring network topology solutions, and supports a standard network recovery time <50ms.
- **LAN Dual Subnet Mode –** supports dual-network setup to transmit serial data simultaneously to remote redundancy servers.