WHITE PAPER

Optimizing PLC Network Performance and Management

Gary Chang

Product Manager

Mark Wu

Technical Writer

Moxa Inc.

MOXA®

Executive Summary

Traditional fieldbus networks were, and some still are, isolated automation systems which require extensive local monitoring and routine onsite maintenance. To increase productivity and reduce operating costs, many manufacturers and plant operators have deployed industrial Ethernet to converge remotely isolated fieldbus systems for centralized control and monitoring.

In addition to systems interoperability, integration of fieldbus segments and industrial Ethernet networks will require the optimization of PLC network performance and manageability. This paper will discuss how three facets of PLC network optimization can ensure high network availability, simplify network monitoring and configuration, and maximize network flexibility.

Overview

The term "automation" was introduced in 1946[1], later published in a magazine in 1948, and defined as "the art of applying mechanical devices to…perform these tasks in timed sequence…under pushbutton control at strategic stations." What engineers had in mind in the 1940s remains fundamentally the same as to what control engineers intend to achieve today with automation; minimizing human involvement while maximizing output capacity, increasing production speed, and ensuring consistent repeatability.

Early automation systems are isolated and generally consist of I/O devices connected directly to PLCs, which then connect to SCADA (supervisory control and data acquisition) systems in local control rooms. Today, a major difference exists in the architecture of modern industrial automation networks, a technology that is increasingly being deployed to connect large-scale distributed systems with remote monitoring/control centers. That technology is industrial Ethernet.

Industrial Ethernet technology consists of various Ethernet-based protocols, developed with deterministic capabilities as robust alternatives to costly proprietary automation systems and, more importantly, enable a highly-scalable and unified infrastructure to converge all network nodes at the administrative, control, and field levels. Many advanced industrial automation systems have deployed gateways to efficiently bridge fieldbus I/O devices to Ethernet based PLCs, switches to connect PLCs and SCADA terminals at remote control centers, to reduce operating costs and improve production efficiency of expanding automation networks.

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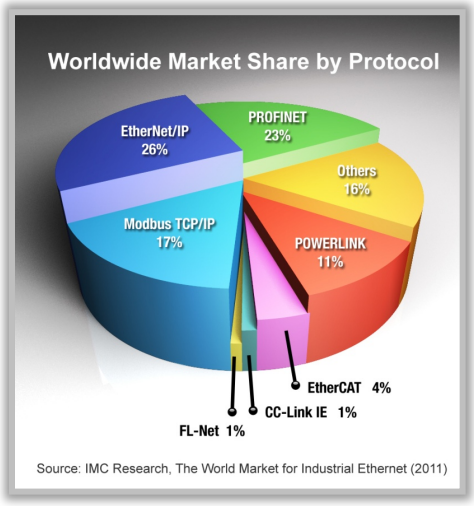
How to contact Moxa
Tel: 1-714-528-6777
Fax: 1-714-528-6778
Web: www.moxa.com
Email: info@moxa.com

According to recent studies conducted by IMS Research, three of the most pervasive Ethernet-based protocols, EtherNet/IP, PROFINET, and Modbus TCP, account for more than 65% of the world's existing industrial automation deployments, and their collective growth from 2010 to 2015 is expected to exceed 18 million new nodes.

However, the worldwide number of existing fieldbus devices (all protocols) will increase from 183 million in 2010 to over 326 million by 2015. This steady growth, despite the increasing popularity of industrial Ethernet, is primarily due to the fact that fieldbus is still considered as the easier, and more cost-effective, protocol to deploy at field-level networks than industrial Ethernet. Another contributing fact is that there are exponentially more nodes at field-level networks than nodes at control/supervisory-level networks. As growing industrial automation networks expand to increase productivity and factory systems converge for centralized control, the integration of various Ethernet-based protocols and bridging of fieldbus systems will be inevitable.



An Ethernet-based single-network infrastructure offers operators the efficiency of centralized network management with greater network scalability and flexibility, higher bandwidth availability, and faster failure recovery. To optimize system performance and improve network manageability, switches and gateways should integrate seamlessly with industrial automation networks for centralized SCADA control and monitoring. However, integrating industrial fieldbus with industrial Ethernet presents integrators and engineers with two considerable challenges:

- Centralized monitoring of all network nodes, including switches, should be available on SCADA systems. However, standard industrial Ethernet switches do not process industrial automation protocols and therefore are unable to be monitored on the same SCADA as the PLC and other I/O devices.

- Existing fieldbus devices can account for a substantial portion of a company's assets, and their integration with industrial Ethernet networks can be done via PLC modules. However, for large-scale control systems, deploying industrial Ethernet gateways would be a more cost-effective solution to integrate fieldbus devices, but a substantial amount of time can be required to manually configure the switches and gateways.

Many manufacturers offer switches and gateways to integrate fieldbus-to-Ethernet communication for automation systems consolidation, with emphasis on device features and system interoperability between components and PLCs. But these are just the basic requirements of systems convergence. Most industrial switches and gateways available today are designed only with automation-centric perspectives. The optimization of the PLC network, such as overall performance, configuration/management efficiency, and application flexibility, seems to have been overlooked.

Components for PLC Network Optimization

As device networks expand into larger control networks through fieldbus-to-Ethernet integration, network deployment and management become more complex, and network performance becomes highly critical. To optimize PLC network performance and management, industrial Ethernet switches and gateways should be designed with a network-centric approach to enhance overall performance, improve configuration efficiency, simplify network management, and provide application flexibility.

High performance ensures high network capability

Performance optimization of industrial automation networks is critical for maximum productivity and reliability. High bandwidth, high data transmission rates, switch ASICs, and hardware features are indispensible components of high network performance. However, these factors are useless if the network is unavailable. Maintaining high network availability not only requires reliable network devices, but also speedy recovery of the network and its components during maintenance or in the event of a connection/device failure.

- **Industrial Ethernet Switches**
  - **High-speed Redundancy**
    Redundancy is a must-have component to ensure industrial automation reliability. Prolonged periods of unplanned system downtime can jeopardize onsite personnel safety, severely impact plant productivity, and possibly damage expensive factory equipment and machinery. Recent refinements in redundancy technologies not only provide millisecond-level network recovery, they can also substantially reduce costs for deployment.

  - **Faster-than-PLC power cycling**
    Power cycling of switches and PLCs is generally required for plant-wide maintenance updates. Most managed switches can take approximately 3 minutes, if not more, to reboot because they have relatively low processing power. PLCs, on the other hand, operate by using simple ladder logic and power cycling normally takes less than one minute. Administrative-level nodes (such as SCADA and HMI) will have no access to control-level and device-level nodes until switches have completed POST (power-on self-test) diagnostics and the bootstrap loading process. The difference between the duration of power cycling times of PLCs and switches will not only delay maintenance efforts, it can even cause port lockouts in some older time-sensitive automation systems. Advanced managed switches are now capable of completing a power cycle in the 10-second range.

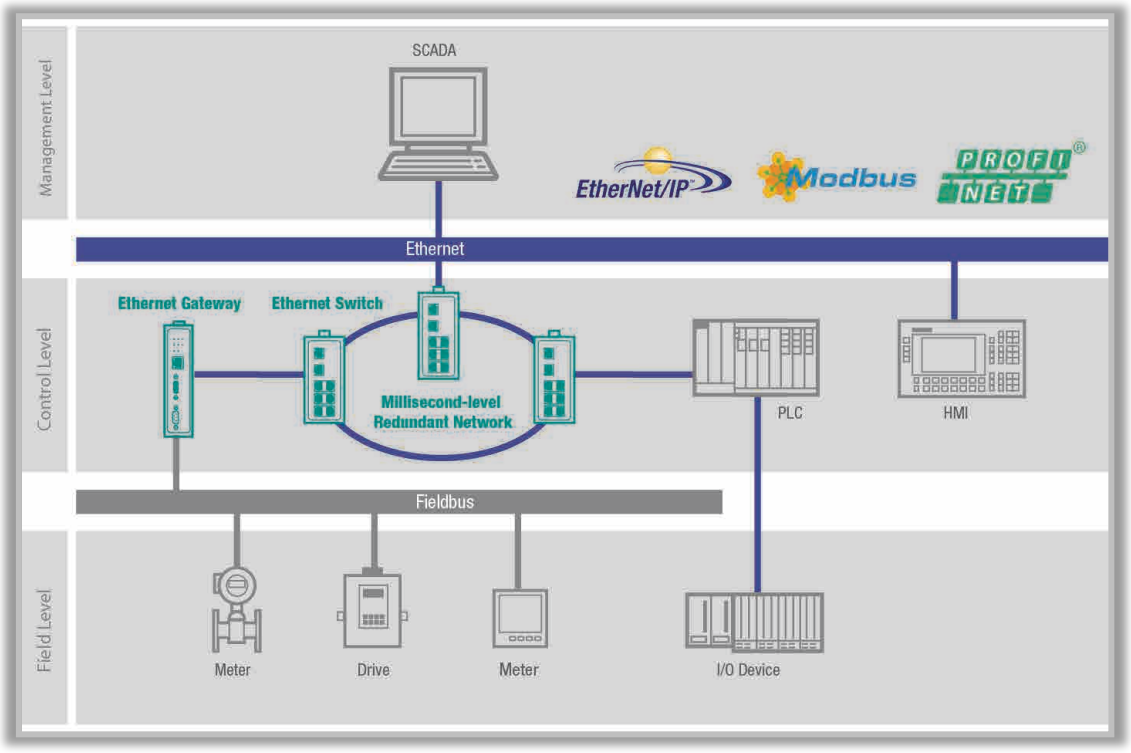
- **Industrial Ethernet Gateways**
  - **Processing power**

    Typical gateways have access to 16-bit processing power, which limits the gateway to 8 simultaneous connections and delays response times. Newly developed 32-bit industrial Ethernet gateways can handle up to 16 concurrent connections (from SCADA/HMI/PLC) without compromising response time or transmission reliability.

  - **Data Prioritization**

    Most switches already offer packet prioritization between administrative-level (SCADA/HMI) and control-level (PLC) devices. Some Ethernet gateways are now also capable of providing device-level (fieldbus I/O) data prioritization to enhance QoS (quality of service) and improve determinism.

The core of industrial automation consists of SCADA, PLC, and I/O devices. Switches and gateways enable fieldbus-to-Ethernet convergence by providing network communication between these core devices at field, control, and supervisory-level networks. For performance optimization of large-scale industrial automation networks, it is imperative that each network component operates with cohesive and timely efficiency.



Advanced efficiency simplifies configuration and monitoring

Efficiency of switch and gateway configuration during fieldbus-to-Ethernet integration has previously been reliant upon the expertise of system integrators. Gateway configuration can be extremely time-consuming, which requires manual input and is verified through system trial-and-error. In addition, the isochronous nature of hard real-time industrial automation systems does not tolerate delays and requires precise calibration of critical parameters, such as gateway response time-out settings, to prevent system errors. Furthermore, optimizing PLC

network management requires tools for network configuration and monitoring, not only to ensure reliable operation and immediate event notification, but also to provide effortless maintenance updates to minimize system downtime.

- **Industrial Ethernet Switches**
  - **Plug-n-play simplicity**

    Switches deployed on the factory network should also be enabled with industrial Ethernet protocols such as PROFINET, Modbus TCP, and EtherNet/IP. This allows switches to be integrated into the SCADA/HMI of industrial automation systems for optimized consolidation of network configuration, management, and control without the need of additional configuration and/or modifications.

  - **Device parameters and monitoring**

    In addition to relay output warnings for on-site network performance monitoring, switch parameters, such as power, port, and redundancy statuses should also be accessible by SCADA systems. Switch visibility in SCADA systems is vital to maintain healthy PLC networks, and access to device parameter allows remote monitoring of switch components, providing operators complete control-level network information.

- **Industrial Ethernet Gateways**
  - **Intelligent auto-detection**

    The latest innovations in Ethernet gateways can eliminate the tedious tasks of fieldbus parameters input and device configurations, which, even for experienced systems integrators, can be extremely complex and time-consuming. Recent gateway developments enable fieldbus-to-Ethernet integration in a fraction of the time by automatically detecting PROFIBUS I/O modules and Modbus device settings to eliminate the possibility of manual-input errors.

  - **Monitoring and diagnostic tools**

    When network communication errors halt production lines on the factory floor, control engineers must quickly locate and resolve the root cause. When problems occur, gateways should be equipped with relay output warnings to immediately trigger an alarm at the control room or a shutoff mechanism on the factory segment to minimize the impact of a system failure. Many intelligent gateways also offer software diagnostic tools to assist control engineers in troubleshooting. When communication errors are determined to be the root cause of a system failure, engineers can quickly access gateway data transmission logs and filter out erroneous fieldbus frames for review and analysis.

Manual input of I/O modules and device time-out settings can take many hours, if not days, to complete. Intelligent switches and gateways can assist system integrators and control engineers to effortlessly deploy, configure, and update industrial automation segments within the network to quickly enable production on the factory floor.

Maximum flexibility to converge various applications

Industrial automation network infrastructures can span across multiple plants in multiple remote locations, where various applications are performed in various industrial environments. Switch and gateway flexibility allows operators to optimize PLC network deployments with devices that are best-suited for applications in industries such as chemical plants, waste water treatment, and oil refineries.

Industrial automation networks will require different types of gateways and switches for different applications. These applications can require different port densities and various combinations of port types, such as fiber, PoE, SFP ports with Fast Ethernet, Gigabit, or 10GbE connectivity. Furthermore, industrial automation applications, whether indoors or outdoors, can present some of the most challenging conditions, pushing devices to their limits. Environmental factors such as extreme temperatures, vibration/shock, corrosion, dust, moisture/humidity, surge, and EMI (electro-magnetic interference), will require the deployment of industrial-grade devices with industry-specific certifications and compliance. Listed below are a few types of application-specific requirements.

- **Wide-temperature operation** is necessary for many outdoor environments, where temperatures can dip well below -30°C at night and rise to well over 70°C in the daytime.
- **Gigabit PoE** can be deployed to combine control-level communication with video surveillance of the factory floor, eliminating the need for external power cords.
- **Fiber** is a media commonly used to provide long-distance communication between remote networks. Also, electro-magnetic interference (EMI) immunity makes fiber the choice for many power industry applications.
- **10GbE** and **Layer 3 switching** are required in control rooms with large-scale surveillance systems to provide the data rates required for HD-quality video transmission.
- **M12** connectors are required for severe outdoor applications, such as mining and transportation industries, where intense vibration and dust can compromise network communication.
- **Ingress protection (IP)** is important for application environments where contaminants and high humidity can cause device malfunction and even failures.

Many vendors offer a selection of switches and gateways specifically designed for a targeted application, without much consideration on how these devices can impact the automation network as a whole. Consequently, operators can be left with a multi-vendor network which does not work as a cohesive whole and can severely impact overall network performance and manageability. Converging various systems and applications within the PLC network requires a wide spectrum of switches and gateways, not only designed and calibrated specifically for each application to provide maximum deployment flexibility, but also conduces to PLC network optimization as a whole.

Deploying a smart and reliable industrial control system requires an optimized industrial network design to help ensure a high-performance, efficient, and flexible platform for daily operation. Moxa provides a selection of networking products for optimization of PLC network performance and management, including industrial Ethernet switches and gateways designed specifically for EtherNet/IP, PROFINET, and Modbus TCP applications.

Moxa's industrial Ethernet switches offer industry-leading redundancy (< 20 ms recovery time), fast booting capability (< 10 seconds start-up time), full status parameters, and flexible topologies to ensure high network reliability, availability, manageability, and flexibility of industrial control systems. Moxa's industrial Ethernet gateways are easy-to-configure for quick integration of legacy field devices to control networks, and easy-to-maintain for rapid monitoring and troubleshooting of fieldbus communications.

With multiple locations for professional support and customization services available, Moxa is the innovative leader in industrial Ethernet solutions for automation networking applications.

For more information on products for PLC network optimization, please visit:

Industrial Ethernet Switches:
http://www.moxa.com/product/Industrial_Ethernet_Switches.htm

Industrial Ethernet Gateways:
http://www.moxa.com/product/Industrial_Ethernet_Gateways.htm

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Credits/sources

1. Pursell, Carroll. A Companion to American Technology. Blackwell Publishing, 2008. Google books. Web. 2 Feb. 2013. <http://books.google.com>