DISTRIBUTED MODULAR I/O TECHNOLOGY GUIDE

5 Reasons to Switch to Distributed Modular I/O

White Paper

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For machine builders there is a great demand to increase the productivity and flexibility of their machines, while maintaining healthy margins. This can be a difficult balancing act between using the most effective technology while working within a shrinking budget. Distributed I/O systems connected to an industrial network allow for I/O data to be spread across the machine and outside of the cabinet; reducing the total component and hardware costs of the system. New developments in distributed I/O technology have lowered the cost per point of the controls design and have reduced the time to integrate.

The focus of this whitepaper is to inform controls engineers working for machine builders about the advantages of distributed modular I/O on an industrial network and how to select the best out-of-the-cabinet controls solution for manufacturing equipment.

A Brief Market Study of Networked I/O

Discrete inputs and outputs have been the workhorse of industrial automation since engineers first started putting sensors and actuators on equipment. Today the market demands more information from every level of the manufacturing process. Current sensor technology and controls devices allow for this level of detailed information to be collected. However, the challenge for every engineer is that these controls solutions must be cost effective and simple to implement.

Interest in industrial networks is growing every year and the main swell of interest is in industrial Ethernet solutions. "The number of new Ethernet nodes installed in the Americas will grow by more than 60% between 2009 and 2014."[1] And 52.5% of the nodes networked or under evaluation for industrial networking are I/O related.[2] However many people find there are some major barriers to using an industrial network in this globalized economy. More than 43% of equipment specifiers in a VDC study[2] stated that the cost of implementation and the lack of internal resources were the primary barriers to their deployment of an industrial network solution. This means that end users are looking for Ethernet networks for many reasons including I/O, but they are reluctant because they also need a cost effective solution.

As can be seen in Figure 1, when asked what the primary operational drivers were for their investment in industrial network solutions, 77.6% of respondents replied they were interested in access to real-time data. The demand in the market for industrial networks is being spurred by the need for more data from the manufacturing floor. 67.2% of those questioned stated that increased productivity of their equipment was an operational driver for their decisions. This begs the conclusion that a piece of equipment with improved data availability and increased machine throughput would likely improve the success and perceived value of a machine's overall design.

However, everything comes with a cost. In the controlseng.com video "The state of Manufacturing,"[3] Bernie Anger (VP & GM of GE Intelligent Platforms) shares that his customer's greatest challenges are risk management, capital efficiency and operational flexibility. "How do we make sure we can sustain the ability to run our business in a more efficient way?" In this globalized and competitive marketplace every ounce of margin needs to be balanced and valued against the technologies available.
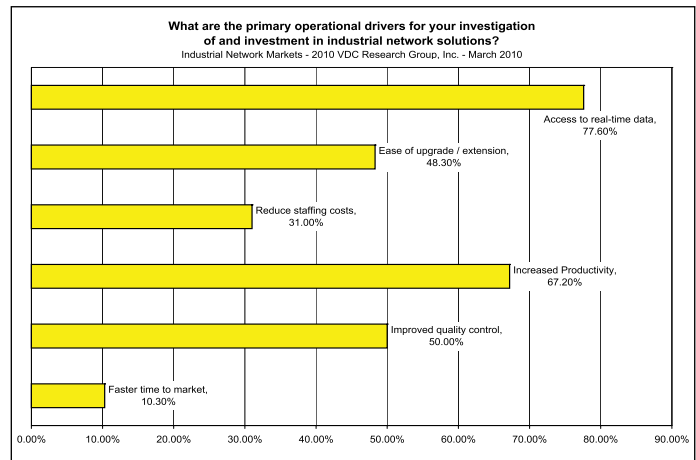
What are the primary operational drivers for your investigation of and investment in industrial network solutions?
Industrial Network Markets - 2010 VDC Research Group, Inc. - March 2010

- Access to real-time data, 77.60%
- Ease of upgrade / extension, 48.30%
- Reduce staffing costs, 31.00%
- Increased Productivity, 67.20%
- Improved quality control, 50.00%
- Faster time to market, 10.30%

Figure 1: Drivers of investment

Cost Effective Controls Design

The thought of implementing an unfamiliar technology can cause some anxiety for any engineer. That being said, every end user's needs and demands are different; so an engineer in today's market is looking at ways to add upgrades or options to their machine that are easy to implement (even after installation) and are customizable to the level that end users have come to expect. There are three primary challenges in cost effectively enhancing a machine's design: creating value in throughput or uptime, reducing the total cost of the machine, and making the machine distinct among the competition.

Our machine is about as fast as it can get.

While most machines are highly productive already, there is always a demand for more throughput. When the limitations are due to mechanical parts or controls on the machine, the reliability and uptime become a point of pain for the end user. Uptime equals real production dollars for all manufacturers and this added value should not be taken lightly. Easy to troubleshoot components with clear diagnostic messages allow maintenance crews and operators to get the machine up and running in shorter periods of time, and enables them to implement repairs with less hassle. By reducing the maintenance cycle of the machine, there also can be significant improvement on the throughput of the machine.

The total machine costs just keep going up!

Industrial commodity and material prices are going up. But end users are less willing to pay for these increases in a growing global economy. So machine builders are tasked with reducing the cost of engineering, the cost in components, and the cost of machine construction. In engineering, the quotation process can be time consuming and frustrating. It is important to be able to quote quickly but it is more important to quote accurately. Wouldn't it be great to be able to specify the same controls components no matter the PLC or industrial network? In development and installation, the labor costs of manufacture, tear-down and setup (at the end user) can quickly cut into the margin of a project. So how do you reduce the control cabinet costs? How do you reduce the labor costs of setup and installation?

How do I make my company and my machines distinct?

Access to real-time data and increased productivity were the two primary operational drivers for an equipment specifier's interest in industrial network solutions. The specifiers were also interested in ease of upgrade as well as quality controls.[2] Thus a focus on more data output as well as throughput is a key factor for a distinct machine. In addition, the machine should be able to expand over time or be modified easily to the needs of the individual end customer. But how do I get more feedback, more diagnostics and more data out of my devices? And how do I add flexibility to make the machine distinct from the competition? How have people solved this in the past?

The Evolution of Distributed I/O

PLC controls have been in use since they gained popularity in the 1970s. Later that decade, demand for distributed controls allowed for inputs and outputs to be collected across the automation process. When looking at the connection between field devices and the I/O there has been an obvious evolution over the last four decades.

Hardwired I/O & Junction Boxes

Originally there were hardwired I/O devices in which every conductor was individually terminated into the controls cabinet, similar to Figure 2. Each sensor had a cable that was run through a cable tray into the controls cabinet; large numbers of sensors or outputs meant large controls cabinets. Hardwired I/O was characterized by maxed out cable trays and overloaded conduits full of wire. Junction boxes, like the example in Figure 3, helped with this issue to a degree but the same controls cabinet issues existed. Both of these practices are still active and accepted today in many engineering circles but have recently come under scrutiny due to the demands for reducing setup, installation labor costs, and environmental issues.

Industrial Networks

The acceptance of the industrial fieldbus in the early 1990s allowed for controls systems to step onto an enlightened path. The ability to communicate intelligently between multiple devices and collect more data than ever before has made an industrial network the next step for more than half of equipment specifiers.[2] As shown in Figure 4, this technology reduces many of the I/O terminations down to a single network cable, allowing for smaller cabinet footprints and simplified hardware installation, right on the machine. I/O data is collected outside the controls cabinet, and with an industrial network more data is available on the process and health of the machine.
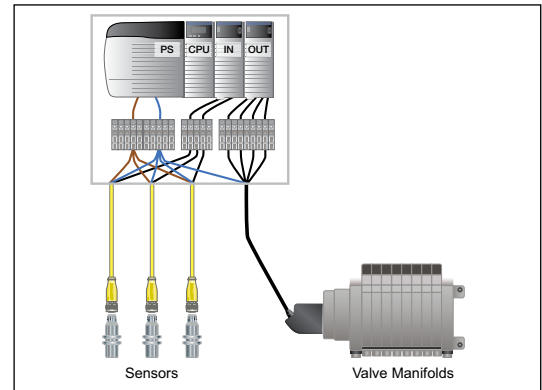

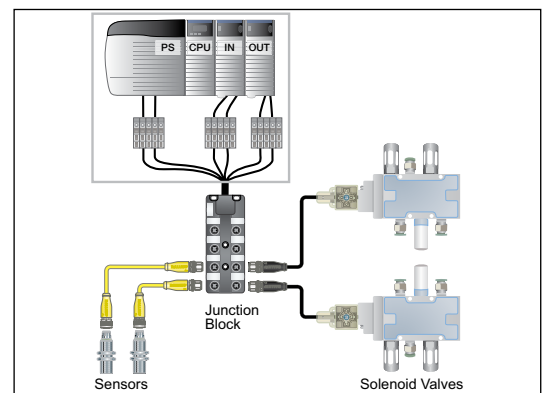**Figure 2:** Hardwired inputs and outputs
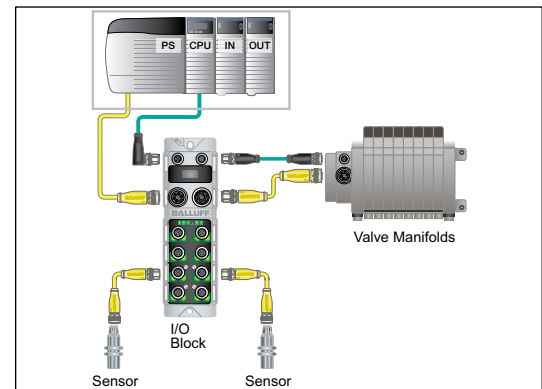

Figure 3: Hardwired junction blocks

Figure 4: Reducing cabinet space with network I/O

The Next Evolution

Industrial networks have strong connections to PLC brands. Only certain PLCs can communicate over certain networks. Each controls device needs to be selected with a single industrial network and controller in mind to ease the integration efforts. There are various types of data needed from the components of a machine: discrete points, analog channels, valve controls, identification data, diagnostic information, etc. A technology that would allow for a network neutral state of the controls equipment would make a machine builder more flexible and cost effective in their design and overhead, no matter the industrial network or controller selected by the end user.

The Solution: Distributed Modular I/O

In attempting to create a more cost effective machine, while implementing the most effective technology, many engineers turn to their controls equipment for answers. Businesses are turning to Distributed Modular I/O solutions for improving their throughput and increasing their flexibility while cutting costs out of their controls design and implementation. By using Distributed Modular I/O solutions, the I/O "slices" are separated from the network communication and are designed for mounting on the machine in small pockets of distributed I/O.

Different from a block I/O solution, Distributed Modular I/O is more flexible in the types of data it can collect. While both solutions are setup in a distributed fashion, in a block I/O solution the individual nodes are dedicated to one specific data type: discrete I/O, valve manifolds, identification data, smart sensor configuration. Each data type then requires a node or IP address on the network and requires further network and auxiliary power cabling to be installed. A network utilizing distributed I/O alone can expose the network cabling to harsh environments and network failures due to damage. Distributed Modular I/O can maintain the industrial network integrity better by keeping the network connections out of the harshest parts of the manufacturing environment.

In a centralized I/O or typical remote I/O solution, there are large volumes of cable runs to manage in a centralized location, usually inside of a large enclosure. Bulky and time consuming to install, centralized I/O requires many installation and development hours. A Distributed Modular I/O solution allows installers to quickly setup and test the I/O hardware since it uses standard connectors and familiar devices. Furthermore, a Distributed Modular I/O solution allows the user to put the exact input/output device precisely where it is needed on the machine, reducing the number of cable runs back to the controls cabinet.

A Distributed Modular I/O solution takes the best components of past I/O devices and combines them into a flexible and cost effective I/O solution. A proper Distributed Modular I/O solution is IP67 (outside of the cabinet) and can distribute multiple types of I/O data. Discrete I/O, from proxes and photoeyes for example, is collected remotely with industry standard quick-connect connectors. It has the ability to space analog I/O signals
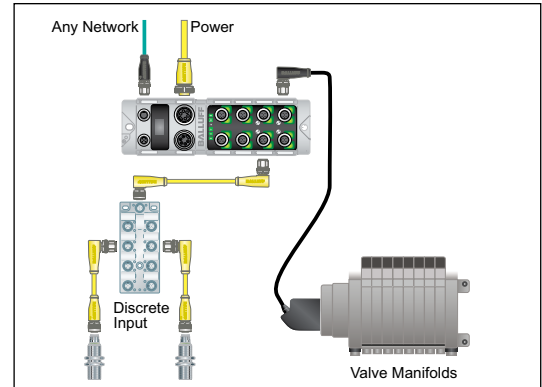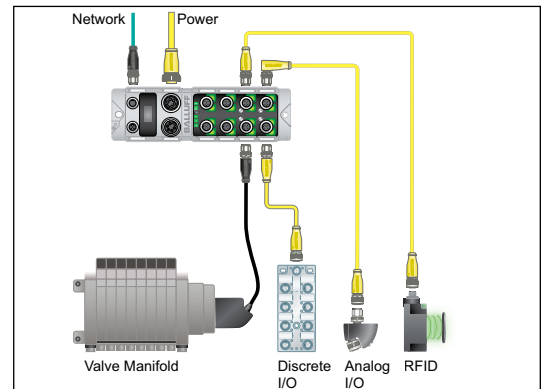

Figure 5: The next evolution

Figure 5: Distributed Modular I/O

Example: Custom Machine Builder

Machine Builder Application: The machine builder was tasked with building a palletized assembly system where each workstation needed to be able to read the unique build instruction of the pallet. There was also the need to integrate the I/O for many sensors and valve manifolds used to run the automation of the workstations and the conveyor equipment.

Goal: To reduce overall controls equipment cost.

Distributed Modular I/O Solution: Discrete input devices, valve manifold controllers and RFID readers reduced the cabinet space and shortened the installation time. The costs associated with the "laborious parallel wiring" of sensors and valve manifolds was dramatically reduced. When tearing the machine down for transport, only a few connections had to be detached and at the installation site a mechanic alone was needed to reconnect the few required connections.
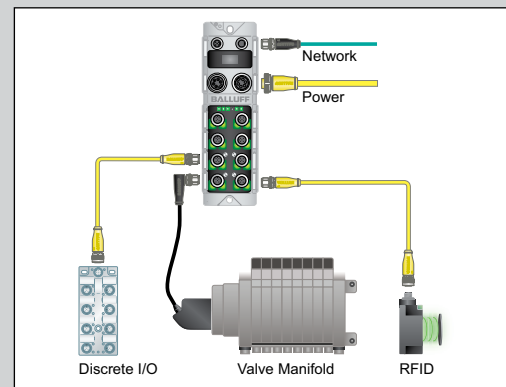
anywhere on the machine without an analog card in the controller or a long shielded cable run through the equipment to a cabinet. It can interface with a valve manifold or communicate with intelligent sensors and RFID processors. Distributed Modular I/O collects all of this information into one IP or node address and communicates directly with the controller over the industrial network.

5 Reasons to Switch to a Distributed Modular I/O solution

A number of important benefits become evident when a Distributed Modular I/O system is implemented into a controls design.

1) Simplifies the Controls Quotation Process. It utilizes the same components for I/O regardless of the PLC brand or industrial network selected. Pricing for controls equipment is standardized from machine to machine which makes calculations easily expandable.

2) Opens Assembly Teams to Additional Projects. Building controls cabinets is skilled work and they are time consuming to assemble, wire, and test properly. An IP67 Distributed Modular I/O solution can be mounted right on the machine quickly with less labor. Everything is then wired with standard industrial connectors with less time needed for installation. Speed in setup allows for more projects per year to go through the assembly floor.

3) Maximizes Spares. Most initial designs include a set of spare I/O points for later development or modifications. Whether the customer wants to add a few sensors to the design or add a single channel of analog to the machine, spares and additions to the design can add major cost to the controls bill of materials. With this solution, spare connections can be a flexible placeholder for any type of I/O until the need arises, without adding any controls cabinet space.

4) Protects the Network Integrity. One important factor in any machine design is to limit the exposure of the industrial network cabling that runs through the machine. By using a Distributed Modular I/O solution the network cabling can be kept out of harms way and only the individual I/O device cables run into aggressive environments.

5) Reduces Total Cost per Point. The labor involved in parallel wiring a valve manifold or terminating a set of discrete sensors is labor intensive. Analog devices can get expensive quickly with shielded cable runs and costly four channel analog input cards, especially when there is only a need for one analog channel. Distributed Modular I/O reduces the labor required in hardware setup and can be customized to reduce I/O hardware costs.

How Distributed Modular I/O Works

Think of a remote "slice" I/O solution. In a typical application, the communication head and the power supply sit on the left hand side and then they are followed along the backplane by the individual I/O devices. Usually there are a limited number of slots available in the backplane and individual slices of controls components can be inserted (discrete 24V input cards or 0-10V analog cards for example). In a similar fashion, a Distributed Modular I/O system has a communications head that talks over an industrial network on one side and collects data as a "master" device on the right hand side. In lieu of a backplane, each "slave" device is connected to an industry standard M12 port utilizing a simple 3-wire sensor cable for communication. With the ability to be installed within a 20 meter radius from the "master" device in any direction, "slave" devices can be easily distributed across the machine, in close proximity to the sensors and actuators that are wired to them.

Utilizing a widely accepted open point-to-point technology, IO-Link (www.io-link.com); a distributed modular I/O system is fieldbus independent; is easily configured and is vendor neutral. Process data shows up as simple packets of bytes in the controller for easy integration. Encapsulating the benefits of IO-Link in his blog, Carl Henning (Deputy

Director of PI North America) states: "'You don't have to manually go to each device to configure it, re-configure it, or extract asset management information from it.' In fact you probably can't access the asset management information at all without IO-Link."[4] Thus the parameterization data allows the devices to be quickly configured using simple read/write commands. And best of all, there is no "sub-bus" to cause headaches, nor is there some new protocol to be educated on.

The paper "IO-Link: The USB interface"[5] summarizes the IO-Link technology best: *"IO-Link is most appropriately compared with the USB interface. Both are cost effective serial point-to-point connections for signal and power transmission and are designed for plug-and-play installation. USB has established itself as the standard for both fast and cost effective connecting of computer peripherals. IO-Link offers everything needed to assume a similar role as the installation system for connecting sensors, actuators, controls, and display elements in machine building. Downward compatibility to non-IO-Link capable standard sensors, immunity to interference as well as the use of unshielded standard 3-conductor cables make IO-Link the ideal solution for this sector of industry."*

Distributed Modular I/O from Balluff

This paper covered many aspects of Distributed Modular I/O and the benefits of this type of technology. When partnering with Balluff on any controls I/O projects, we bring the following advantages to the design table:

Industrial Network Neutral. EtherNet/IP, Profinet, Profibus, CC-Link – there is a master device for many of the industrial networks that work with your PLC. Supporting add-on-instructions, test code, data-tables and all of the necessary pieces to get you up and running quickly are easily available.

Market Leader in Distributed Modular I/O utilizing IO-Link.
Balluff has the most devices available in the market for this non-proprietary open I/O solution.

- Discrete I/O in many form factors for a variety of I/O applications.
- Analog I/O can get you analog for a cost effective price.
- Valve Manifold Control connectors for pneumatic motion control.
- Color, measurement, and edge detection sensors.
- Non-contact connectors to bridge an air-gap or axis of rotation.
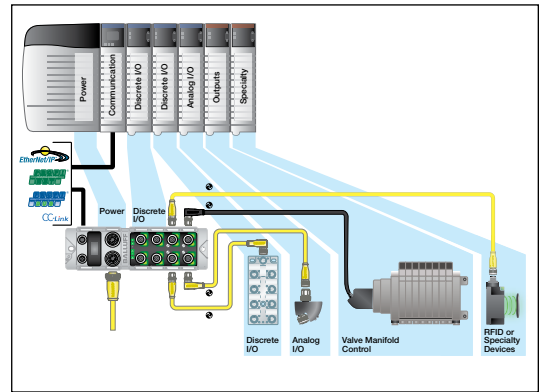- RFID processors for data tracking and logistics applications.
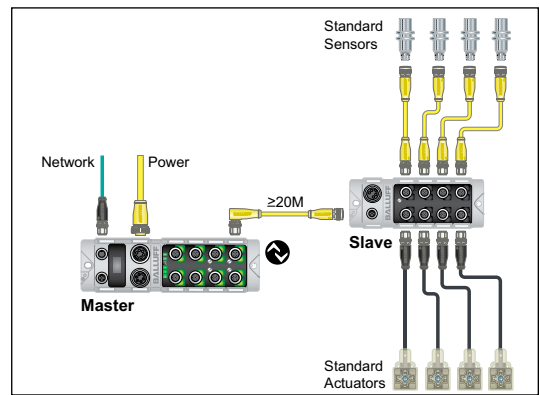

Figure 7: How it works


Figure 8: Master/Slave Point-to-Point

Figure 9: IO-Link consortium and vendors

Example: Cost Savings on Discrete I/O
Machine Builder Application: The machine builder designs and builds machining centers for automotive drive-train components.

Goal: To improve the cost per point of discrete I/O, collect diagnostic I/O data and protect the fieldbus cabling from failure.

Distributed Modular I/O Solution: By mounting the I/O devices near the sensors, they reduced their costs on sensor cables, reduced the amount of network cables and removed the network connections from a hostile environment. The Distributed Modular I/O solution also collected many points of diagnostic data for troubleshooting the machine. This particular customer was able to save 60% of their component costs alone over their original I/O system.
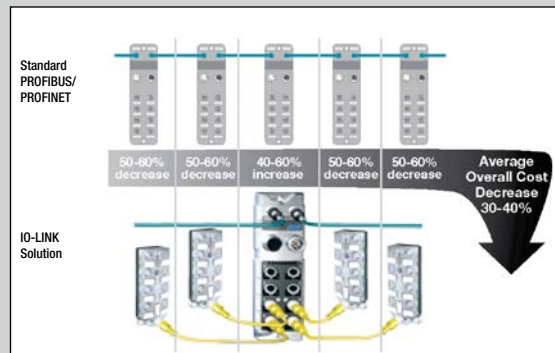
Rugged I/O from a Known Sensor Supplier. Balluff has been making rugged sensor products for over 50 years. The durable and reliable engineering that goes into our sensor design is continued in our rugged IP67 I/O products.

Local and Global Support. Balluff can support you day or night in 54 countries across the globe; as well as support you locally with our premier distributor & sales network. Our technical support staff is on-call 24/7 in Florence, KY and is eager to assist.

Next Step. Compare your current I/O solution with Balluff's Distributed Modular I/O solution. Email your I/O concept to technicalsupport@balluff.com and one of our experienced application engineers will help you put together a bill of materials to demonstrate the cost savings.

References:

1. Title: World Market for Industrial Networking – 2010 Edition
   Author: John B Morse
   Company: IMS Research www.IMSresearch.com
   Published: Aug 2010
   Type: Published Research Study

2. Title: VDC Research Webcast – Industrial Network Markets – User Requirements Update
   Presented By: Chris Rezendes Executive VP copyright 2010
   Company: VDC Research Group, Inc. www.vdcresearch.com
   Date: 3/18/2010
   Type: Webinar Presentation

3. Title: The State of Manufacturing
   Produced By: Peter Welander, copyright 2011 CFE Media
   Date: 4/12/2011
   Type: Video
   Published: www.controlseng.com

4. Title: Hanover Fair 2011 Part 5: IO-Link
   Author: Carl Henning
   Date: 18 May 2011
   Published: The PROFIblog us.profibus.com/profiblog
   Type: Blog Entry

5. Title: IO-Link – The USB Interface for the Sensor/Actuator Level
   Authors: Dr. Gerhard Drunk (xpertgate GmbH+CoKG), Albert Feinaugle (Balluff GmbH)
   Type: Technical Paper

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Will Healy III is a network and connectivity market manager for Balluff North America, based in Florence, KY.

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