Ethernet I/O in the Age of IIoT

Advancements in access to data seems synonymous with the sun rising and falling

Data is everywhere. The amount of information processed every day is mind boggling. We are constantly reminded, often alarmingly so, that the age of Big Data is our epic panacea. Conditioned like Pavlov's dogs, we now expect and seek more and more data, speedier access and technology via IoT, IIoT, 5G's rollout, MIMO Wi-Fi, Industry 4.0, etc.

For the commercial and private users, the blinding frequency of advancements in access to data seems synonymous with the sun rising and falling: it will just happen. But here in the industrial automation industry, speed and access are only part of the equation. As the saying goes: "Trash in, trash out;" poor quality data yields poor quality results. With our fixation on speed and unlimited access to a massive and growing cloud of digital data, the desire for convenient access has overshadowed the importance of signal integrity at the analog level. Analog may seem boring and slow, often equated to the "Stone Age" compared to digital data. In our industrial world, however, it is the integrity of the initial analog measurement that has direct impact on the quality of results.

It is here where we have to look through the cloud of data convenience and not forget that while Industrial Ethernet is winning out over proprietary industrial communication networks and topologies, signal measurement integrity at the I/O level is still of utmost importance.

Ethernet ubiquity

It is nearly impossible to find a Fortune 500 company that has not installed plenty of Ethernet and fiber backbones throughout their corporate campuses and manufacturing facilities. Even small, privately held companies have adopted the once thick and cumbersome coax called Ethernet. Now, with UTP (Unshielded Twisted Pair) and fiber being utilized at the physical and data link layers (1 and 2 of the OSI Model), Ethernet has gained unfettered admission right onto the plant floor.

Ethernet's ease of installation and low cost has made it the de-facto standard for networking at both the industrial and corporate level. Speedy broadband connections are now affordable for use by just about anyone. Industrial RJ-45 connectors, patch cables, hardened switches and network cards are as inexpensive and prevalent as desktop calculators. You would be hard pressed to find a manufacturing facility constructed in this millennium that didn't have fiber or UTP cable embedded all throughout its walls.

It was once proclaimed by many that "Ethernet's place is in the front office. It will never make it out to the plant floor." While Ethernet's argued impediments range from lack of determinism to limited transmission distances, we now know that its capacity for determinism, when properly designed with switches and smaller collision domains, is manageable. Distance limitations can be overcome by the use of fiber, repeaters, and even wireless systems.

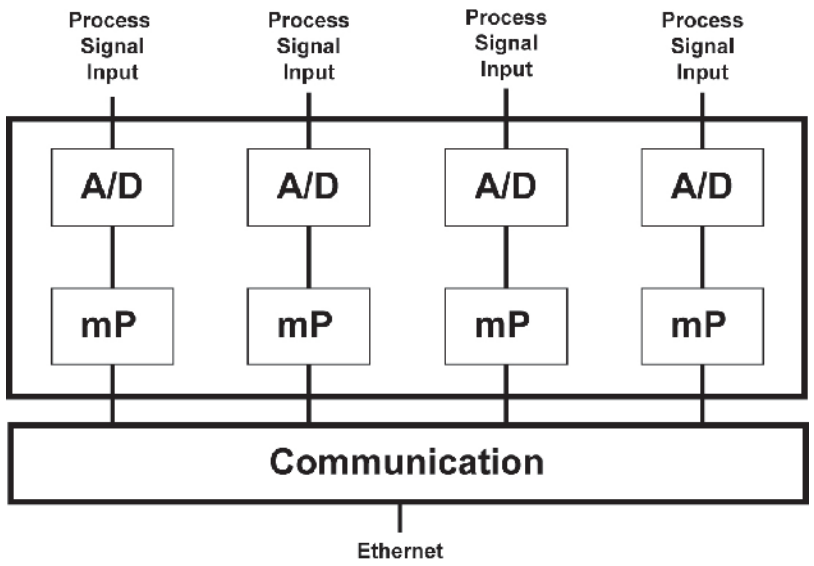

Figure 1. Reliable I/O systems that use an individual A/D converter and microprocessor (mP) for each I/O channel avoid single points of failure because a problem with one I/O channel has no effect on any of the other channels.

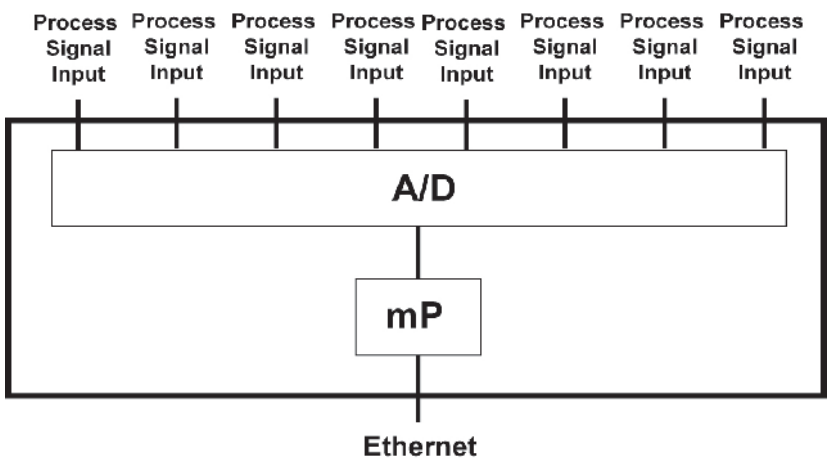

Figure 2. A traditional I/O multiplexer processes all of its signal inputs and outputs through a common A/C converter and microprocessor, leaving all I/O channels extremely vulnerable to signal points of failure.

Sensor-to-ERP-to-cloud

Information is power. The ability to gather time-critical information, digest it, and react upon it is the only way manufacturing companies have to stay in touch with customer's needs and demands. Without it, companies implode. Today, ERP (Enterprise Resource Planning) systems exist in most all companies. Whether packaged or custom, their purpose remains the same: to compile data for examination and decision-making. Initially these reports were "Front Office" reports. Today, they consist of the last widget or batch that just came out of production 15 minutes ago. This data typically comes from a MES (Manufacturing Execution System) package where it was obtained through a SCADA system via a PLC, BPCS or remote I/O device.

The lower half of the communication tree is where the difficulty lies. Data needs to get from the bottom of the organization to the top, efficiently. While Ethernet ties these upper level systems together, many distributed I/O communication networks use proprietary protocols. With Ethernet-enabled I/O, many of these difficult layers can be circumvented by tying directly to upper level systems via FTP, HTML, and even OPC over Ethernet.

Protocol medley

With many twisted pair and coax networks, you are locked into using only one particular protocol simultaneously. For instance, if you are running Modbus/RTU over twisted pair, you cannot transmit any other protocol over the same twisted pair unless you first stop the system's Modbus Master from polling the Modbus slave(s) to allow communication of the other protocol.

Alternatively, by using Ethernet I/O, you can have several protocols operating over the same Ethernet physical layer. For example, suppose you want to take plant floor data to a relational database while also viewing this data with your browser, and historically trending it with your HMI. In the Modbus/RTU example, you would have to go through some type of gateway and/or combination of OPC servers and HMI's to accomplish this.

However, with an Ethernet remote I/O system that speaks Modbus/TCP, you can have an embedded web server and an OPC server that allow all of this data to be requested simultaneously over the same UTP or fiber cabling with no additional communication gateways involved. In short, Ethernet allows various protocols to co-exist over Ethernet at the same time. TCP, IP, UDP, SNMP, Modbus/TCP, HTML, SMTP and OPC can all operate in parallel, often in concert. This provides a compelling argument for preventive maintenance teams to quickly diagnose and troubleshoot plant operations and activity.

Embedded web servers to the rescue

Many Ethernet I/O systems have embedded FTP (File Transfer Protocol)

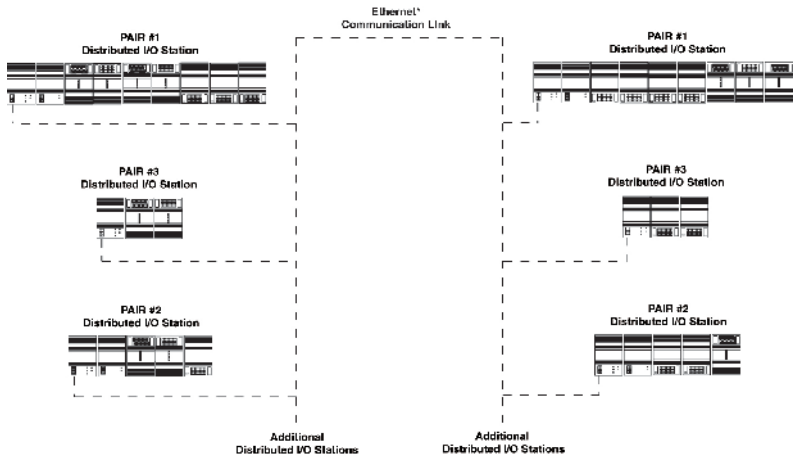

Figure 3. A Peer-to-Peer distributed Ethernet I/O network can be used to economically transmit process signals between the field and control room.

servers and web (HTML) servers that can be used for real time viewing of data, historical collection, and configuration of I/O system. Ever tried to quickly take a look into a PLC that is not Ethernet-based without using PLC programming software or a customer HMI screen? Chances are you haven't because most traditional PLC systems require one or the other.

Many simple applications need an I/O system that can monitor just one or two critical points every so often, perhaps for troubleshooting. Ethernet I/O systems with built in web servers allow anyone with access to the intranet to use Internet Explorer or a similar web browser to view real time data without paying for a costly HMI node or site license. Furthermore, embedded web servers allow for WAN access to real time data from anywhere in the world. Security considerations must, of course, be reviewed to determine the need for network encryption and security paraphernalia.

Protocol considerations

While Ethernet gives end users more power and flexibility, don't make the mistake in presuming that because it's on Ethernet, it will easily communicate with everything else that is on Ethernet. Ethernet provides a framework of rules for the physical connections, and rules about "who can talk when." Layer 7 of the OSI model, which refers to the application layer, is probably the most important layer of all because this is where the protocol is defined.

An I/O system and host system that both operate over Ethernet may never be able to communicate with one another. This is because the protocol chosen by the Ethernet I/O vendor determines how easily your connectivity will be with other "off the shelf" or vendor supplied software. Protocols like Modbus/TCP, Ethernet/IP, HSE and OPC are some of the more popular "open" protocols available today. Almost all HMI vendors and control system vendors support one or more of these protocols.

Be wary of vendors pushing their own Ethernet proprietary protocol. It may end up costing you a lot of time and money when you ultimately run into messy compatibility issues. In today's economy, "cost of ownership" has been replaced with "cost of entry." Projects are evaluated and won based on the up front turnkey cost rather than looking at the long-term cost of maintaining the system after installation and commissioning. When choosing Ethernet I/O, be sure that your vendor is not pushing you into the dreaded, and expensive, corner of proprietary.

Plant floor expectations – trash-in entry point

Installing Ethernet I/O in clean, cool and non-hostile environments presents few obstacles. But even when the I/O itself resides in comfortable conditions, great lengths must still be taken to protect and isolate UTP and fiber backbones from noise, heat and vibration.

Many I/O systems are now installed in harsh conditions in locations where field mount instrumentation has traditionally been installed. This includes environments where high and low temperatures and RFI/EMI levels may exist. Therefore, it is imperative that the Ethernet I/O systems and accessories selected are up to the task. Be sure to choose Ethernet I/O that provides the following attributes:

- The ability to withstand high and low ambient temperature conditions of -40°C to 85°C (-40°F to 185°F);
- Provides channel-to- channel, case-to-channel, and channel-to-communication back plane signal isolation;
- Has dedicated A/D converter and microprocessors for each I/O channel (Figure 1) to avoid failures of entire blocks of I/O channels as is common in I/O systems (or multiplexers) that use a single A/D converter and microprocessor for multiple channels (Figure 2);
- Has high input resolution for added accuracy for precision measurements of (> 18 bit A/D and D/A resolution); and
- Is RFI/EMI protected to >20V/m to shield it from measurement errors caused by stray electrical noise. Keep in mind that RFI/EMI can penetrate right through plastic I/O module housings, so I/O systems that have metal housing are a big plus.

Control, math, and Peer-to-Peer capability

As control capability gets pushed further into the field, specify remote I/O that has the ability to accommodate control and math capabilities that one day might be needed. Some remote I/O vendors are implementing full-fledged control capability by offering a RTOS (Real Time Operating System), RTC (Real Time Clock) and RTCE (Real Time Control Engine) within their platforms. Math capabilities also allow many Ethernet remote I/O systems to handle functions that were typically handled by an expensive PLC. This may include acting as a flow computer, remote terminal unit (RTU), and a high/low selector.

Peer-to-Peer communication capability with independent I/O systems is also a growing trend. In a convenient and cost-effective way, Ethernet and fiber backbones now provide migration of signals from one side of the plant to the other (Figure 3). Some type of channel-mapping system that is inherent to the I/O system can be very useful when spare twisted pairs are no longer available.

Ethernet I/O's future

While securing signal integrity with the properly selected Ethernet I/O products, data integrity is every vendor and client's next imminent concern. Cyber security is not a new topic, but industrial vendors of Ethernet enabled products are already feverishly working towards ensuring their products cannot be accessed or manipulated by any unauthorized or rogue entity. Newer products and vendors will now be paying much more close attention to how their software is written, what standards it is written to and how much access is allowed to the product once installed at customer sites. Front end signal integrity to back end data integrity with full security is the new benchmark for all future Ethernet I/O products.

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