

AutomationWorld[®] TACTICAL BRIEF

A Structured Approach to the Physical Network

CONTENTS

- 02. Application Profiles Simplify Industrial Networks
- 05. Improve Industrial Ethernet Network Uptime
- 07. How to Design a Structured Approach to Cabling

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Application Profiles Simplify Industrial Networks

Network providers are using profiles to shorten setup time while also focusing on making it easier to lay out networking architectures.

By Terry Costlow, Automation World Contributing Writer

The widespread adoption of Ethernet has eliminated many communication challenges, but connectivity still isn't simple. Vendors throughout the supply chain are devising new ways to help users connect devices while striving to improve efficiency and speed.

Now that Ethernet is the standard link for both front office and industrial operations, corporations are looking for techniques that make it easier to share data throughout the enterprise. Many are focusing on ways to reduce the number of protocols they deploy.

"Specialization is ending," says Dan McGrath, a Panduit engineer and spokesman for the [Industrial IP Advantage](#), a coalition of companies supporting the use of Internet protocol. "The move to industrial Ethernet has coincided with a move to single-protocol operation, with that protocol supporting all disciplines as a single plantwide communications solution."

Though the combination of TCP/IP makes that goal possible, using a single protocol isn't

always possible. Many versions of Ethernet are used to meet varying requirements for industrial applications. Most plant floors employ equipment from a range of vendors that use different flavors of Ethernet.

Networking specialists are devising new ways to further simplify the task of networking equipment on the plant floor. Some groups are developing profiles that provide a common approach for a given industry or application. Many are also devising techniques that make it easier to operate in multi-protocol environments. Others are focusing on ways to make it easier to set up networks, while the entire industry explores varying bandwidth requirements.

For the past few years, ease of use has been one of the major efforts in networking. That focus has come as the basic tasks of communication have solidified. The protocols themselves aren't changing much, giving industry groups time to focus on developing

Accelerate Deployments While Reducing Risks



The Panduit Integrated Network Zone System enables network communications from control room to factory floor and reduces deployment time by up to 75%.

- Improve reliability, security, and safety
- Localize network traffic to improve network resiliency
- Reduce cost of future expansion.

Continued Application Profiles Simplify Industrial Networks

profiles that address broad focus areas. These profiles provide a solid starting point for integrators.

Profiles also make it more straightforward to share information. In an era based on remote manufacturing and outsourcing, the ability to communicate with different groups has become quite important. When teams all use the same profile, it improves communication and helps companies configure systems using equipment from various suppliers.

The ability to piggyback safety onto Ethernet is another major step that's simplified networking installations. As this trend moves further into the mainstream, engineers are devising techniques that help improve efficiency. For example, it's fairly straightforward to limit emergency shutdowns to specific areas of a line, in contrast to the full-line shutdowns that were common with dedicated safety networks.

Network developers are also leveraging the many advances that come with using Internet protocols. The compatibility is a boon for maintenance personnel who know how to use common business tools. These tools can be used to troubleshoot industrial systems.

Configuration challenges

When integrators and managers set up networks, topologies and architectures are among the early issues that must be resolved. Equipment and component developers are using different strategies

to make it easier to set up networks and add or update equipment as needs evolve. Adding a second port is a common technique.

Often, the path to simplify networking architectures depends on the definition of simplicity. An architecture that's easy to set up may not be the best approach when developers look at the bigger picture and consider future expansion.

"Using managed switches and a structured cabling may seem counterintuitive, since linear topologies with unmanaged switches are far simpler for small systems," says Paul Brooks, a Rockwell Automation manager representing the Industrial IP Advantage. "Few Ethernet installations stay small, because the value is in the information and that information can't be stranded. In medium and large networks, the incremental effort to properly architect the physical and switch infrastructure will result in a network that is far easier to maintain, diagnose and extend, resulting in reduced total cost of ownership and ultimately reduced training burden.

Though many companies are bullish on managed switches, they aren't universally revered. Some technologies don't have switches, contending that they hamper rather than help performance.

Redundancy is another expanding trend. As the price of equipment comes down, it's easier to add equipment that ensures that a single failure won't shut down a full line. The huge potential cost of unplanned shutdowns often makes it easy to justify any additional

Continued Application Profiles Simplify Industrial Networks

expense. Many protocols make it simple to add duplicate hardware.

Need speed?

Regardless of the protocol or topology that's being used, engineers will spend a fair amount of time talking about speed. For many applications, 100 Mbps Ethernet provides enough bandwidth to meet all requirements. But when functions like motion control and video are added, the need for speed becomes more of a concern.

Backbones are another area where higher speeds are necessary. Many integrators use fast networks for backbones, with less expensive links used for equipment that doesn't have the same bandwidth demands.

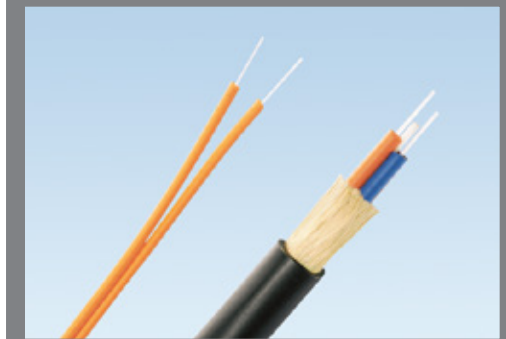
"We anticipate that 100 Mbps full duplex

will serve the needs of edge devices for the foreseeable future," McGrath says. "1 Gbps is becoming common at the infrastructure level (switch to switch) and will become the norm connecting to servers and increasingly to high-performance controllers."

Much of the information sent between machines is not particularly time-critical. That lets system designers give special priority to data types or machines that have more demanding requirements.

The effort to guarantee delivery capabilities is happening at many levels. Much activity occurs at the equipment level and during network integration. Component suppliers are also striving to make it simpler for equipment designers to ensure that data packets arrive on time.

Provide a Strong Infrastructure Opti-Core® IndustrialNet™



Polymer Coated Fiber (PCF) Cables are ideal for installation in harsh, industrial environments and are suitable for applications that demand high mechanical integrity and reliability. They are available in both interconnect (FBSP52--WW-ENG) and breakout (FBSP51--WW-ENG) versions. Small form-factor simplex or duplex LC connectors (FBSP55--WW-ENG) are designed for use with graded index, OM1 and OM2, Polymer Coated Fiber (PCF) in industrial networks with minimal installer training.

Improve Industrial Ethernet Network Uptime

Industrial IP Advantage

By Robert Reid, Panduit Sr Product Development Manager

What we are seeing today in manufacturing is an update of plant network architectures with solutions that securely merge information and control data to improve performance, security and safety within the plant. Network uptime is becoming increasingly important as Ethernet is starting to be deployed for critical and time-based processes, where keeping such discrete networks active through a fault without stopping critical processes is paramount.

Given that greater than 60% of Ethernet link failures are related to physical infrastructure (Grenier, 2011), it is important from the outset to design and build a resilient network that is architected to recover (converge) quickly from a failure condition.

Switching and signaling delays are affected by media type (Fiber/Copper), media length, number of switch hops and transceiver type, whereas processing and reservation time are independent.

Convergence occurs as a result of a change in network topology, i.e., a physical link failure. When this occurs, a routing algorithm is run to build a new routing table based on the failure condition/location. Once all the routing tables have been updated, convergence is complete.

The convergence time to recover and restore from a failed path condition depends on several factors. In restoration, switching occurs after backup paths are computed following the receipt of failure notification. The convergence time to recover a single path is the sum

of the following:

- Signal delay: time to signal a network failure between nodes (largest component)
- New path processing delay: time taken to compute an alternate path
- New path reservation delay: time required to reserve on newly computed path
- Switching delay: the time required to switch from affected path to new path

For a detailed experimental validation of convergence time over different media (copper fiber) and transceiver sets, refer to joint Rockwell Automation and Cisco work on network resiliency.

One of the main findings of this study is that fiber offers higher resiliency through convergence times for uplinks and rings as compared to copper. In the network architectures covered, network availability and performance benefits described can be achieved by deploying robust fiber optic cabling channels as shown in the Converged Plantwide Ethernet (CPwE) Design and Implementation Guide (ENET-TD001).

One way to achieve high resiliency on uplinks is to deploy a redundant star topology utilizing a redundant pair of fiber links on a single switch, one active and one acting as a standby (Cisco FlexLinks and LACP for example). Convergence times here can be

Continued Improve Industrial Ethernet Network Uptime

less than 50 ms. of convergence.

High resiliency/low convergence time on rings can also be achieved through protocol (REP - Resilient Ethernet Protocol) with fiber where we have critical processes that require a few ms of convergence.

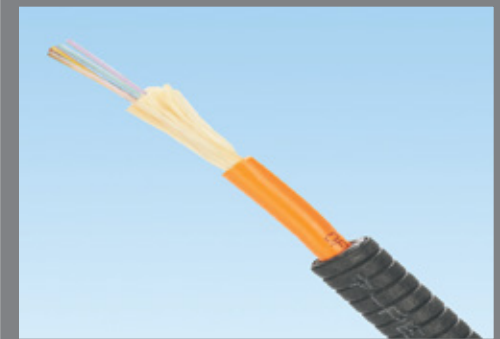
Obviously, not all industrial Ethernet applications have strict requirements on convergence time. Required convergence times depend on the tolerance of the system to withstand a loss of communications and the risk posed. Convergence time requirements vary from information processing, such as Human Machine Interface (HMI) applications, where less than 1 second is acceptable, to critical motion control applications where a handful of msec is required. Choice of physical infrastructure (architecture, media types, transceiver sets) vs convergence requirements should be studied in the light of total installed cost.

The most common pushback to deploying

fiber in such networks, is that solutions tend to be expensive and “craft sensitive” with high learning curves. Fiber solutions today have evolved to be much easier to deploy in factories and plants and there are new ways to terminate that are more “electrician friendly”. The “Deploying Panduit Polymer Coated Fiber (PCF) Cable” video shows deployment and termination of an Interconnect cable within a cabinet for an industrial application.

New installer friendly industrial automation fiber optic cables are designed with technicians in mind and are ideal for harsh, device-level industrial installations. Cost effective, large diameter, high strength GiPC fiber (Graded Index Plastic Clad Fiber), like hook-up wire, is easy to prepare and terminate with LC Crimp and Cleave connectors using hand-held tools and minimal training. A good resource for applying fiber with industrial applications is the Fiber Optic Infrastructure Application Guide.

Protect fiber cable with rugged DCF Cable



Opti-Core® Dielectric Conduited Fiber (DCF) Cables are designed for use in horizontal installations and backbones within buildings to provide high-density connectivity. Rugged conduit extruded over cable outer jacket eliminates the need for additional channel protection providing a smaller crush resistant pathway. All-dielectric construction eliminates the need for grounding and bonding, reducing installation time/cost. Optional DCF Fiber Strain Relief assists in bend radius control.

How to Design a Structured Approach to Cabling

Industrial IP Advantage

By Andy Banathy, Industrial Automation Solution Architect, Panduit - May 2013

More devices mean more data racing at higher rates across modern networks. The factors that favor structured cabling systems over the traditional point-to-point approach are multiplying every day in plants.

Old industrial control systems – many of them proprietary and often based on point-to-point cabling using screw-terminal connections – have given way to the ease of ubiquitous Ethernet and IP technology. This shift has helped spark an explosion of digital devices on plant floors, and increased the demand for the higher performance, bandwidth and reliability offered by a highly structured, standards-based network infrastructure.

More devices mean more data racing at higher rates across modern networks. Industrial data rates have risen from kilobits per second, to megabits per second, and even gigabit per second in some shop floor applications. To effectively operate at those rates – ensuring plant uptime and keeping costs down – modern networks need a well-engineered and validated cabling structure.

Structured cabling systems also are capable of evolving with the future. Industrial data rates eventually will meet and potentially surpass the 10-gigabit per-second level already common on the IT side. Meanwhile, industrial processes and machines are becoming more intelligent, employing advanced instrumentation, sensors and wireless technology.

Best-in-class manufacturers can achieve as much as 99.9% uptime and 90% OEE, providing their organizations lower total cost of ownership (TCO) and greater operating margins. Physical network design plays an important role.

For all these reasons and more, structured cabling systems are replacing the often haphazard and ad hoc point-to-point approach. In a structured scheme, cabling is systematically laid out, and managed to accommodate all today's and tomorrow's industrial communication needs, including voice, data and video.

Gaining the full benefits of structured cabling requires an equally systematic approach to conceptualizing, specifying, installing, testing and maintaining plant wide networks. Watch the recorded webinar “A Standards-Based Approach to the Industrial Physical Network” that reviews how standards based physical network topologies, cabling best practices including structured and point-to-point cabling methodologies, and designing for the environment can help provide a high performance, reliable and scalable plant network.

Defining the structured approach

Structured cabling systems comprise five subsystems in a facility:

- **The demarcation point**, where the telephone or Internet company ends and connects to the on-premises wiring
- **The equipment or telecommunications room**, which houses

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How to Design a Structured Approach to Cabling

equipment and consolidation points

- **Vertical or riser cabling**, which connects equipment rooms, usually between different floors
- **Horizontal wiring** that connects equipment rooms to individual outlets or work areas, usually on the same floor
- **The work area**, where user equipment connects through outlets to the horizontal cabling system

Zone Cabling Architecture Characteristics

A highly effective way to deploy EtherNet/IP solutions throughout the architecture is to physically distribute cabling runs using a zone cabling architecture for all plant networks. Zone cabling enables facility systems to be converged with Ethernet cabling pathways as they are being designed.. These systems are converged within a common pathway and then terminated within zone enclosures distributed throughout the plant. See the white paper, “Scaling the Plant Network” on improving reliability, security,

and safety of Industrial Automation systems with up to a 30% reduction in deployment costs and 75% savings in deployment time.

Cabling in each of these subsystem areas follows a defined form, composed typically of an equipment cord (a patch cord at the equipment end), the permanent link (fixed, solid conductor cabling) and a work area cord (i.e. a patch cord connecting to a work station). This arrangement is called the channel. Other configurations featuring additional connections in the channel are permissible.

The permanent link is a pivotal feature of any structured cabling system. For example, it runs from the telecommunications room (TR) to a distribution point (e.g. outlet or a patch panel.) That permanent link allows the uplink to be tested from the machine to the higher-level network, helping ensure the connection and the machine both will perform as needed. Likewise, in a ring network that connects multiple processes, a structured cabling configuration allows each link to be tested.

Contrast this methodology to the point-to-

Reliable Data Transfer for the Control Panel



IndustrialNet™ Category 5e Shielded 600 V-rated Patch Cords provide the ideal solution to support reliable Industrial Ethernet data transfer in the control panel, in the presence of external utility supply voltages. The robust, highly flexible cable used in the patch cord construction is UL rated Appliance Wiring Material and has a durable TPE jacket. The patch cords use shielded cable to ensure highest EMI performance and are available in a wide variety of lengths.

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How to Design a Structured Approach to Cabling

point cabling system approach, which seldom – if ever – involves testing. Instead, when plant personnel need to add another machine or extend the reach of a cable, they may simply use a patch cord and plug it into a switch panel. Indeed, some experienced control engineers are accustomed to creating their own patch cords by stripping off the jacket on a wire and attaching a connector on each end. These patch cords terminate in a plug, rather than a jack.

Such point-to-point practices might suffice with shorter patch-cord lengths. But this “extension cord” approach can fail to deliver full performance if a patch cord becomes 80 or 90 meters long. The reason: Stranded conductor cabling – which is prevalent in point-to-point cabling approaches – has less conductivity, and hence, higher insertion loss than the solid conductor cabling used in structured cabling systems.

And in a whole factory, point-to-point connections can result in network sprawl. Surrounded by hundreds and even thousands of unstructured, non-standard and unidentified connections, automation and IT people can lose track of what’s connected to what.

Collaboration between IT groups and automation staff is key to the success of any structured cabling project. IT people are highly familiar with structured cabling at the enterprise level, while automation people best understand the factory environment around machines.

But the collaboration can’t stop there. Maintenance and operations personnel – as well as outside experts – can play essential roles in

the implementation and smooth operation of structured network.

Follow these steps to implement and maintain an optimal structured cabling infrastructure:

1. Educate yourself. Get familiar with the standards and best practices established by organizations such as the Telecommunications Industry Association (TIA), the IEC, and ODVA, which offers information on machine-level EtherNet/IP best practices.

Common best practices for critical fiber and copper connections within network infrastructures include the ability to:

- Terminate horizontal runs to patch field connectors to form permanent link.
- Validate performance with standards-based tests and equipment.
- Easily replace patch cords if they are damaged or suspect. You do not need to touch the horizontal cable.
- Improve troubleshooting with well identified, structured connections that support staff can easily manage.

Standards organizations also have established parameters on network operating factors such as the error-rate performance. If the error rate starts to become too high, it slows down the network – and possibly could cause failure of the link.

Take advantage of structured cabling design guides from companies – for example the Fiber Optic Application Guide from

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How to Design a Structured Approach to Cabling

Rockwell Automation, Panduit, and Cisco – that specify how to design and deploy structured cabling for fiber and copper systems. Seminars and other types of structured cabling training are also available.

The Internet Protocol (IP) encompasses the use of advanced networking technology, infrastructure and practices to create the secure communications fabric necessary to support every device and process within your plant. Visit and register at www.industrial-ip.org to keep your finger on the pulse of the latest news and updates.

2. Establish your goals and objectives. Assess your needs today, while keeping the future firmly in mind. Where will your operation be in five or 10 years? If you want to go to gigabit-per-second equipment-data rates, structured cabling offers the optimal support, and can be tested to validate that desired performance levels are met.

With structured networking, industrial plants become more scalable, especially if they invest in the recommended 30-to-40-percent spare

cabling at the time of initial installation.

3. Design the infrastructure and draft specifications. Many standards-based tools are available to help design your structured cabling network, including Visio and CAD. Additionally, many highly experienced third-party advisory services can help plants execute this critical step in the process.

Develop a specification document that establishes your structured cabling standards, and the materials required for your particular operation. Robust specifications will simplify the rest of the process, including installation, testing, operations and maintenance.

Specifications will cover how to implement the plant network for reliability, security and physical considerations. Those include the integrity of the cabling itself, since substandard cabling could come with serious consequences.

IT and automation personnel should collaborate on the specification document to drive best practices throughout their facility. Specifications often detail how to implement structured cabling to connect the enterprise

Maximum Protection for Data Transfer



The IndustrialNet™ M12 D-code to RJ45 panel mount adapter provides an ideal interface from the active equipment inside an industrial control panel to the frequently harsh environment encountered on the shop floor. The RJ45 jack is suitable for industry-wide use of RJ45 based patch cords, and the external M12 D-code jack when mated with the M12 plug on an external network cable is IP67 rated for maximum protection. The adapter is shielded ensuring highest EMI performance.

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How to Design a Structured Approach to Cabling

level to distribution zones, and how to bring cabling into the process and individual machines.

This document also allows you to specify your standards on required bandwidth performance, so you have consistency for today and you're future-ready. You also can specify where it's critical to locate testing patch points and what your requirements are for testing.

Protecting the network from the environment is another key consideration in many plants. If you have electromagnetic interference (EMI) risks, then you may need shielded cabling or conduits. The TIA and IEC have established standards related to environmental assessment to help in the process.

You may also want to develop physical identification strategies, such as using color-coded cabling and jacks, and labeling ports. Such strategies will help reduce risks in installation, and far into the future because personnel will be able to clearly understand where various cables should connect.

Specifications should also include any necessary security tactics, including lockable enclosures, port block-outs and plug lock-ins that limit access and help prevent unauthorized connections or removal of patch cords.

4. Installation – Because of the many details included in installation, this is the step with the greatest potential for error. For example, plants that want to support gigabit per second communications may buy the correct Category 6 cabling, but it must

be installed correctly to deliver that rate.

Make sure your installer understands the intricacies of working with structured cabling – details like bend radius and the twist of the cable, the routing, and protecting the network from noise sources. You can take advantage of third-party certified installers, or make sure your own installers have the necessary expertise by attending training classes that are available.

There also are integrated, standardized installation tools and products on the market to help reduce the amount of training and expertise needed. One example would be an enclosure that's pre-wired using all the best practices for patching and cabling.

Keep your installations neat and clean. Bundle cables when routing both long- distance and short-distance cable. That way, you can easily troubleshoot the system, make any necessary changes to adjust to production demands, and properly maintain your system long-term. Ensure standards-based labeling schemes are used.

5. Testing. This is where a standards-based structured cabling network really shines. Testing equipment is readily available on the market to help ensure you're getting the performance you paid for – and that you can count on it well into the future.

Without testing, you risk startup delays, downtime, callbacks to the manufacturer and a host of other costly huge headaches.

But with successful testing results in hand to benchmark performance, you can use scheduled shutdowns or upgrading

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How to Design a Structured Approach to Cabling

opportunities to retest and validate your network – the backbone of your automation system.

6. Operations and maintenance. While the design and installation of a structured cabling network is usually undertaken by a specialized group – often a third-party – the system ultimately becomes the responsibility of the industrial automation user.

To avoid subsequent degradation of the system, you have to keep leveraging the capabilities and best practices designed into the system – or risk losing control of it.

A common problem is the return of the old point-to-point practices. Someone on the plant floor may decide to put in a new cord to solve a problem or serve a temporary need. But more problems can arise if they don't bundle correctly, or fail to identify the connection. Soon, you could

have multiple dangling cords – and no idea why.

Or you may end up with surplus cabling on the floor because personnel used a 10-foot patch cord where they should have used a much shorter one.

Then there's the chance that someone may go in and unblock a port and forget to block it up. Now you're left with a potential access-point to the system.

Such patchwork problems can be avoided by clearly establishing and strictly enforcing operational and maintenance policies regarded structured cabling networks. Plants can also employ monitoring tools for the operational phase that can detect problems with your network traffic and physical infrastructure, such as the condition of your switches and servers, as well as environmental and security controls.

See Why Industrial IP is the Future of Connectivity



Industrial IP Advantage is here to help you make the most of networking technologies - existing and emerging - that make integration and the flow of information effortless. This community will keep you up to date with the latest trends, developments, implementation advice and opinions on the use of IP in industrial applications. Visit <http://www.industrial-ip.org>