Smart Communication: Critical Connections in the Factory of the Future

By: Subhajit Bagchi, vice president of engineering, industrial networking and security at Belden

In the factories of the future, smart communications will become increasingly critical in all aspects of the operation. As models for the Industrial Internet of Things (IIoT) mature and become hardened realities, the technologies and strategies for connecting machines will be essential for enabling increased efficiency, resiliency and productivity.

Moving toward a truly connected factory environment requires recognizing the fundamental shift from discrete silos to an integrated stack that connects all layers of the operation – from the production floor to the back office and global networks as well as third party data sources. Advanced communication technology is essential for driving enormous increases in efficiency in this model and eliminating the obstacles for communication between the server and field levels.

What Smart Communications Networks Must Deliver

The factory of the future will be built upon cyber-physical systems, which are the integration of computation, networking and physical processes.

It’s estimated that the number of connected devices will double or triple in these operations. In this environment, optimal performance of the communications network will be defined by the ability of the network to:

- Reliably and securely connect a large number of devices
- Transfer large amounts of data in real-time
- Leverage wireless technology for remote connectivity, both within the factory and remotely
- Play a valuable role in ensuring cybersecurity for all equipment and systems

Examining the ways in which the communications and network technologies available today support these objectives offers a foundation for moving ahead on a smart communications strategy.

Designing the Smart Communications Network

While network complexity will increase in the factories of the future, manufacturers will remain diligent in ensuring the lowest cost and highest efficiency. Achieving these objectives will drive several shifts in connectivity and network topology, including:

1) All communications will be based on IP protocol families, and Ethernet will be the underlying communication protocol for consistent and unified communication.
2) The connectivity of devices will be hierarchical. Today, the field level is divided into logical cells, but as the amount of data generated in the cells will be significantly higher, this model will simplify network management and operation. Logical communication overlays and Publish-Subscribe systems will connect devices across all levels of the hierarchy.
3) The use of star topologies will increase due to the advantages of lower latency and higher reliability. Simulations have shown that the use of one larger switch for connections delivers higher Mean-Time-Between-Failure (MTBF).
4) Extensively meshed network topologies will also increase. Line or ring topologies will also be used, providing cabling advantages and requiring less management efforts.

Combined with new protocols, these networks will be easier to manage with centralized cloud services, make better use of resources and reduce costs. New services that leverage this connectivity can increase productivity, create new production processes and offer better products, such as customer-specific designs and feature sets.

**Speed and Reliability: The Hallmarks of a Data-Driven Industrial Operation**

In most factory applications, fast Ethernet with 100 mega bits per second (mbps) is the standard. As the volume of data grows, driving the need for higher data rates, the appetite for Gigabit Ethernet with 1000 mbps will escalate. An additional driver for higher line speeds is the demand for shorter forwarding delays in the microsecond range. Finally, high definition video streams as well as cloud based analytics and control also drive the need for high bandwidth and low latency networks.

Several trends will even accelerate the adoption:

1) Lower costs for faster connections, as new chip developments integrate Gigabit Ethernet
2) Lower power consumption driven by advances in semiconductor processes
3) Simplified cabling, which will allow Gigabit Ethernet to run on a single pair of copper wires (as opposed to the four pairs required today)

Speed is good, but the ability to provide a guaranteed maximum latency for data transfer is even better. In manufacturing, the time required for data to be transferred from the source to the destination and then back to the source is primarily driven by the process, but a guaranteed maximum latency is imperative if the vision of a data-driven industrial operation is to be achieved.

Closing the gap between what exists today for data latency guarantees (some real-time Ethernet protocols) and an Ethernet standard will be achieved through one or more of these communication infrastructure elements:

- **Time synchronization based on IEEE 1588 Precision Time Protocol (PTP):** Allows decentralized synchronized clocks to run on all components with an accuracy of less than one microsecond, making it possible to separate processes from communication and allow actions to be time-driven rather than event-driven. The network becomes the time source.

- **Increased data rates:** Made possible by the adoption of Gigabit Ethernet, delivers significant improvement for real-time applications. Lower latencies of data packets and improved data forwarding inside high-performance switches mean that switches are blocked only a fraction of the time.

- **The Time-Sensitive Networking (TSN) work group, under the umbrella of IEEE 802 for LAN networks:** Working to define a deterministic vision of Ethernet. Early work focuses on several technical concepts including ways to control the flow of real-time data packets from within the
switch, a bandwidth reservation protocol for all required resources on the network, and a pre-emption framework which would allow high-priority packets to pre-empt low priority packets in the queue.

The Reliable Wireless Network is Coming

In the factory of the future, the dominance of wired communications will continue. However, several advances in the reliability of wireless networking products are making the adoption of this highly cost effective technology easier for industrial environments.

- Enhanced electrostatic discharge protection for hazardous environments
- Wireless mesh technology for quick network reconfiguration and service assurance
- Redundancy protocols to make wireless communication a viable option for reliable control and monitoring

Especially in hazardous areas, the flexibility afforded by wireless connectivity will increase the use of industrial wireless products designed for such environments. Wireless is turning from a technology for early adopters to a reliable and efficient solution for any modern factory or plant.

Securing the Communications Network from Cyber Threats

There is no question that increased connectivity and the availability of information and communication technologies that rely on open standards is a positive move in industrial manufacturing. When data is available in real time, manufacturers can make faster and better decisions, and accelerate process improvements.

At the same time, there’s a greater risk to the system by creating more interconnections. Guarding against breaches – whether intentional or accidental – is essential for ensuring network availability, confidentiality, integrity and accountability.

The smart communications network will support security functions designed to meet these objectives:

- Encryption to protect confidentiality and prevent unauthorized interception of data
- Access control and authentication to ensure that only devices allowed to “talk” to one another do so, blocking users without explicit access to the network
- Zones and conduits that separate critical and non-critical sections of the factory
- Zone security controls for industrial protocols to protect against deliberate attacks and prevent unintentional threats from affecting critical assets

Getting Started: A Holistic Approach is Best

To achieve digitally integrated engineering and horizontal integration of the entire value chain, as well as vertical integration and connectivity across all levels of production, it’s best to adopt a holistic view.
Advances in communications and networking technologies are helping manufacturers to streamline and optimize the entire value chain. Organizations that begin with a vision that encompasses the entire process will be well-positioned to build the smart communications network for their factory of the future.