What’s Needed to Implement Today’s Industrial IoT Architecture

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Manufacturing and other industrial environments are starting to reap the productivity benefits of industrial internet of things (IIoT) technologies. Industries are using these adaptive solutions to optimize resource utilization, reduce unplanned downtime, and adapt their manufacturing flow to changing market requirements. Many organizations are now asking not whether to implement an IIoT framework, but how to best implement one. This blog post provides some direction.

For maximum operational efficiency and throughput, the Siemens electronics plant in Amberg, Germany, has automated the production of the company’s Simatic programmable logic controllers (PLCs). According to a case study published by IHS in 2018, the plant is so highly automated that “… products controlled their own manufacturing processes using a unique barcode to communicate and share requirements with production robots. An individual PLC could then take corrective action to avoid damage in the production process, and automatically replenish components in order to meet delivery deadlines.” Machines handle 75% of the value chain on their own.[1]

This Siemens plant generates 15-17 million data points each day, from information such as temperature profiles to data on the speed of reflow, solder pace, solder quantity, and supplier components. Indeed, data from automated facilities provides the lifeblood of the analysis that is conducted in order to improve efficiency and productivity. With this level of automation and big data analysis, organizations are experiencing tremendous impact in terms of defect reduction and quality improvement. On the Siemens plant, the IHS study reports: “As a result of the introduction of this process, quality has increased substantially. Whereas the production facility had 500 defects per million (dpm) back in 1989, it now has a mere 11 dpm. The Amberg plant realizes consistency from design to production with nearly seamless monitoring throughout the value chain with a production quality rate of 99.9989 percent.” In addition, “By using the data gathered through its smart machines, Siemens was also able to increase the transparency of the manufacturing process and energy efficiency measures, lowering energy costs by 12%.”[2]

The Siemens case study is just one of many, and exemplifies why now is good time to focus on ways to architect a factory's hardware to support the implementation phase of the IIoT.

Figure 1. Automated factories are reaping uptime and other productivity benefits, thanks to small, efficient, and reliable semiconductor components.

Today's Factory Pyramid

Visualizing today's factory network, one can picture a pyramid with a range of edge devices that collect information and run the production machines. The control layer, which is increasingly distributed across the plant, is above this edge layer.

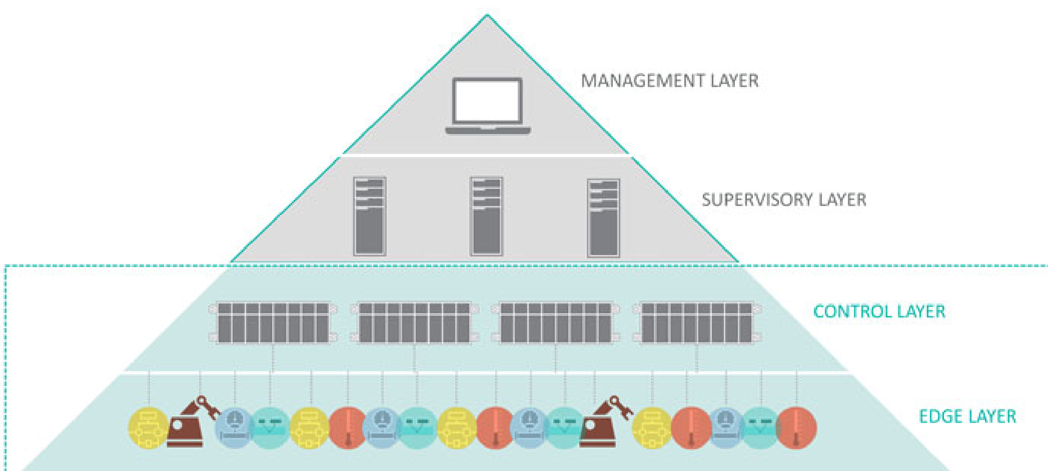

Figure 2. Hardware network architecture of a modern factory.

At the very top of the pyramid sits the management layer—this is where intelligent algorithms work to optimize machine throughput, predict potential failures, and enable an adaptive manufacturing flow. This process can occur in a private or public cloud; however, we may find that, at least for now, many plants and factories are more comfortable with the concept of storing their data on internal servers.

Industries that are implementing IIoT technologies are experiencing two key hardware-related factors. One lies in the rise of the number of smart, connected sensors that are gathering the crucial data which feeds big data analysis. Second, there's a steady migration of intelligence that is embedded within the edge devices.

This example illustrates what is happening inside many factories:

- Smarter sensors are communicating a richer data set to the cloud
- First-level analysis of vibration data is being performed at the machine level
- Multiple temperature points are collected and correlated before the data is sent to the controller
- Actuators have the intelligence to change a machine's performance and characteristics

With this new network structure comes more capability and intelligence at the "edge" of the factory network. These new sets of edge-device architectures demand high performance from components that must be tiny enough to fit within an existing piece of factory equipment and rugged enough to withstand the harsh environment that is manufacturing. This changing edge architecture affects the design of various systems.

Expanding Use of Smart Sensors

In an IoT implementation, a multitude of sensors collects data, pre-processes it, and sends it off to the IO hubs and/or distributed controllers. Over the years, these sensors have increased in functionality while shrinking in size.

As an example, let's take a look at the ubiquitous safety light curtain–opto-electronic devices that are used to safeguard personnel working near moving machinery that can potentially cause harm, such as presses, winders, and palletizers. Safety light curtains can be used as an alternative to mechanical barriers and other forms of traditional machine guarding. By reducing the need for physical guards and barriers, safety light curtains can increase the maintainability of the equipment they are guarding. In the 1960s, these systems were fairly large. Today's light curtains are much smaller and packed with more capabilities. With their intelligence, they can detect precisely which light beams are broken. As these devices continue to get smaller, we can deploy them in various mini sub-assemblies–and use the information of the exact location of a light curtain breach to optimize the sub-assembly design.

The architecture of smarter, connected sensors is enabled by different semiconductor technologies. As Figure 3 highlights, sensors are increasingly powered by microprocessors. In addition, they incorporate sophisticated serial transceivers and they need complex power subsystems.

Figure 3. Intelligent, connected sensors need complex building blocks.

Small Industrial Controllers Do More

PLCs processing all of the data collected in factories and manufacturing plants are getting smaller and increasing in channel density. It is not uncommon to find the number of IO channels going from 8 in a single digital input module to 32. As for the shrinking form-factor, we are now seeing the rise of micro PLCs, compact PLCs, nano PLCs, etc. As controllers get increasingly distributed on the factory floor, they must be small enough to fit on a sub-assembly line or, in some cases, even on a complex machine. These small sizes and higher channel counts come thanks to smaller, more integrated, and more reliable components.

Let's discuss an example that shows how advanced semiconductor technology helps to achieve smaller PLC architectures. A typical system has many power subsystems and, since modern microprocessors/DSPs demand multiple, well-regulated power rails, the number and complexity of power subsystems is on the rise. Figure 4 illustrates how progressive integration has reduced the size of the power subsystem.

Early power subsystems were discrete with many components outside the controller chip. Integrating FETs and compensation elements halved the size of the power solution. The emergence of power modules which integrated even the magnetics halved the power solution size again. Today, the latest generation of power modules feature innovative packaging technology that allows an even more dramatic reduction in size for a sub-set of load currents.

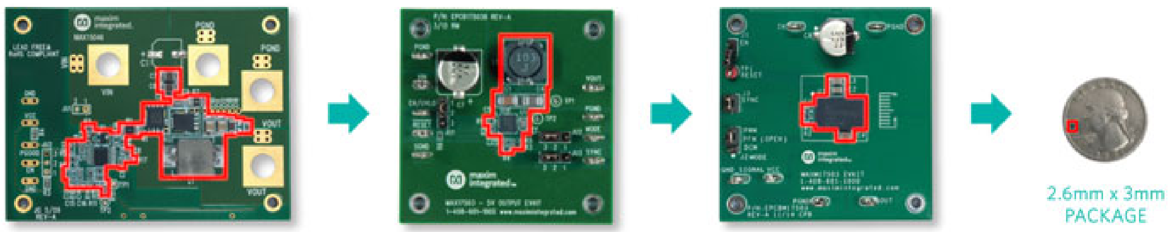

Figure 4. Substantial size reduction of power solutions in industrial systems over time.

What the Future Looks Like for IIoT Architectures

Next-generation IIoT solutions are aimed at increasing productivity, providing adaptive manufacturing, and delivering machine-level heath and status information to make mission-critical, real-time decisions. Further unlocking another element of industrial convergence calls for improving the availability, quality, and amount of real-time data that can be collected and uploaded to the cloud. As you can imagine, enabling these capabilities requires an even smaller footprint and better efficiency. Maxim's new Go-IO IIoT reference design provides 17 software-configurable IOs—including isolated digital inputs, digital outputs, IO-Link masters, and isolated RS-485 with integrated power—in a footprint of less than one cubic inch. Designed for rapid prototyping and development of configurable industrial-control systems, the Go-IO reference design is an example of the underlying technology that's needed to enable adaptive manufacturing. For a more in-depth look at this topic, read our article, "Empowering Design Innovation for IIoT," in Electronic Specifier.

References

[1,2] Industrial IoT Case Studies ›