Industrial Automation Consolidation Supports Smart Factories

Increased levels of automation add intelligence to the factory floor but also add complexity. However, the development of industrial automation, ***Internet of Things (IoT)*** and the consolidation of several principles of factory automation can simplify the equipment and processes needed to create smart factories that are efficient, reliable, secure and cost-effective.

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Increased levels of automation mean that factories operate at greater speeds, and must be flexible to change production supply easily and with minimal downtime. Equally they must be adaptable to meet the increased output levels driven by the demands of new markets, yet be sensitive to power consumption on grounds of both energy efficiency and cost. With each acquisition of equipment, there is also a requirement to realize a return on investment, sooner rather than later, as factory space and operating costs continue to increase. Industrial automation parts are also required to be rugged and resilient, able to operate in the most demanding environments, where noise, dust, water may be present. The component parts of industrial automation, PLC (Programmable Logic Controllers) HMI (Human Machine Interface), drives and sensors are all required to work in extremes of temperature, moisture, vibration, yet still provide accurate, deterministic, real-time control.

The new-wave of industrial automation requires the right silicon, software, tools and support for transmission, sensors, process instrumentation, industrial communication and control as well as interface technology for a low-power, real-time automation system.

Communication between equipment and devices within the process flow will play a larger part in the intelligent automation process, sometimes recognized as the "Fourth Industrial Revolution." (The steam engine, the conveyor belt and the first phase of IT and automation technologies being the first three.)

Communication can be used in a smart factory in several ways. It can relay information about repair and maintenance needs in advance, saving downtime as well as maintenance and repair bills. It can also be used to store and analyse data, to help manage inventory, stock levels, ordering and to manage the supply chain. Early warning systems can direct maintenance staff to take preventative measures to avoid stopping the production process. The use of predictive maintenance, warning of a possible weakness further down the line, can reduce not just downtime, but also tracks inventory levels as fewer spare parts will need to be stocked, and only ordered when imminently required.

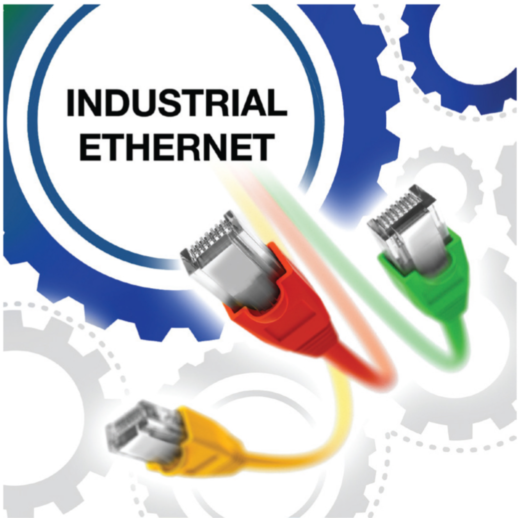

Figure 1. Industrial Ethernet adds real-time and deterministic delivery of I/O data in an industrial automation system.

Communication

Industrial communication, like Industrial Ethernet networks, PROFIBUS and Fieldbus, is a highly reliable communication channel within factory automation. It typically connects the PLC (Programmable Logic Controller) to the motors and sensors in the factory. It is typically based on a protocol that runs on an Ethernet framework, but adds deterministic latencies as well as some safety-specific aspects.

By connecting devices, control systems and management, the automation process can be efficient and streamlined. Ethernet networking allows maximum flexibility to connect devices in large networks with different types of services, such as data, voice and video. Industrial Ethernet adds real-time and deterministic delivery of I/O data in an industrial automation system. It is also characterized by a fast reaction time of typically 100ms and is a flexible network topology. A number of nodes can be incorporated into the system to meet the needs of the particular application.

Ethernet networking consists of a physical layer and data link layer, which is specified by IEEE 802.3, and a TCP/IP (Transmission Control Protocol/ Internet Protocol) networking stack.

Internet of Things (IoT) for industrial automation supports additional wireless communication and low power, short distance communication, such as Near Field Communication (NFC), using a contactless transceiver and dynamic transponder interface to wireless microcontrollers and a range of wireless, connected sensors, added using the Bluetooth, low energy SensorTag kit. For the industrial automation environment, there is a clear split of real-time communication used for production cycle and service communication used for maintenance and logistics.

Inductive, magneto-resistive, optical, pressure and ultrasonic sensors detect, position or identify an object or a rotating axis in an automated system. Each sensor requires a specific signal chain, which places demands on the designer to provide the right signal acquisition solution, while minimizing design time. Attention must also be paid to energy consumption using wireless networks. Arranging the sensor nodes in a mesh network, with sensors acting as an end-point with others functioning as repeaters is energy-efficient, as it reduces RF transmit power to create a low-power network as in ZigBee or 6LoWPAN wireless networks.

Industrial IoT

Industrial automation IoT is still in its infancy. The easiest way to deploy it is to connect the PLC or the HMI (Human Machine Interface) to the cloud to provide cloud visibility to the underlying industrial network. This requires some very strict security mechanism to make sure no attacks from the cloud can interfere with the factory automation. In commercial settings, such disruption, accidental or malicious, can be expensive, but on utilities, such as water or electricity supplies, such a disruption could cripple communities or put lives in danger.

A different way to address security and/or interference of automation systems is by opening a parallel channel to the industrial nodes, using non real-time IoT channels, typically over wireless connections, to complete non-mission-critical tasks such as maintenance, diagnostics and software upgrades.

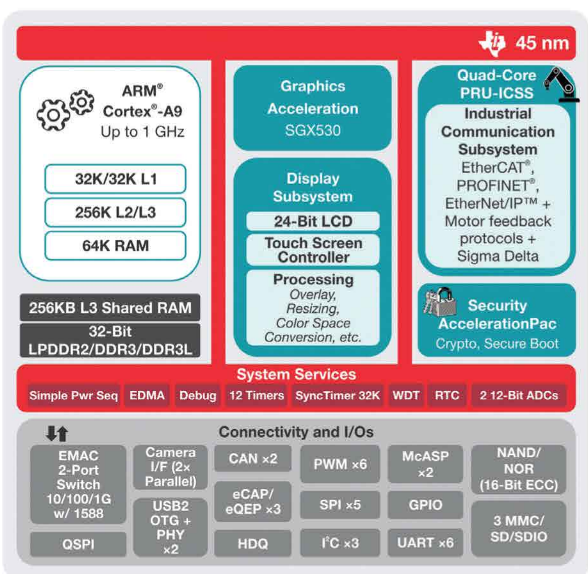

Figure 2. A functional block diagram of the Sitara AM437x processor.

The advantage of connecting "everything" in the smart factory provides the basis for a more efficient and more flexible production schedule. Adding communication between product and machine can revolutionize the process. Doing this allows the product to talk to the machine and define its destiny or end-use, advising if a particular process or part is required, for example. At the same time, the communication of the product, machine and operator through industrial cloud networks breaks the hierarchy of the industrial automation pyramid to a heterogeneous network.

This raises the requirement of network security, as in this model, the smart factory is no longer a closed communication system and will require secure, reliable operation in a wider sphere.

Centralized control

The cyber physical systems of sensors and actuators embedded in physical devices to do this have to be user-friendly. It is important that people using the system can recognize and react to any problems that the intelligent factory flags up.

As the automation process becomes increasingly networked, the factories' inventories may be reduced, but its supplier network may grow, meaning suppliers from around the globe may need to be co-ordinated from a single, centralized control point.

The use of multi-core hardware can consolidate the management of increasing data loads. Each core can be partitioned to control and monitor a particular workload, for example, automation control or HMI to use the hardware effectively yet with a level of integration that is cost-effective, and in a space-conscious footprint. As real estate values increase, if more capacity can be provided in less space, there are real savings in the operating costs, rental and maintenance of an industrial automation or manufacturing plant.

To adapt to new markets and applications, multi-core processors, such as the Texas Instruments Sitara™ AM437x processor family [Figure 1], can be used to partition tasks or workloads as described. The processor is based on an ARM Cortex-A9 core and a quad-core PRU-ICSS (Programmable Real-Time Unit Subsystem and Industrial Communication Subsystem) co-processor for deterministic, real-time processing, including industrial communication protocols, such as EtherCAT, PROFINET, PROFIBUS, EtherNet/IP, Ethernet Powerlink, Sercos or EnDat.

The Sitara processor family is an example of a common, programmable, hardware platform that forms the basis of a cost-effective, flexible industrial automation system. The ARM-based processor family with integrated ICSS supports multiple protocols to power industrial communications and provides the headroom for future protocol adoptions.

The ICSS provides a more cost-effective, flexible and future-proof solution for industrial communications as compared to FPGAs or ASICs as the integration into a single chip allows manufacturers to implement more cost-effective, deterministic, efficient and software-programmable automation systems that can be adapted to suit the industrial market's demands as required.

The PRU-ICSS co-processor allows dual and simultaneous industrial protocol deterministic, real-time processing and direct access to I/Os and low-latency requirements to meet the increased levels of complexity demanded by intelligent industrial automation.

A Quad Serial Peripheral Interface (QSPI) controls a serial data link as a master, or it can be used as a slave, reacting to a serial data link. The interface is fast enough to allow system designers to support eXecute-In-Place (XIP) with flexibility for code partitioning and the use of lower cost NOR Flash or less DDR memory to save system costs without impeding performance. This increased level of control and communication further contributes to the smart factory, where flexibility and adaptability are key to respond to fast-changing markets.

The level of integration also contributes to power savings and space reductions for a simplified infrastructure, with less equipment to manage, secure and maintain.

Connectivity

Similarly, the ability to communicate within the plant, or externally, defines smart factory automation. The SimpleLink™ Wi-Fi CC3100 and CC3200 Internet on a chip platforms (Figure 2) allow system designers to add Wi-Fi and Internet to electronic devices, such as sensors and actuators, to create a connected gateway. The WiFi module enables remote access to sensor, which can be configure through a remote web interface, with data stored in the cloud.

The CC3100 and CC3200 are low power platforms, intended use with battery operated devices, with low power and low power radio modes. While the CC3100 solution can be used with a microcontroller, the CC3200 offering has an integrated ARM Cortex-M4 microcontroller, which allows users to add their own code.

Adding connectivity in itself creates a security problem, which can leave industrial areas vulnerable to accidental or malicious attack. Initially, IoT is expected to be used for maintenance, diagnostics, data collection, software upgrades, as well as less time-sensitive control applications. Texas Instruments (TI) understands that

Figure 3. Connectivity can be by a number of protocols. SimpleLink introduces Wi-Fi connectivity to an industrial setting.

Figure 4. The smart factory will consolidate functionality.

different industrial environments may have very different needs in respect to latency, distance, bandwidth, power or topology, and concludes that one size with not fit all.

One advantage of using IoT in industrial automation is the complete transparency of production process it offers, with real-time interaction of the process life cycle. This is from product design, customer online configuration, through to sales and support teams using a real-time connection to the manufacturing floor to provide updates and other data about the project as a customer service.

By its nature, IoT may have some latency, or deterministic latency, issues, as it accesses the cloud. The issue of security, as the data is circulated wider than the closed factory network, is currently being addressed, and TI believes it is only a matter of time before better solutions will emerge, as new standards emerge.

The smart factory, where more parts of the industrial process will be networked is a realistic proposition, with many component parts already available to achieve an intelligent, reliable, cost and energy-efficient level of automation. The ability to integrate functionality, safely and efficiently, combined with ease of use for all operators within the control system will advance the concept further. Incorporating the security levels and safeguards to protect the widely networked, interlinked partners is the final part to complete the picture.

Learn more about TI Factory Automation Solutions at www.ti.com/automation

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