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"Building Smarter Manufacturing With The Internet of Things (IoT)"

Part 2. of "The IoT Series"

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Manufacturing: IOT and the Next Industrial Revolution

Since the Industrial Revolution, manufacturing has been transformative for countries and companies. In 2012, the World Economic Forum published a research report titled "The future of manufacturing: Opportunities to drive economic growth." The research stated, "manufacturing has been immensely important to the prosperity of nations, with over 70% of the income variations of 128 nations explained by differences in manufactured product export data alone."[1] In 2012, The Economist claimed we are entering the third industrial revolution, which is based on the digitization of manufacturing[2]. Others refer to this as "Smarter Manufacturing".

According to a December 2013 survey by the American Society for Quality (ASQ), only 13 percent of the manufacturers surveyed said they use smart manufacturing within their organization. Of those organizations that claim to have implemented smart manufacturing, 82 percent say they have experienced increased efficiency, 49 percent experienced fewer product defects and 45 percent experienced increased customer satisfaction.[3]

The development and adoption of the Internet of Things (IoT) is a critical element of smarter manufacturing. Though manufacturing companies have been implementing sensors and computerized automation for decades, the sensors, Programmable Logic Controllers (PLC) and PC-based controllers and management systems are largely disconnected from IT and operational systems. These systems are organized in hierarchical fashion within individual data silos and often lack connections to internal systems. There are several reasons for these legacy structures, including significant security issues. These legacy structures differ from the open, highly connected IP network structures that play such a large role in the value propositions of IoT. While the transition to more open network architectures and data sharing of IoT poses challenges in manufacturing and industrial markets, the combination of IoT, Big Data, and M2M optimization will bring profound opportunities.

IoT describes a system where items in the physical world, and sensors within or attached to these items, are connected to the Internet via wireless and wired network connections. The Internet of Things will connect and share data from inanimate objects. IoT will also gather and transmit data from sensors

connected to living objects such as people, animals and plants. IoT will connect everything from industrial equipment to everyday objects that range from medical devices to automobiles. IoT can share this data with systems and with people. (For more information on the definition of IoT read Part 1 of the series "The IoT Primer").

In the case of manufacturing, high value production equipment has been heavily instrumented for some time in a closed, hard-wired network environment. Industrial standard sensors, controllers and networks are expensive and upgrade projects in existing facilities are not easy. The growth of IoT on the consumer side has driven cost reductions in sensors, controllers, and communications through high volume semiconductor manufacturing. However, industrial standard equipment is constrained by a huge installed base of legacy equipment and standards.

As costs of industrial standard "smart" sensors with IP communications and embedded controls falls, these solutions will be implemented across the whole range of manufacturing equipment and in new areas that have not seen heavy investment in automation, such as Balance of Plant[4] (BoP) equipment and supply chain logistics. IoT will benefit manufacturing companies by collecting data from these sensors and communicating that data to factory floor workers, plant managers, software systems and many aspects of the supply chain.

Where's The Value In IoT For Manufacturing?

Bosch, a German manufacturer of consumer and industrial products, refers to the next wave of manufacturing with IoT-enabled systems as Industry 4.0.[5] Stefan Ferber, Director for business development of the IoT at Bosch Software Innovations, said "Industry 1.0 was the invention of mechanical help, Industry 2.0 was mass production, pioneered by Henry Ford, Industry 3.0 brought electronics and control systems to the shop floor, and Industry 4.0 is peer-to-peer communication between products, systems and machines."[6]

The basic principle of Industry 4.0 is the essence of IoT and smart manufacturing. By connecting machines, a manufacturer can create intelligent networks along the entire value chain that communicate and control each other autonomously with significantly reduced intervention by operators. Bosch, GE and Johnson Controls describe an IoT-enabled vision where machines predict failure

and trigger maintenance processes autonomously rather than relying on unreliable monitoring by maintenance personnel. Another IoT example is self-organized logistics that react to unexpected changes in production, such as materials shortages and bottlenecks. Manufacturers will use technology to deliver dynamic, efficient, and automated manufacturing processes. IoT delivers new value by connecting:

- **People.** Connected sensors will provide an unprecedented level of visibility into the factory operations and supply chain flow in a much broader range of manufacturing than just the very high value processes currently enabled. IoT in manufacturing will improve business by connecting people to the right information, over the right device at the point of need and cross company boundaries to include suppliers, maintenance partners, and distribution chains. New mobile-ready software will allow plant managers to have access to data such as equipment efficiency, line efficiency, data visualization tools and alerts from any location at much lower costs than previous custom systems.
- **Process.** In the first phases of IoT deployments, manufacturers will seek visibility into specific visibility and supply problems. Manufacturers may deploy these systems of use third party managed solutions to get started. As IoT becomes more pervasive, manufacturers will enable faster information flow, faster decisions, and greater market responsiveness by connecting devices into both operational and business software processes. Machine to machine (M2M) communications will enable new levels of automation. For example, GM uses sensor data to decide if it's too humid to paint an automobile. If the system defines the conditions are unfavorable, the automobile will be routed to another area of the manufacturing process, reducing repainting and maximizing plant uptime. This change alone saved the company millions of dollars.
- **Data.** Mobility and the IoT will change the types of devices that connect into a company's systems and these newly connected devices will produce new types of data. IoT will connect physical items such as sensors, actuators, video cameras and RFID readers – to the Internet and to each other. Big data processing and analytics, either on-premise or in the cloud, will collect and analyze data from IoT-enabled devices. These solutions will turn data into context that can be used to help people and machines make more relevant and valuable decisions.

What It Means For Your Business? IoT Manufacturing Use Cases

IoT impacts every business, but has the ability to radically transform industrial businesses such as manufacturing, utilities and aviation. There will be an exponential number of machines and devices that will transmit both large and small amounts of data. Smart manufacturing companies will use analytics to enact smarter decisions and more efficient operations. IoT, big data analysis and IP networks will help manufacturers prolong their asset lifespan while simultaneously optimizing efficiency and minimizing energy consumption. Smart manufacturing systems will link production and business domains such as Material Requirements Planning (MRP), Manufacturing Resource Planning (MRPII) and Manufacturing Execution Systems (MES). There are many potential business use cases for IoT in manufacturing. Several examples of process improvements that IoT can impact include:

- **Factory visibility.** IoT data and IP networks will connect what's happening on the factory floor to enterprise-based systems and decision makers. IoT will provide production line information to decision makers and improve factory efficiency. For example, a plant manager walking the production floor could also use IoT and visibility tools to access the efficiency of each machine, view production from any location, and reduce the time to decision and action. For example, GE mobile-enabled SCADA applications allow tablets to display performance data and status updates traditionally available only on PCs.

  Instead of being chained to a control room, facilities managers and production personnel will have easy access to real-time information and collaborate more effectively. Mark Bernardo, the general manager of automation software for GE Intelligent Platforms, says "When you equip people with mobile technology, you can dramatically shrink the delta between when a problem occurs and when it's acted upon. If there's a quality control problem in a production line, they can shut down the line before it continues to create products that will all be waste."[7]

  The benefits of visibility will extend beyond the enterprise to a wide range of suppliers and third party providers of services, consumables and capital goods. IoT systems will enable extensive involvement by third party suppliers in the direct operations and maintenance of manufacturing plants with

new service and supply business models based on increased visibility and remote monitoring. Suppliers of capital equipment may now be able to offer business models that involve production based revenue rather than capital equipment sales if equipment can be monitored sufficiently for both output and maintenance status. Parts, services and consumables suppliers within Maintenance, Repair and Operations (MRO) will use IoT to monitor distributed inventories, tank levels of process fluids, wear parts conditions, and production rates. This will create entirely new and very closely linked business relationships between manufacturers and their suppliers.

- **Automation.** Plant networks have been isolated from each other and from local and distant business networks. Today, we can use IoT and IP Networks to connect everything within a plant and provide connectivity and information sharing across multiple locations and business networks. Once machinery and systems are connected within the plant, manufacturers can use this information to automate workflows to maintain and optimize production systems without human intervention. One example of this is Harley-Davidson's use of IoT in its York, PA motorcycle plant. The company installed software that keeps a record of how different equipment is performing, such as the speed of fans in the painting booth. The software can automatically adjust the machinery if it detects that a measurement – such as fan speed, temperature, or humidity – has deviated from acceptable ranges[8].

- **Energy management.** In many industries, energy is frequently the second largest operating cost. But many companies lack cost effective measurement systems and modeling tools and/or performance and management tools to optimize energy use in individual production operations, much less in real-time across multiple operations, facilities, or an entire supply chain. There are numerous ways that IoT and automation of environmental controls such as HVAC and electricity can create cost savings for manufacturers. Connected energy solutions can provide peak demand charge avoidance and enable economy model operations. Certain IoT-enabled HVAC systems also offer integrated weather data and prediction analysis to help manufacturers understand expenses and plan energy usage. GE says efficiency improvements of 5% in a small industrial power plant generating 15MW can save over $200,000 on average per year.

- **Proactive maintenance.** Manufacturers have widely accepted the concept of preventative and condition-based monitoring but many are still in the process of implementing these programs. Lower cost sensors, wireless connectivity and big data processing tools make it cheaper and easier to collect actual performance data and monitor equipment health. If the manufacturer has equipment that's supposed to operate within a certain temperature range, the company can use sensors to actively monitor when it goes out of range and prevent malfunctions. Measuring vibrations to detect out of spec operations is another example. Businesses, particularly industrial businesses, lose money when equipment fails. With new sensor information, IoT can help a manufacturer improve overall equipment effectiveness (OEE), save money by minimizing equipment failure and allow the company to perform planned maintenance.

- **Connected Supply Chain.** Just in time manufacturing isn't a new concept, but IoT, analytics and IP networks will help manufacturers gain a better understanding of the supply chain information that can be delivered in real-time. By connecting the production line and balance of plant equipment to suppliers, all parties can understand interdependencies, the flow of materials, and manufacturing cycle times. IoT enabled systems can be configured for location tracking, remote health monitoring of inventory, and reporting of parts and products as they move through the supply chain, among many other things. IoT systems can also collect and feed delivery information into an ERP system; providing up-to-date information to accounting functions for billing. Real-time information access will help manufacturers identify issues before they happen, lower their inventory costs and potentially reduce capital requirements.

How to Get Started: Laying The Foundation For IoT in Manufacturing

There are at least four technology elements that provide the foundation for smart manufacturing. These include (but are not limited to):

- **Network.** Cisco research states only 4 percent of the devices on the manufacturing floor are actually connected to a network. Many manufacturers have used proprietary networks in the past. A smart manufacturing environment requires a standardized IP-centric network that will enable all devices within a

plant to communicate to both operational and enterprise business systems. A standard IP network also makes it easier to connect and collaborate with suppliers and customers to improve supply chain visibility. Manufacturers need robust networks that can cope with RF challenges in the plant, harsh environmental conditions and reliability for transmission of alarms and real-time data stream processing. For example, GM implemented a standards-based network architecture, called the Plant Floor Controls Network (PFCN), to standardize the design of each plant network and establish a single engineering team that monitors and troubleshoots network operations globally. PFCN helped GM reduce network downtime by approximately 70%[9].

- **Security.** IT security was the most oft-cited obstacle to setting up smart factories. Operations managers need to ensure that safeguards are built into the solution including security procedures such as hardware encryption, physical building security and network security for data in transit. The network must also allow secure remote access to systems. Security and networking solutions must also be engineered to withstand harsh environmental conditions, such as heat and moisture, that aren't present in typical networks. Identity and authentication structures will also need to be updated to support "things" as well as people.

- **Software systems.** Today's IoT data is different than the data we use to operate our systems. It requires collecting a wide range of data from a variety of sensors. These software systems and models must translate information from the physical world into actionable insight that can be used by humans and machines. For example, Toyota is using Rockwell's software for real time error corrections in the plant. With improved troubleshooting capabilities and error correction, Toyota has minimized rework and scrap rates in its Alabama plant, which has resulted in an annual cost saving of $550,000.[10]

- **Big data and analytics.** While manufacturers have been generating big data for many years, companies have had limited ability to store, analyze and effectively use all the data that was available. New big data processing tools are enabling real-time data stream analysis that can provide dramatic improvements in real time problem solving and cost avoidance. Big data and analytics will be the foundation for areas such as forecasting, proactive maintenance and automation. Conagra Mills makes 800 different kinds of flour for its customers. It uses

predictive tools and services to forecast pricing, capacity requirements and customer demand. This allowed the company to maximize revenues through improved margin decisions and increase production capacity utilization by 5%.[11]

Conclusion

Where are we headed? IoT will fundamentally change how products are invented, manufactured, shipped and sold. Leading manufacturers are designing for constantly evolving, evergreen products and services. It requires a completely new approach to designing products as well as factories and systems that support a manufacturing process. With IoT, IP networks and analytics, manufacturers can become more efficient, improve worker safety and offer new business models. IoT will help manufacturers improve resource efficiency, safety and return on assets. Manufacturers that master this new dynamic will have a variety of new opportunities for revenue growth and cost savings.

About Lopez Research

Lopez Research, founded in 2008, is a market research and strategy consulting firm that specializes enterprise mobility, Internet of Things, and context-aware services. Its main research theme is o"Right-time Experiences", which are design applications, services and experiences that deliver the right information or service at the point of need. The company's mission is to understand the evolution of these trends, provide thought leadership, and assist its enterprise and technology vendor clients in building winning market strategies. Lopez Research combines survey-

based research and predictive analysis to gain insight into coming trends. The company provides clients and readers with the bridge between business leadership and technology adoption. www.lopezresearch.com

Endnotes

[1] http://www3.weforum.org/docs/WEF_MOB_FutureManufacturing_Report_2012.pdf

[2] http://www.economist.com/node/21553017

[3] http://www.prweb.com/releases/2013/12/prweb11430148.htm

[4] The "balance of plant" of a system is the components not included in the primary system itself, including blowers, compressors, pumps, and other necessary (but not primary) components.

[5] http://www.bosch-si.com/solutions/manufacturing/industry-4-0/industry-4-0.html

[6] "The Internet of Things business index: A quiet revolution gathers pace."

[7] http://www.biztechmagazine.com/article/2013/12/united-airlines-and-ge-make-room-mobility

[8] http://online.wsj.com/news/articles/SB10001424127887324059704578472671425572966

[9] http://www.cisco.com/web/strategy/docs/manufacturing/Cisco-AutoCaseStudy-GM.pdf

[10] http://www.industryweek.com/blog/how-will-internet-things-help-manufacturing

[11] http://www.ibm.com/smarterplanet/us/en/leadership/conagra/