From Smart Manufacturing to Manufacturing Smart

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*Why manufacturing is a core enabler of the Internet of Things.*

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Recent initiatives at the national level, whether in the United States (e.g., the announcement of the Advanced Manufacturing Partnership Steering Committee 2.0 in September 2013 by President Obama following the initial launch in 2011) or abroad (see the recent development of the Industry 4.0 project in Germany), underscore the direct impact of intelligent manufacturing on economic growth and competitiveness.

It has been recently suggested [by Michael Mandel in a Progressive Policy Institute memo] that a "network of sensors in a factory, for example, hooked to powerful data analysis capacity, could greatly improve the productivity and flexibility of production, and perhaps lead to a rebirth of manufacturing in the U.S." Meanwhile, at the M2M Summit in Düsseldorf, a presentation from the Association of Telecommunications and Value-Added Service Providers (VATM) of Germany claimed that "no doubt about it: Industry 4.0 is needed to keep Germany competitive." The German Federal Ministry of Education and Research adds on its website that Industry 4.0’s goal “is to develop completely new business models and tap the considerable potential for optimization in the areas of production and logistics.”

In a seminal *Time* magazine message, Dr. Sujeet Chand of Rockwell Automation and Dr. Jim Davis of UCLA in July 2010 clearly stated that "smart manufacturing marries information, technology and human ingenuity to bring about a rapid revolution in the development and application of manufacturing intelligence to every aspect of business. It will
fundamentally change how products are invented, manufactured, shipped and sold. It will improve worker safety and protect the environment by making zero emissions, zero-incident manufacturing possible."

A few years later, this same emphasis on operational efficiencies is still very much front and center in the manufacturing discussion. Bernd Leukert, head of Application Innovation and a member of the Global Managing Board of SAP AG, commenting on Industry 4.0 in a December 2013 interview (Industry 4.0 Is Not An Optional Exercise) points out that “the use of smart devices will drive a new wave of digitalization, awareness and automation that will re-invent the manufacturing industry; it will fundamentally change how products are ordered, built, and consumed thereby creating a new kind of normal.”

**Smart Manufacturing**
The technologies used for the implementation of “smart manufacturing” or “smart production” span a wide spectrum of domains. They are often referred to as Internet of Things (IoT) technologies, i.e., the combination of a sensing/actuating device with a communication network (wired or wireless) and a software application to move, read and interpret data.

The causality between IoT and the transformation of manufacturing was underlined in a recent roundtable between executives at Robert Bosch and McKinsey experts on the Internet of Things and the Future of Manufacturing. According to McKinsey Partner Dr. Markus Löffler, “the Internet of Things has already set in motion the idea of a fourth industrial revolution—a new wave of technological changes that will decentralize production control and trigger a paradigm shift in manufacturing.”

Thomas Friedman in a September 2013 article for The New York Times (“When Complexity Is Free”) describes how Smart Manufacturing (without using the expression) and the Internet of Things (he uses the expression along with “Industrial Internet”, GE’s moniker for it) are transforming GE. Shorter feedback loops, collaboration and crowdsourcing, and pervasiveness of sensors are stretching the confines of manufacturing.

What is particularly striking in Friedman’s paper is the involvement of scientists, engineers and marketing experts in manufacturing; it is a collaborative undertaking that is no longer left to technicians alone. It is about the optimization of the whole value chain along which costs are cut and revenues generated. “With all this data,” Friedman explains, “GE is developing new service businesses that offer not just to manage an airline’s or railroad’s engines, but how fast all its planes or trains go, how flight and train schedules are coordinated and even how its equipment is parked to get optimal performance and energy efficiency.”

Improvements in advanced sensing and actuating; automation; coordination of systems of systems; end-to-end supply chain performance; and process integration aim at making the production of goods adaptable, agile, customer-driven, collaborative, resource-efficient, responsive and safe. This is quite a challenging order that is both deep and wide, which might meet with some resistance here and there. Nevertheless, the objectives and directions are clear.

The stakes are high, Dr. Jochen Köckler, Member of the Managing Board at Deutsche Messe — the organizers behind Hannover Messe 2014 — cannot be more explicit: “flexibility and efficiency – these are the keys to continued survival in a highly competitive international market. Therefore, the task now is to take the next steps – and, more important, the right steps – to ensure that industry realizes its vision of smart, flexible factories.”
Manufacturing Smart

However, while IoT technologies are growingly and significantly overhauling the boundaries of manufacturing, the influence of manufacturing on IoT is no less impactful.

It is important to recall that IoT is (and nothing more than) a metaphor that captures a dramatic societal metamorphosis. IoT is about the integration of everyday objects in the communications space on par with humans. According to this vision, all the things, however big or small, that surround or are part of us would have the potential to be reached and, possibly, activated and interfaced with remotely. This is a result of converging trends such as but not limited to the arrival of IPv6 (Internet Protocol version 6) in June 2012. IPv6 can accommodate 340 trillion trillion trillion (undecillion) IP addresses (that's a lot of them!)

This has led around the world to an ebullient exuberance regarding the size and attractiveness of the market. Innovators and inventors have rapidly come up with creative solutions in all aspects of the economic fabric. Some of them have been widely highlighted for their ingenuity and novelty such as thermostats, pill bottles, car parking applications, hand-washing stations, scales, dog collars and all kinds of wearable solutions to name a few.

As this new frontier is being conquered with the type of unbridled enthusiasm that was probably inherent to the intrepid pioneers of the American West, we are still in the burgeoning phase of a long cycle. In August 2013, Gartner released its Hype Cycle for Emerging Technologies for the year. It showed IoT with over ten years to go before “mainstream adoption starts to take off”, which Gartner describes as the “plateau of productivity”.

It stands to reason that for something to be adopted, it needs to be there in the first place. This cannot happen without advanced manufacturing providing the building blocks of the future IoT-centered society, i.e., “smart” capabilities. Any and every object will need to have embedded in them “potential for intelligence.”

As discussed above when describing “smart manufacturing”, some companies, GE being one of them, are already inserting remote sensing as an integral component of the product to offer a host of services that enhance their value proposition to their customers.

Likewise for electric utilities, advanced manufacturing brings to life a new generation of power electronics, adding value to both suppliers and consumers of electricity through enabling seamless two-way data and electrical flows.

But “manufacturing smart” will in all likelihood go beyond proprietary ecosystems.

What we are suggesting here is that we expect market (in addition to regulatory) forces will be pushing for incorporating IoT capabilities that can be universally exploited beyond the initial intended use.

In much the same way as new houses come equipped with electric outlets (and still perhaps with phone jacks and cable TV outlets); cars with on-board diagnostics (OBD) reporting capabilities (in addition to, in some countries, a mandated emergency-calling device); television sets and computers with all kinds of connectors and ports, all products, including the most mundane ones, will probably include tags, sensors and/or actuators that could be activated, very likely through third parties, to enhance the so-called consumer experience.

An interesting project at ETH Zurich, which aims at exploring potential uses of smart meter data in order to offer new
services to end users while taking into account privacy constraints, is a current example that illustrates how innovation can be induced from IoT functionalities already in place.

Should this vision (i.e., a push for embedding IoT capabilities) bear out, manufacturing will be redefined as it broadens its scope to not only include optimized processes and systems, at the heart of "smart manufacturing", but also sensing and actuating capabilities, central to the emerging IoT-shaped society.

Printed, organic and flexible electronics might be one of the catalysts needed to adjust manufacturing processes to IoT. Commenting on a new report from IDTechEx on "Printed, Organic & Flexible Electronics: Forecasts, Players & Opportunities 2013-2023", Faye Rivkin of Industry Market Trends (IMT, October 8, 2013) notes that "printed electronics will allow manufacturers to replace some components with cheaper, higher performing alternatives or even completely replace a conventionally-manufactured device," observing that, as a result of several technological advances, the "components, including transistors, antennas, circuits, connecting components, displays, sensors and batteries, are lighter and have more functionality than conventionally-manufactured electronics."

We need, however, to remain cautiously optimistic. When it comes to the Internet of Things, printed electronics certainly has attractive selling points but also still some limitations (see Dr. G. Venkatesh's article in the July-September 2013 issue of the Journal of the Indian Institute of Science on "Semiconductor Solutions for the Internet of Things: The Role of Event Detection, Asynchronous Design, Energy Harvesting and Flexible Electronics"). And yet the fact remains that costs are declining and performance is improving. What if, in a not too distant future, printed electronics devices could become a cost-effective proposition for IoT deployment and take over all the functionalities of active RFID or those found today in Real Time Locating Systems (RTLS) and machine-to-machine (M2M) modules? The possibilities are intriguing and certainly worth exploring.

In parallel to printed electronics and to a much broader degree, the "disruptive transformation of electronics design and manufacturing" that could be brought about by what IBM calls the "new software-defined supply chain", which rests on 3D printing (a.k.a. additive manufacturing), intelligent robotics and open source electronics, could alter significantly the speed of the integration and the magnitude of the IoT capabilities embedded into products (see Executive Report from IBM Global Services, July 2013). According to Partha Bose, IBM's Leader of Global Electronics Practice, "the defining feature of this new era will be a shift from a "hard-wired" manufacturing model to one defined and controlled by software."

As Paul Brody, IBM's Global Business Services Vice President and Global Electronics Industry Lead, during his presentation on IBM's "brand new analysis" on software-defined supply chain at the St. Petersburg International Economic Forum, ominously predicted: "it [open source electronics environment] won't just improve the ease of customization development; it's going to start making products truly exceptionally smart. When you can put the equivalent of an entire PC on a door knob or a toothbrush, it's going to make these products smart. And these products are going to be network-connected!" The words revolution and upheaval come to mind.

The global manufacturing industry, tested by swift and sweeping technological advances, is in the throes of a monumental transformation, which will end up shaking society up and build the foundation of an internet where most things can be identified, interconnected and activated, i.e., the IoT.
Regardless of how it happens, manufacturers have a vested interest in inserting IoT capabilities inside their finished products. Third parties will be able to provide new value added services, very importantly, throughout time, thereby magnifying the value of the original product, if the manufacturers cannot to do so, e.g., for lack of resources or simply being out of the market.

Along the way, new challenges (e.g., in the areas of standardization, security, privacy, education, training, regulation, law and policy) will appear more or less rapidly on the horizon, standing in the way of this vision's implementation. But it is a safe bet that they will be overcome, albeit perhaps at a slow pace (see Gartner's hype cycle for emerging technologies). The terrain surveyed in this article nevertheless leads to very appealing mileposts, i.e., simplification, efficacy, efficiency, and, at the end, profitability. As a result, progressive manufacturing companies should be in the process of putting in place an efficient ecosystem that allow them to smartly manufacture smart things!

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