PEOPLE AND MACHINES WORKING IN SYNC

The Building Blocks of Industry 4.0

The business models of industrial companies are about to change radically, and they must adapt their skill sets to the digital world or get left behind. Through an analysis of interviews, case studies and collaborations with firms at the leading edge of this field, we can identify the key building blocks for the successful implementation of Industry 4.0, and its implications.

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During the global financial crisis, countries with a solid manufacturing base suffered less than service-based economies. This was certainly the case for Germany, whose Mittelstand of small and medium-sized firms, many of them manufacturing-based, were able to maintain or expand their workforce. Recognizing that manufacturing contributes greatly to job creation and innovation, the German government laid out its future industrial policy in 2011, called Industry 4.0, a term which has since entered the vernacular. Other countries are following suit, including the United States, with administrations since Obama aiming to re-industrialize the economy.

In fact, smart machines, products and infrastructure can already be connected to collaborate in dynamic ways. This networked model of production – in which all levels of IT systems within a company and across companies in a value chain are connected and share data and information – is the next iteration of everything that came before. When fully deployed, Industry 4.0 holds the promise of reconfigurable production systems and intelligent, networked tools, machines, facilities and products that communicate among themselves and with the workforce, using augmented reality or other means of communicating relevant data quickly, intuitively and efficiently. Moreover, smart products and components will provide information, and the production system will automatically adapt to product-specific needs. Tools, machines, facilities and products will contain sensors that provide data necessary for decision-making. Because this can be done in an automated way, people will focus more on generating value for customers, and less on monitoring machines or production processes.

FIVE BUILDING BLOCKS

Industry 4.0 holds implications for value creation, business models, downstream services and work organization. To reap the benefits, however, five building blocks have to be in place.

1 Data Generation and Capture

First, the physical system needs to be mapped digitally, so that it can be analyzed and optimized. The cost of sensors, RFID and other key communication technologies has come down significantly, and they are now ubiquitous enough to be leveraged for Industry 4.0. In addition, the IPv6 Internet protocol is finally ready to replace the current standard, IPv4. IPv6 offers 340 undecillion (a number followed by 36 zeros) unique addresses. This allows unique and faster point-to-point connections, including for mobile devices. More important, with IPv6, everything that can be found in a factory or value chain – machines, tools, individuals, products and customers – can be assigned its own IP address, which means assets and working capital can be traced more precisely.

For those worried about the huge volumes of data this will generate, the good news is that the cost of storing big data is dropping exponentially. Moreover, the decentralized storage capabilities of the cloud permit multiplatform access, continuous hardware updates and conversion from Capex to Opex, without any asset investments. The large volume of data from many different sources, with significant variety and the need to be processed quickly, can be handled through smart filters and distributed intelligence at the level of the component, piece, product, tool and/or machine. That is, basic decisions can be made in situ, without "connecting." Only in case of emergency (i.e. when something out of the ordinary occurs) is data sent to the cloud to be analyzed more closely. Other solutions come through advanced algorithms and machine learning, which will help us identify patterns emerging from the great volume of data. These condensed data will be highly valuable, not just for the task at hand but also at the meta-level, when analyzing company-wide or value chain-wide data. In this regard, platforms become important.

2 Data Analytics

Fortunately, we already have cyber-physical systems capable of processing and analyzing the great quantity of data involved in Industry 4.0. When a factory is digitally connected, rich data insights can be

gathered, optimized and used, not only to improve operational processes, but also at the strategic level for decision-making.

Say you have separate manufacturing facilities in Europe and Asia. Data analytics can compare demand patterns, leading to better forecasting or early detection of market trends. When similar problems emerge in different facilities, they may indicate a systemic problem with a machine, a process or a supplier, and preventive maintenance can be undertaken. Any entity that has access to all these data – preferably via a platform – will gain a better understanding of where things currently stand, as well as trends for economic modeling.

Of course, this calls for more scientists skilled in analyzing and interpreting these data, and new worker profiles.

❸ Human/Machine Interaction

The integration of numerous IT systems at various levels of the organization requires sophisticated management. Several companies have developed cloud-based platforms for industrial use, including Siemens' MindSphere and General Electric's Predix. One of the most challenging interfaces, however, is between humans and machines.

When someone has to make a decision, any information that has been generated from data gathered in the production network has to be presented in an integrated, intuitive way, and in the right context. Products such as Microsoft's HoloLens holographic glasses offer solutions to this problem. These glasses make it possible to view data interactively in 3D (for example, color-coded graphics instead of Excel tables) and allow workers to perform maintenance remotely from any location.

Say a machine has a problem that an onsite worker cannot solve. The holographic glasses make it possible to share a 3D image with headquarters on another continent, where a resident expert can talk the user through the steps of repairing the machine. Social media can also help: company employees or others in the value chain can post problems and get support from the wider community. Cisco, Audi and NASA, among others, are experimenting with these approaches.

Collaborative robots, or cobots, resolve problems related to high worker turnover and rapid increases in production

❹ Flexible Production

Recent advances in robotics, automation and additive manufacturing are now capable of giving factories the flexibility they need to respond to changes in demand, leading to more efficient processes and business models.

Consider collaborative robots, or cobots: a technological leap based on built-in sensors. Unlike other robots that had to be cordoned off from workers to protect the latter from injury (increasing costs), cobots react or stop when they come into contact with a worker. This lets people work closer to robots, performing cooperative tasks, as happens at plants for gearbox assembly in the automotive sector. In addition, for the first time, robots are able to "sense" things as complex as the change in center of gravity of a beer mug or the bend in a rubber hose.

Given their smaller sizes, cobots are of growing interest to Asian manufacturers of electronics products (such as cell phones). They can be placed in 60cm x 60cm work spaces in giant factories, thus resolving problems related to high worker turnover and rapid increases in production (when a highly successful product is launched, as many as 50 percent more workers are required). In the automotive industry, a robot equipped with a camera (the most versatile sensor) and the right software could "learn" the best weld spots for manufacturing a car. If such robots were connected to a platform, other robots and the platform itself could also benefit from this learning.

The other technology with great disruptive potential is industrial 3D printing (not to be confused with printers from the Maker Movement, which is B2C). 3D printing makes it possible to generate highly complex components without molds, resulting in features that were unthinkable with traditional manufacturing (lathes, drills and so on). The fact that 3D printing eliminates molds means that there are no significant economy-of-scale effects. And, as its name implies, additive manufacturing is based on adding only the material necessary to making the product – almost without waste.

Europe has global leaders both in robotics (KUKA and ABB) and in 3D printing (EOS and Concept Laser). The most important aspect of these technologies in relation to the connected factory is their great potential to lower barriers to the manufacturing sector. With highly flexible robots and industrial 3D printing there will be "printer farms" (similar to the concept of cloud "server farms"). These farms will allow companies, such as those in the automotive industry, to manufacture products without having these machines in their factories or on their balance sheets. This will be a very disruptive change in value chains worldwide.

5 Intellectual Property

Providing reliable IP protection will be a key requirement for establishing platform-based business models in Industry 4.0. With 3D printing, anyone who has access to the designs, a 3D printer and the raw material would be able to produce "originals."

Two interfaces need special attention for their vulnerability to external manipulation: the link between production data and business data; and the link between mobile devices used for human-machine interaction and the corporate IT structure (especially in a bring-your-own-device environment). Given the complexity of Industry 4.0 systems, the best way to protect your business is to start at the lowest level – where data are created and captured via sensors and at the transmission points. The exponential growth of connected elements makes this a challenging yet vitally important issue.

FUTURE IMPLICATIONS

Moving toward Industry 4.0 has several serious implications.

● Worker profiles

The profiles of people working in industry will change across all levels. Engineers, for example, will have to learn new approaches to product and process design, because 3D printing offers much more freedom than current technologies. The ubiquity of the Internet and the immediate access to the knowledge stored in it will change the concept of knowledge worker. Knowledge workers will go from being highly trained experts to being professionals capable of finding solutions to complex problems quickly, based on experience and smart use of the Internet. These new professionals will be known as "cyberworkers."

● Cybersecurity

When all machines, tools, working capital, IT systems and even people are connected through the Internet, any manipulation of data at any level will lead to consequences ranging from suboptimal performance to catastrophic failure.

● Software-defined differentiation

The move toward networked production assets and smart products with connected sensors and computing capabilities will drive products toward software-based individualization. Hence, product differentiation will be software-defined rather than hardware-driven. This pushes the point of product differentiation to the customer, resulting in significant supply-chain savings and reducing operations complexity.

● Platform business models

The advantage of platform business models over traditional supply chains is that they scale faster and are more flexible. This means that established industry leaders and entire sectors will be confronted with new competitive challenges, and they run the risk of being disrupted.

Meanwhile, Industry 4.0 is not taking place in a vacuum. Innovations happening in other fields – in process technologies, advanced materials, nanotechnology, cognitive systems and advanced mechatronic systems – have the potential to shake up the whole structure of production systems. When these wider developments are combined with data-driven platform business models, you have the perfect setting for recombinant innovation. Given these features of Industry 4.0, we can anticipate the emergence of platform business models in the asset-heavy manufacturing sector. Siemens, General Electric and others are already offering products as a service.

We can also expect to see new production technologies – 3D printing, cobots, sensors – being recombined and bringing about other new technologies. An acceleration of new technological developments, driven in part by the ongoing digitalization of industry, will give rise to untold business models and opportunities. To play a leading role in this future world, manufacturers will have to develop competencies in connected factories, products and services as well as in platform business models. Only then will manufacturers be able to address one of the biggest challenges of Industry 4.0: the construction of completely new structures that leverage the full potential of the entirely digital factory – a factory with a future.

Source: Sachon, M., "Five Building Blocks for Cyber-Physical Value Chains." *IESE Insight*, issue 33 (2017): pp. 15-22.