THE INTERNET OF THINGS: TRANSFORMING MANUFACTURING

Manufacturers must transform their business processes and fundamentally rethink how they create, operate, and service smart, connected products in the new era of the Internet of Things.

By James E. Heppelmann

We live in an increasingly smart and connected world. The number of physical devices or "things" connected to the Internet now exceeds the total number of humans on the planet. According to some industry predictions, we're now accelerating this trend to as many as 50 billion connected devices by the end of this decade.

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For manufacturers, the implications of this emerging world of the Internet of Things (IoT) are huge.

The Internet of Things is comprised of the three core components (see Figure 1). It includes a collection of smart, connected products, product systems, and other things connected through an Internet-like communication infrastructure to a computing infrastructure that is creating new forms of value. Data from the product condition, operation, and environment are delivered in real time, enabling capabilities to control, service, and upgrade the product and system performance.

For manufacturers—basically all those companies in the business of producing "Things"—these innovations not only have the potential to generate incredible amounts of new value, but also to disrupt the status quo. The capabilities created and data generated by this new generation of smart, connected products requires new thinking about the enterprise applications and the connected ecosystem to optimize current business processes, drive better decision-making, and expand areas of innovation.

According to a recent McKinsey Global Institute report, the Internet of Things has the potential to unleash as much as $6.2 trillion in new global economic value annually by 2025. McKinsey also projects that 80 to 100 percent of all manufacturers will be using IoT applications by then, leading to a potential economic impact of as much as $2.3 trillion for the global manufacturing industry alone.

Forces of Transformation

There are a number of underlying forces driving this IoT transformation, some of which are long-standing, while others are more recent. Individually, any one of these forces is disruptive. Together, they represent a radical transformational shift that is creating a whole new world of smart, connected products.

› **Digitization:** Advances in plant automation, combined with new digital design and production systems, have replaced traditional analog product and service information with accurate, virtual representations that can be easily leveraged across the value chain—from engineering to the factory floor and across multiple service platforms.

› **Globalization:** As manufacturers digitize product and service information and leverage the Internet, they are increasingly overcoming historical geo-

graphic boundaries, eliminating economic and regional divisions and opening up new markets.

› **Regulation:** As manufacturers design, build, sell, and service globally in the pursuit of new markets, they are confronted with increasing regulation. This involves more than just the enforcement of governmental rules, but also nongovernmental organizational policies, and industry standards related to environment, health, safety, and trade.

› **Personalization:** As manufacturers seek to differentiate across global markets, they are driven to offer greater customer choice at scale. They must now efficiently tailor products and services to accommodate regional and personal preferences, responding to the growing influence of consumers, and the increasing consumerization of information technologies.

› **Software-intensive Products**: As manufacturers seek to more efficiently meet the growing diversity of customer demand, they are increasingly turning to software as a key differentiator. Integrated systems of hardware and software are becoming ever-more capable of delivering sophisticated human-to-machine interaction, self-diagnostics, and in-depth service data to help add new value to products.

› **Servitization:** As manufacturers deliver ongoing value through smart products, new service-centric business models have emerged. Fundamental business model shifts are under way in which products evolve to become integrated "bundles" of services, capable of delivering new value continuously throughout the customer experience lifecycle.

› **Connectivity:** As manufacturers seek to unleash greater value from their increasingly smart products, they are adding connectivity to those products. Pervasive networks of physical entities, embedded with sensors and individually addressable, are enabling new levels of sophisticated monitoring, control, and communication.

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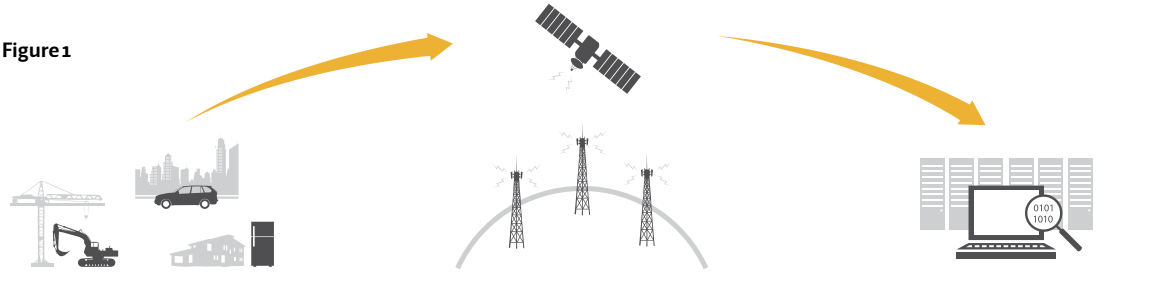
Value Shifts

These powerful forces of transformation are also driving a shift in the sources of value and differentiation across the industry. Manufacturers now have opportunities to create new sources of competitive advantage, but only

Figure 1



THINGS
Smart, connected products and other Things combine processors, sensors, and software with connectivity.

COMMUNICATION INFRASTRUCTURE
Wired and wireless (Wi-Fi, 4G, Bluetooth, Zigbee) networks connect Things to the Internet and each other.

COMPUTING INFRASTRUCTURE
Data capture and analytics tools, and new business and software applications create new forms of value.

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if they heed the three essential value shifts now under way.

First, the emphasis of value is shifting from hardware to software. Products have evolved from purely physical components to complex systems combining processors, sensors, software, and digital user interfaces. As manufacturers seek to accelerate product innovation and efficiently meet the growing diversity of customer demand and regulation, they increasingly turn to software. One example: The automobile now has on average 100 million lines of code to enable variable driving modes, various engine and emission configurations, adaptive cruise control, and hands-free commands.

Value is also shifting from product to the cloud. While smart products have enabled new capabilities, there is a limit to the incremental value that can be generated from within the product itself. But when the digital component of a product connects with the cloud, the capabilities of that product are vastly extended. Manufacturers are finding that moving product capabilities to the cloud enables operational efficiencies, improves the user experience, and accelerates innovation. For example, Wi-Fi music systems shift the primary user interface from the product to the cloud to dramatically simplify the product design, improve user experience, and better integrate with other apps and services.

Finally, value is shifting from product to service. Market forces and competition have diminished the viability of product-centric strategies that maximize returns at the moment of sale, and led to a burgeoning business model shift. Products are integrated with services that deliver new value throughout the entire product lifecycle or simply deliver the desired outcome via an on-demand service. One example: Aircraft engine manufacturers sell hours of flight instead of engines, driving manufacturers to optimize product up-time, develop value-add services, and enable operators to better manage costs.

These three essential value shifts are creating new sources of competitive advantage, but they also require new skills, infrastructure, cultural norms, and operational models. For manufacturers that transform to meet the demands of a smart, connected world, this combination of software, the cloud, and services will be the crucible of innovation and the basis for differentiation, new business models, and disruption in the future. Those who don't place their current competitive advantage at risk.

Capabilities of Smart, Connected Products

So how can manufacturers begin to capitalize on these shifts in value for both themselves and their customers?

Smart, connected products enable six new and unique categories of capabilities that manufacturers should consider and adopt strategically.

1. Monitor Condition/Operation: Products can now assess their own condition, performance, operation, and usage status. John Deere's WorkSight technology connects its equipment to monitoring dashboards so company managers can see where an entire fleet of vehicles is at any time, and evaluate the performance of that equipment in real-time. Diagnostic data flows wirelessly to a technician who may show up at a

worksite with a replacement part before a driver has even noticed a problem.

2. Monitor Environment: Products can now assess the external environment through sensors and data sources. Auto-industry supplier Continental AG makes windshield wiper systems with rain-sensors and software that control how rapidly the wipers sweep the windshield depending on the volume of rain. Continental also lets car makers connect the sensors to vehicle control systems that tell the car to roll up the windows or close the sunroof when rain starts.

3. Remote Control: Products can easily be operated remotely in real time. The General Atomics MQ-9 Reaper is an unmanned aerial vehicle capable of remote controlled or autonomous flight operations. These products provide troops with a 24-hour "eye in the sky" seven days a week. Each aircraft can stay aloft for up to 17 hours at a time while the trained crew, located safely at a base, steer the craft, analyze the images, and act on what they see. In addition, they are about one-tenth the cost of traditional warplanes.

4. Personalize/Customize: Products now can be efficiently tailored by the end user or manufacturer before, or even after, a product is sold. The Ford Model T was infamously available in any color as long as it was black. A century later, Motorola's Droid Maxx is similarly limited in its physical diversity, but is infinitely customizable through the Android mobile platform and apps that can be added and configured to create a truly personalized product at the cost of a mass produced product.

5. Service/Upgrade: Products can also be serviced, updated and enhanced instantly and from anywhere. Trane, a maker of heating, ventilation, and air conditioning (HVAC) systems that is part of Ingersoll-Rand Corp, makes systems that contain extensive digital sensors connected to its Intelligent Services Center. Trane Intelligent Services are able to resolve 30 percent of HVAC problems remotely without sending a service truck. Some 40 percent of problems are diagnosed in 30 minutes or less. This allows Trane and its customers to reduce costs and improve equipment up-time.

6. Autonomous: Products are increasingly capable of self-operating, learning, updating, and correcting by analyzing real-time data. Google first revealed that it had been working on self-driving cars in 2010. Since then, Google's vehicles have logged hundreds of thousands of miles on public roads, and data now shows that autonomous cars drive more smoothly and more safely than those piloted by human drivers. Expanding connectivity to include other systems will also make it possible for cars to send hazard warnings to each other, adapt based on traffic and weather information, and even interact with signals as they approach intersections.

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The Need To Transform

Harnessing these new capabilities, manufacturers must begin to transform existing business processes and fundamentally rethink how they create, operate, and service smart, connected products for an IoT world.

› Transforming How Products Are Created

Manufacturers must plan and design flexible platforms that will deliver personalization, value-added services, and product enhancements remotely both before and after the product is in the market.

Manufacturers must design out the complexity created by combining processors, sensors, software, digital user interfaces, and connectivity, and deliver a simple user experience that aligns with the customer needs.

Manufacturers must also incorporate product usage data into R&D processes and drive new functionality, define specifications, and increase customer intimacy.

› Transforming How Products Are Serviced

Manufacturers must plan and deliver remote software and service updates in real time, with minimal customer disruption, and at minimal marginal cost.

Manufacturers must plan and optimize product and service parts management and inventory control by tracking assets and analyzing real-time product usage data to predict parts needs.

Manufacturers must further automate service execution by actively monitoring product condition, environment, and operation to automatically determine the correct service event, provide the correct parts and people, and then continually improve service delivery based on actual results.

› Transforming Business Models

Manufacturers must rethink business processes and business models to maximize returns across the entire useful life of the product, and not just at the point of sale.

Manufacturers must plan for increased complexity in an expanded partner and supplier ecosystem, and consider the opportunities and threats they create.

Manufacturers must capture and analyze product usage data to optimize processes and enable new capabilities, and consider entering new business areas by finding ways to monetize the data.

Ultimately, there's a huge opportunity for companies that can successfully enable smart, connected products for an IoT world to create new product and service advantages across all aspects of manufacturing. **M**

"Smart, connected products blur the line between products and services and enable an entirely new set of capabilities."