
accenture technology
Driving Unconventional Growth through the Industrial Internet of Things
High performance. Delivered.
Strategy | Consulting | Digital | Technology | Operations

The Industrial Internet of Things has been heralded primarily as a way to improve operational efficiency. But in today's environment, companies can also benefit greatly by seeing it as a tool for finding growth in unexpected opportunities.

In the future, successful companies will use the Industrial Internet of Things to capture new growth through three approaches: boost revenues by increasing production and creating new hybrid business models, exploit intelligent technologies to fuel innovation, and transform their workforce.

By Paul Daugherty, Prith Banerjee, Walid Negm and Allan E. Alter


REVENUE INCREASE

The Michelin Group uses sensors inside tires combined with analytics to coach truck fleet drivers on how to save fuel.

Taleris (a General Electric-Accenture joint venture) deploys analytics to help airlines minimize disruptions from mechanical failures and weather delays.

Daimler, with its Car2Go service, has taken its business beyond simply building cars to renting them almost as easily as buying milk at the corner convenience store.

The Industrial Internet of Things (IIoT) is a major trend with significant implications for the global economy. It spans industries representing 62 percent of gross domestic product (GDP) among G20 nations, according to Oxford Economics,[1] including manufacturing, mining, agriculture, oil and gas, and utilities. It also encompasses companies that depend on durable physical goods to conduct business, such as organizations that operate hospitals, warehouses and ports or that offer transportation, logistics and healthcare services.

Not surprisingly, the IIoT's potential payoff is enormous. The most conservative independent estimates place spending on the IIoT worldwide at $20 billion in 2012, with spending expected to reach $500 billion by 2020. More optimistic predictions of the value created by the IIoT range as high as $15 trillion of global GDP by 2030.[2]

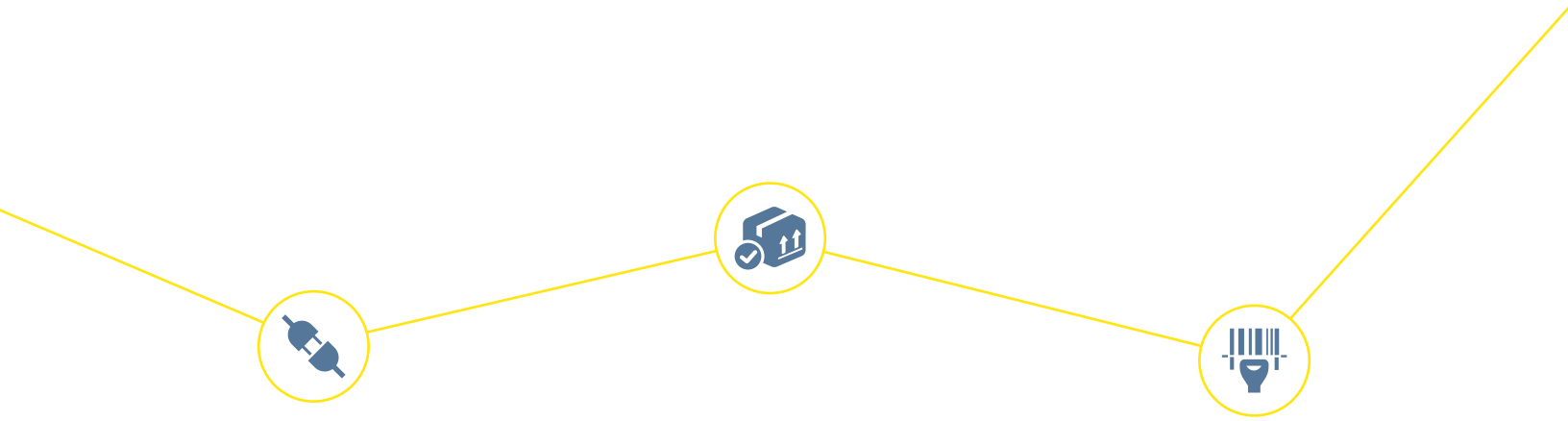
Operational efficiency is one of the key attractions of the IIoT, and early adopters are focused on these benefits. By introducing automation and more flexible production techniques, for instance, manufacturers could boost their productivity by as much as 30 percent.[3]

Predictive maintenance of assets is one such area of focus, saving up to 12 percent over scheduled repairs, reducing overall maintenance costs up to 30 percent and eliminating breakdowns up to 70 percent.[4] For example, Thames Water, the largest provider of water and wastewater services in the UK, is using sensors, analytics and real-time data to help the utility company anticipate equipment failures and respond more quickly to critical situations, such as leaks or adverse weather events.[5]

However, there is more to the story. Although companies are viewing and beginning to leverage the IIoT as an operational efficiency strategy, it also offers rich potential for those that make equipment and products to introduce new digital products and services, generating entirely new sources of revenue to improve both the top and bottom lines. Separately for owners and operators of equipment, such as companies in a process industry, there is a real opportunity for increased revenues. The easy win is to avoid downtime and plant and facility shutdowns, thereby increasing production throughput. For example, a petrochemical producer can rely on predictive maintenance to avoid unnecessary shutdowns and keep products flowing. Apache Corporation, an oil and gas exploration and production company, is using this approach to predict onshore and offshore oil pump failures to help minimize lost production. Executives at Apache claim that if the global oil industry improved pump performance by even 1 percent, it would increase oil production by half a million barrels a day and earn the industry an additional $19 billion a year.[6] Or take a mining operation, where the ability to quickly conduct an assay of the ore when a drill bit unexpectedly hits hard rock enables miners to resume work in a fraction of the time required before.[7]

For now, at the dawn of the IIoT, manufacturers are going after the low-hanging fruit by improving the maintenance and repair services they already offer. But some trailblazer companies are forging ahead with unconventional ways to use the IIoT to provide value to customers, including CLAAS KGaA mbH, General Electric, Michelin, Virtual Radiologic Corp. and ZF Friedrichshafen AG.

While these companies represent inspiring examples, it is important to recognize that the IIoT offers radically new ways to make and think about products and to operate assets and facilities. Many companies are just now beginning to make the transition, and it may not be easy for some industrial, transportation and service-sector



executives to capitalize on the opportunity to sell new digital offerings. However, those that hesitate could be quickly outmaneuvered by existing competitors and new entrants. (See "Will your products be intelligent by 2020?")

In fact, once industries become digital, they also become digitally contestable, meaning companies from outside the traditional industry confines can enter and compete more easily. Think of Google's moves into driverless automobiles, which are likely to disrupt multiple industries, including car insurance and government licensing. Another example is Apple's HealthKit. The platform, which enables health and fitness applications to work together, brings the company into a healthcare data ecosystem now occupied by caregivers, insurers and pharmaceuticals.[8]

To succeed in digitally contestable industries with the IIoT, executives will need to formulate new business models and go-to-market strategies at the macro level, rethink their core business and operations, and introduce intelligence into products, services, processes and more. They will also have to open up their manufacturing operations, production facilities and product designs to new information technologies. The IIoT is both a growth play and a defensive maneuver for today's manufacturers, energy producers and service providers. If incumbents do not identify and exploit these opportunities, new entrants and startups will begin to influence and capture their customers.

So how can executives at industrial companies exploit the revenue-generating opportunities of the IIoT? Accenture's research on IIoT uses cases and current thinking, along with our conversations with clients and subject matter experts, suggests that executives must meet three imperatives: boost revenues by increasing production and creating hybrid business models, fuel innovation with intelligent technologies, and transform the workforce for the IIoT. In addition, we outline seven steps to help companies move forward quickly and confidently to harness the IIoT's potential.

These companies are identifying new growth opportunities by adding digital services and innovations to their product mix. Their executives see the vast potential of the IIoT: the universe of intelligent industrial products, processes and services that communicate with each other and with people over a global network.

Boost revenues by increasing production and creating hybrid business models

As stated in the 2014 Accenture Technology Vision, "Every business is a digital business," the digital-physical blur is turning industrial companies into customer service companies.[9] Manufacturing, energy and other industrial executives tell Accenture that new services, competitors and ways of operating their businesses will transform their industries.[10]

Asset owners and operators will spend on these digital services to help them increase their production and efficiency. They will also invest in their own novel solutions to improve the performance of existing assets and processes as well as collaboration across the supply chain—whether the business is chemicals, mining, energy or agriculture.

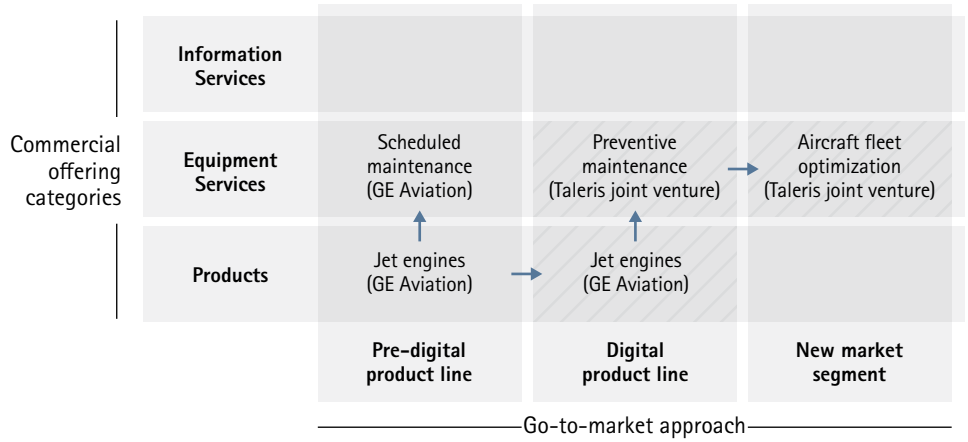
Digital services—offerings that combine information, transactional and professional services—will lie at the heart of these shifts. Some companies are already converting products into product-service hybrids, which we define as connected, intelligent physical goods capable of producing data for use in digital services.

Figure 1: How companies are finding opportunity through the Industrial Internet of Things

The IIoT presents companies with opportunities to upgrade and offer new services, improve products, and enter new markets. Consider how General Electric, Michelin and CLAAS are going to market with product-service hybrids by adding digital services (shaded boxes) to their pre-digital products (solid boxes). But even companies that do not sell products, such as Virtual Radiologic, can take advantage of opportunities to expand into digital services.

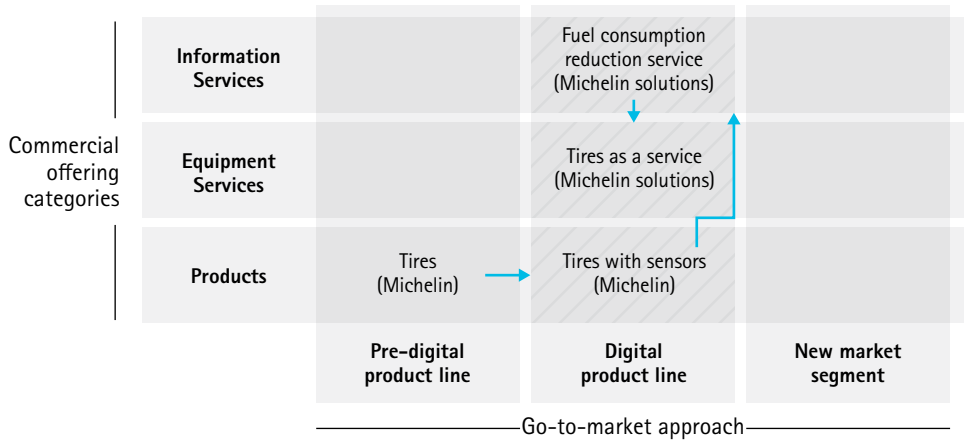
General Electric

General Electric's aircraft engine maintenance business, born out of its jet engine business, is now moving to preventive maintenance and expanding into aircraft fleet optimization.



Michelin

Michelin is helping truck fleet managers reduce fuel consumption and costs and allowing them to pay for tires on a kilometers-driven basis.

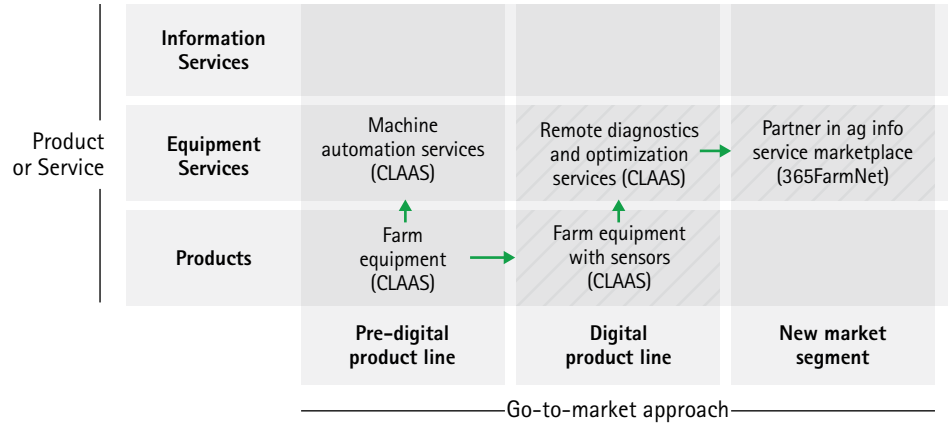


These hybrids will be the primary vehicle to tap into this opportunity. They enable companies to create hybrid business models, combining product sales and leasing with recurring income streams from digital services. These digital services will also enable firms in resource-extracting and process industries to make better decisions, enjoy better visibility along the value chain and improve productivity in other ways.

These product-service hybrids should go well beyond incremental improvements, such as feature changes; they must address unmet customer needs or solve critical business problems with breakthrough solutions. (See Figure 1.) However, these product-service hybrids need not be first to the market.[11] Nor must the service provider be the same company as the product manufacturer: a service provider can hybridize another company's product by capturing the data it creates, as Virtual Radiologic does with its analytics service.

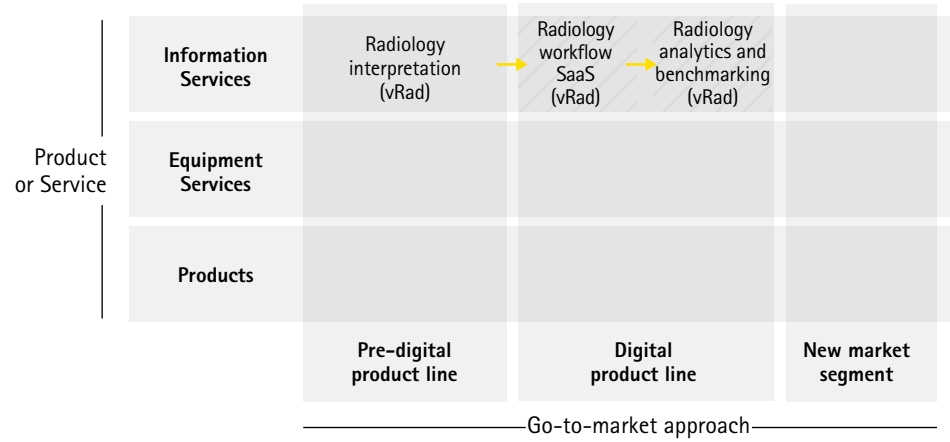
CLAAS

Farmers can operate CLAAS equipment on autopilot, receive advice on how to improve crop flow and minimize grain losses, or automatically optimize equipment performance. The company is now partnering with other organizations to provide information services to growers via a marketplace called 365FarmNet.



Virtual Radiologic

vRad began life as an X-ray interpretation service. It has since expanded into the IT services business, offering software services business and more recently an analytics service.



Key

Information services sell data and insights or manage a market that sells data.

Equipment services sell product operations and optimization services or sell the product using an as-a-service or for-performance payment model.

Source: Company websites.

Success as a purveyor of hybrid product-services will not come easily. Companies must compete and collaborate with players from different industries, all attempting to find a competitive edge with digital technology.[12] To create new value and foster growth, Accenture recommends the following.

Think unconventionally about customer value

Of course, selling services requires a different business and operating model from selling products. But which model? Look for models that create value for customers as well as your company in unconventional ways.

Another approach is to combine high tech to identify savings opportunities with a high touch approach to gaining them. Michelin solutions built an ecosystem of experts to deliver its new EFFIFUEL™ service. The service uses high tech and high touch to reduce fuel costs in truck fleets. Sensors inside vehicles collect data on fuel consumption, tire pressure, temperature, speed and location. This data is then transmitted to a cloud service of a Michelin solutions partner, and that's where the human touch begins. Michelin solutions fuel experts analyze the data and make recommendations to the fleet manager and Michelin solutions instructors train drivers in how to use less diesel fuel when driving. Result: truck fleet managers can save 2 liters of fuel for every 100 kilometers driven. Michelin has become more than a tire manufacturer—with the launch of the Michelin solutions business, it's also a fuel savings partner.

As a partner to truck fleet managers, Michelin maintains a human touch with this service. This product-service hybrid includes driver training, and the recommendations come from Michelin experts rather than a web service. EFFIFUEL clients also have the option of paying for tires on a per-kilometer-driven basis—an example of selling a product as a service.[13] This innovative service is a prime example of thinking differently about revenue opportunities.

Daimler AG is pursuing another approach to increase value for customers: a flexible, convenient pay-per-use model for city dwellers needing cars. Car2Go customers use an app to find the car that is parked nearest to them. They open the door with a membership card, drive to their destination, and simply park the car on the street and lock it up. Car2Go competes with conventional taxis, cab alternatives like Uber and hourly car rental services. However, Car2Go differentiates itself on price and convenience—both of which are key customer values. Customers can choose to pay by the mile, the hour or the day. The rates are lower than for taxis, and there is no need to reserve, return or order a car; the cars can be parked and found anywhere.[14]

Other potential models include adding optional services and features, offering customization (using software and modules to create equipment that meets specific customer preferences), and creating new marketplaces.[15] Take 365FarmNet, a consortium whose members include Allianz SE, Bayer AG, and farm-equipment makers CLAAS KGaA mbH and AMAZONEN-WERKE H. Dreyer GmbH. The consortium has established a marketplace for agricultural information where growers can buy GPS, diagnostic, crop, fertilizer and other data from any consortium member; download it to their computers and farm equipment; and use it to take action, such as drawing up crop plans for the coming planting seasons.[16] In this way, CLAAS and AMAZONEN-WERKE are treating their products as platforms, enabling third parties to create information services that are used with their equipment.

Be the most valuable information provider

Sell products and your customers interact with you only when they want to fix or prevent problems. Sell services and you gain multiple opportunities to create customer touch points, build trust and establish customer loyalty. For manufacturers, information services can increase customer preference for a product. But services are also an entry point for competitors to get between your company and its customers. Think about it: A company does not have to be a radiology equipment maker to offer X-ray analysis services. And if the service becomes especially valuable to customers, it can end up being more important than the product itself. The company that offers the service can then influence product buying decisions.

This is why being the most valuable information provider—the source of external information that customers rely on the most to run their business—is so critical. However, the old adage that you cannot go it alone applies here. Finding the right business partners is critical to launching product-service hybrids, as few companies have all the skills and technologies necessary within their company. For instance, when it comes to the agricultural information business, the battle to become the trusted source of decision support for farmers is being waged now. Companies such as DuPont and Dow Chemical are forming partnerships to develop and supply precision agriculture solutions to growers. Those alliances are challenging Monsanto Co. Recently, to bolster its FieldScripts seed-planting service, Monsanto acquired weather information provider Climate Corporation and Precision Planting, which provides tools and information to boost crop yields.[17]

Share more equipment data with partners

The product-service hybrid concept also applies to asset owners and operators. Any piece of equipment becomes a productivity-enhancing hybrid if it generates data and the operator puts that data to work as a digital service within its supply chain. However, companies are often wary of sharing information about their operations with their closest partners, even if it hurts productivity. Of course, executives need to be careful about how they share valuable information. But the IIoT can give companies much greater control over their supply chain and their processes than ever

before. Take the oil industry: oil exploration and production companies rarely share drilling plans and detailed operational data with oil field service companies. This slows down production by delaying the movement of equipment onto drilling sites. But if oil producers share planning, forecasting, equipment health, field service and work schedules, they can dramatically increase production. The rising tide of data can float all boats.

Treat services as R&D for products

Which new features will asset owners and operators want? What will industrial products do in the future, and what will they look like? Only time will reveal answers to these questions. This presents challenges for some industrial sectors. For instance, heavy equipment makers risk offering new products before the market is ready to accept them, because such products have relatively small customer bases and take years to wear out and justify replacing—unlike short-lived, inexpensive consumer technology.

As many large technology companies have found, providers of product-service hybrids now have a faster and less costly alternative for releasing innovative products: they can experiment with developing and offering new services. By doing so, they can see how customers use information-based features and gain insights into their needs. And as enterprises start offering cloud-based IIoT services, they can quickly test features to uncover the capabilities customers find most valuable and continue to offer the ones customers like best. Over time, as companies better understand customers' needs, they can use what they have learned from selling services to build a well-targeted generation of products designed for the IIoT.

Some companies are taking their first steps on this path to innovation. Ford Motor Company has adopted a crowdsourcing approach: its OpenXC open software and hardware development platform enables anyone to create experimental applications and accessories such as a nighttime collision warning application.[18] Such exploration can also point the way to new business opportunities. The climate technology unit of an industrial equipment manufacturer is another case in point. The unit's management discovered that sensors in its refrigeration compressors provided a stream of potentially useful data. After speaking with clients about their industrial cooling needs, executives identified an even larger opportunity: providing continuous temperature monitoring services for produce during transport.[19]

Whether disrupting their industry with new business models, R&D or information services, most companies will need outside partners to create and market breakthrough product-service hybrids. Few companies will have all the business skills required to launch them, since these skills are not part of their current core business model. The precision agriculture alliances and Accenture's IIoT joint ventures—including the Taleris aircraft fleet optimization partnership with General Electric (see "Case study: Taleris") and the Omnetric smart grid joint venture with Siemens—are examples of alliances between companies with complementary knowledge and experience that are using their combined strengths to launch new services and attract new customers.

Case study: Taleris

Delays and cancellations cost commercial passenger and cargo airlines in the US over $11 billion a year in maintenance costs, crew wages, logistical costs and lost customers.[45] Taleris, a joint venture between Accenture and GE Aviation that was founded in 2012, cannot change the weather that often causes those delays and cancellations. But it can eliminate avoidable maintenance costs, increase aircraft availability and minimize disruptions before they occur.

Taleris, which has more than 30 airline clients around the world, is an intelligent airline fleet optimization service. The service diagnoses and predicts aircraft maintenance issues before they occur, whether or not the equipment was manufactured by GE. The service combines GE's advanced prognostics technologies, developed over 20 years in military and civil applications, with Accenture's planning optimization and recovery technologies.

Taleris uses sensors to monitor aircraft parts, components and systems "from tip to tail." It employs analytics to identify anomalies in engineering systems and their overall health, to analyze the root cause of anomalies, and to determine when units need replacement or repair. By knowing when maintenance is needed across a fleet, Taleris turns unscheduled maintenance and periodic maintenance into optimally scheduled maintenance. Airlines can schedule the best time and location for maintenance, as well as arrange for aircraft to cover routes for any that are grounded. The service thus minimizes the disruption and cost of maintenance work by reducing aircraft downtime, streamlining spare-parts logistics, and arranging for backup aircraft and crew.

When service is disrupted owing to weather or other issues, Taleris is designed to bring the best economic outcome. It considers cost drivers such as fuel costs as well as factors of crew availability and passenger inconvenience.[46]

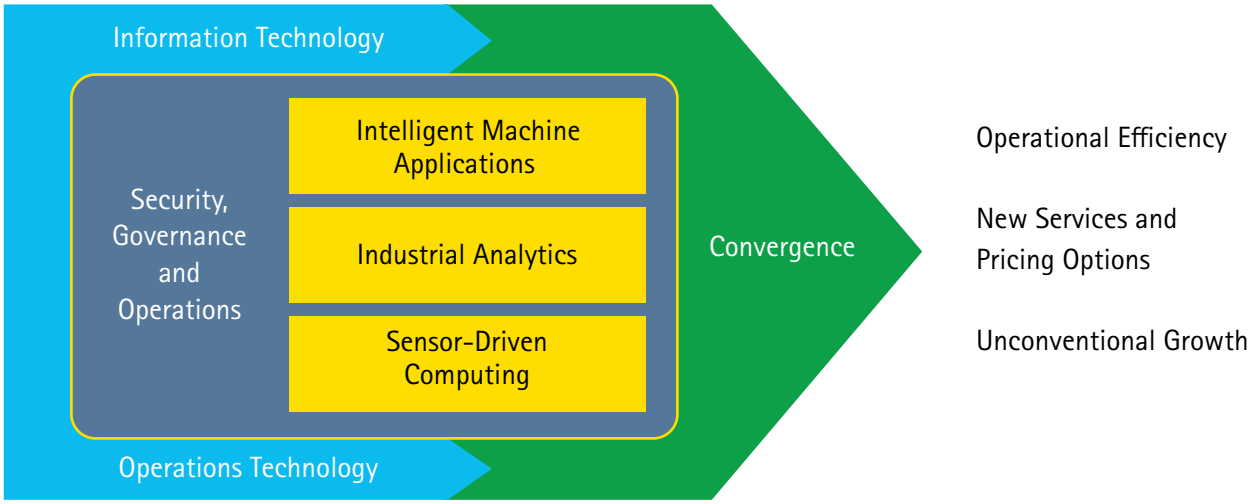
Exploit intelligent technologies to fuel breakthrough innovations

Innovation is critical to developing and delivering differentiated new product-service hybrids that drive growth. To reap the full benefits of the IIoT, companies will need to excel at exploiting three technology capabilities: sensor-driven computing, industrial analytics and intelligent machine applications. (See Figure 2.)

By deploying these capabilities, companies can weave together previously unavailable, or inaccessible, enterprise and machine-generated data to create new monetization opportunities.

Sensors, analytics and intelligent machine applications, and the in-house or third-party-sourced IIoT platform that will bind them together, will supplant the now separate worlds of information technology (IT) and operational technology (OT). (See "Connecting IT and OT.") Today's patchwork of separately evolved, vendor-specific and proprietary infrastructure will be replaced, over time, with interoperable platforms. This patchwork creates a hurdle today, so it will be necessary to modernize and bring together both operational and information technology in support of a new generation of intelligent equipment in the future.

Figure 2: Three Industrial Internet of Things capabilities to master



Will your products be intelligent by 2020?

It is hard enough defining human intelligence, let alone agreeing on what makes a physical product intelligent. In the 1970s, bar codes were state-of-the-art when it came to product intelligence. Today, machine intelligence derives from a large array of sensors and real-time decision-making software. Luxury cars are loaded with as many as a hundred microprocessor-based electronic control units and around 100 million lines of software. Yet we are still just beginning the journey.[44]

In the near future, intelligent products will:

- Initiate tasks and communicate with other equipment.
- Tailor their user interfaces, recommendations and movements to meet customer preferences.
- Strengthen their features—and thus the benefits they provide customers—through software improvements.
- Learn how to lower their operating costs.
- Optimize their yield and productivity.
- Prevent accidents and failures during operation.
- Take action in uncertain or adverse conditions.

Sensor-driven computing

Sensors give objects the power of perception—into conditions such as temperature, pressure, voltage, motion, chemistry and usage. Sensor-driven computing converts perception into insights (using the industrial analytics described below) that operators and systems can act on. As with most technology advancements, sensors are swiftly becoming smaller, cheaper and more sophisticated. In fact, Spansion Inc. has begun making sensors that do not use batteries.[20] These characteristics make sensors an exponential technology, promising repeated doublings in improvement in price and performance over short intervals of time.[21] For example, in 2007 the average cost of an accelerometer sensor was $3; in 2014, the average is 54 cents.[22] By 2020, component costs will have come down to the point that connectivity will become a standard feature, even for processors costing less than $1.[23]

In addition, new ways to collect sensor data, low-power devices and algorithms that interpret raw signals are opening up product innovation. ZF Friedrichshafen AG's TraXon PreVision GPS product, for instance, extends the life of truck transmissions and reduces fuel consumption. It collects data about drivers' behavior, adds topographical data to its analysis and "tells" a vehicle's transmission computers when to shift gears.[24]

Industrial analytics

Industrial analytics turns data from sensors and other sources into actionable insights. For example, GE's latest locomotive has 250 sensors that measure 150,000 data points per minute.[25] The end user—whether it is a machine enmeshed in a process or an individual—can use these analytics to interpret the massive streams of incoming data from the locomotive's sensors, along with information and operational systems, to drive real-time decision making and to anticipate events.

In another example, Caterpillar has started using industrial analytics to help its dealers succeed. The company harnesses and analyzes data from its machines, engines and services and transmits the resulting insights to dealers, enabling them to anticipate problems, proactively schedule maintenance and help customers manage their fleets more efficiently.[26] Caterpillar says its dealers in total can capture anywhere from $9 billion to $18 billion in revenue each year should they move customers from "fix when fail" to predictive maintenance along with other actions. Caterpillar benefits by lowering its warranty fulfillment costs and boosting sales of new machines as well as parts and services.[27]

Healthcare companies are also finding opportunities to offer analytics services. Take Virtual Radiologic Corp. (vRad), a tele-radiology services company. vRad has collected data from more than 22 million X-ray, MRI and tomography readings and patient studies. Now it has launched an analytics service that benchmarks radiology equipment utilization and results.

Besides improving staff scheduling, providers can discover whether radiologists are over- or under-utilizing advanced imaging equipment. They can then shift the use of expensive MRI equipment to situations where it is likely to result in positive, and therefore revenue-producing, diagnoses.[28] vRad is an example of the kind of information service that product manufacturers may want to offer on their own or through a partner.

Intelligent machine applications

Soon, manufacturers will no longer build machines that have only mechanical functions—they will now include intelligence. The applications that come with machines will be the vehicle for generating new revenue streams out of these product-service hybrids. And technology advances are making it easier to integrate physical devices and their accompanying software with third-party services. For example, product and application lifecycle management tools, by addressing integration issues and ensuring cross-domain collaboration, help developers build innovative applications.

Take connected products like the Nest thermostat, which ships with a user-friendly interface that lets consumers set their preferences and understand and manage their energy consumption. If these intelligent thermostats are integrated with electric utilities through demand-response applications by the likes of C3 Energy or Opower, utilities can create incentives for consumers to reduce consumption during peak hours. This will help maintain the stability of the electric grid while encouraging consumption at times of low demand.[29]

Applications can also serve as the media for machine-to-machine interactions. Volvo's CareTrack, for example, generates reports that help fleet managers track wear and tear on the vehicles.[30]

And consider SAP's pilot with BMW's connected vehicles. SAP sees cars as conduits for information services. Cars can receive offers from merchants as they drive nearby or receive information about available parking spots.[31] Taking the connected vehicles concept further, we envision a scenario where drivers will no longer pay at the gas pumps and gasoline retailers will no longer have to pay credit card fees. The gas pump would recognize the car and know how many liters or gallons of gas were put in the tank. At the end of the month, the consumer would get a bill from the gasoline retailer.

Furthermore, scenarios like these need not be limited to equipment; anything can be made into an intelligent machine. Roads can be embedded with sensors that gather data on traffic and with materials that recharge electric vehicles while being driven. Recognizing the latter opportunity, Qualcomm has begun licensing an electric vehicle recharging product to automakers for testing.[32]

As these examples show, connected products and software offer exciting new prospects for industrial companies. And technology advances are making it easier to integrate physical devices and their accompanying software with third-party services. For example, new product lifecycle management tools address integration issues, ensure cross-domain R&D collaboration and allow developers to build innovative applications.[33]

Paths to the Industrial Internet of Things platforms

Reaping optimal value from intelligent technologies requires a robust technical architecture and infrastructure. IIoT platforms will be critical to the success of manufacturers and service providers. These companies need the IIoT platforms to develop product-service hybrids, enable the development of applications by third parties, provide APIs for sharing data and control the channel for delivering services to their customers. Asset owners and operators will use these platforms to operate equipment and applications, to deliver and analyze data, to link and control processes, and to connect with other companies in their ecosystems.

At this time, IIoT platforms are still emerging, and none has achieved dominance in an industry sector. Open architecture advocates are just starting to develop shared, nonproprietary platforms and approaches. It's also possible that asset owners and operators will not only be consumers of platforms but will also seek to operate platforms of their own making.

For now, the capabilities of the first IIoT platforms are anchored in the three technology families discussed above:

- **Sensor-driven Computing:** OSIsoft provides real-time data management for manufacturers, utilities and mining. The company is building a platform for collecting sensor data and controlling processes to help customers improve yield, conserve energy or resolve batch production issues.[34]
- **Industrial Analytics:** GE Software offers its own IIoT platform called Predix for its lucrative predictive maintenance business. The platform provides industrial analytics to help customers avoid equipment downtime, optimize profits and manage risks.[35]
- **Intelligent Machine Applications:** PTC, with its acquisition of ThingWorx and Axeda, has built its IIoT platform to rapidly develop and run innovative applications for connected products.[36]

Several consortia of technology and industrial companies have emerged, jockeying to set the standards for interoperability and ecosystem participation. The IIoT Consortium (IIC) is working on connecting and integrating machines with people, processes and data via a common architecture and interoperable mindset. The Open Interconnect Consortia and the AllSeen Alliance are two recently launched open source Internet of Things consortia.[37]

IIoT platforms are still in the early stages of maturity. Executives will have to carefully choose and manage their platforms, explore the technical challenges, expect gaps in information sharing and interoperability, and work with their company's closest partners to bridge them.

Fostering confidence in the Industrial Internet of Things

What can possibly go wrong when manufacturing plants, equipment or remote facilities are interconnected and online?

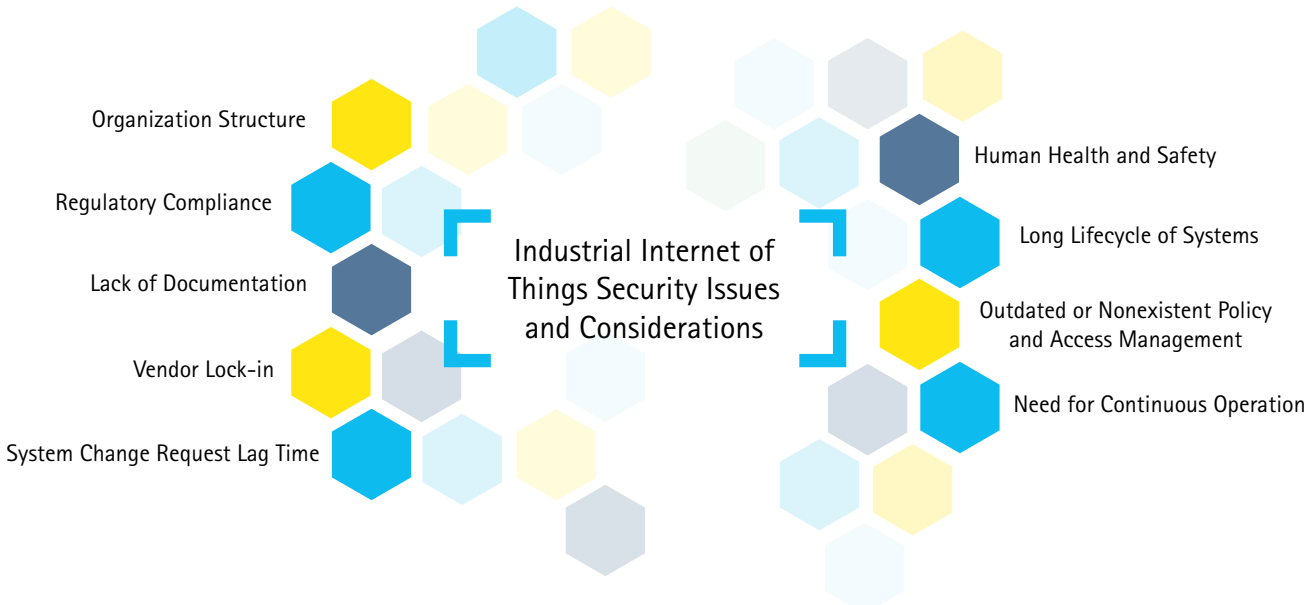
Plenty—including disruptions to operations, sabotage and loss of life from broken infrastructure, cyber attacks and data theft by criminals, foreign governments and disgruntled employees. Recently, an oil rig's control systems were reportedly hacked when saboteurs were able to tilt the rig's platform, while another rig became so riddled with computer malware that it took weeks for the operator to make it seaworthy again.[47]

Given these security threats and other considerations (see Figure 3), it is clear that the IIoT must be underpinned by a well-thought-out cyber-physical security architecture. Executives can support this goal by augmenting their current risk management practices with the following actions:

- Apply noninvasive techniques to patch remote assets, and use industrial control and automation systems that cannot be easily shut down.
- Manage obsolete and legacy operating systems, hosts and devices that have limited or no security built into them.
- Identify and inventory the vast number of sensors, devices and equipment that are on the network. (An electric utility grid might have millions of devices and sensors.)
- Detect and remediate counterfeit or compromised software and hardware.
- Safeguard the integrity of information and systems so that unauthorized access is detected and data that falls into the wrong hands is not corrupted and reintroduced into critical processes.
- Control and monitor network connections to ensure that only appropriate ones exist between sensitive industrial equipment.
- Build in fail-safe mechanisms to make sure that compromised IT systems that run industrial-control systems cause no physical harm to people and property or other severe consequences.
- Understand adversaries' motivations, and adapt risk mitigation strategies to the main danger, such as one-time theft of records, sabotage or ongoing espionage.

Figure 3: Challenges to the defense and resilience of the Industrial Internet of Things

Companies, policy makers, customers and other stakeholders will have to work together to mitigate the risks of intelligent equipment connected to networks.



Transform the workforce for IIoT

The IIoT will open up new workforce needs as it creates redundancy in others. Yes, it will computerize certain tasks and workflow, in particular, repetitive jobs that have so far resisted automation. To capture the bigger opportunities presented by the IIoT, companies will especially need to look for skills in data science, software development, hardware engineering, testing, operations, marketing and sales. Moreover, they will need this expanded talent base to handle three critical activities:

Creating the new Industrial Internet of Things service sector

Offering product-service hybrids will require a workforce to create, support and sell them. Such employees will include product managers, software developers to create and test new information services, hardware designers to develop the products, data scientists to create and interpret analytics, and user interface and experience designers.[38] Downstream, sales managers and marketers will be needed to position and sell the new offerings, within product and service providers and across sales channels. Take Predix, GE Software's platform for the IIoT. As of this writing, GE Software has openings for software, hardware and analytics engineers; test and documentation, cloud, and infrastructure engineers; mobile software developers and software architects; software and services support; product training; and talent acquisition.[39] New categories of services will emerge because of the IIoT. Skycatch, a manufacturer of unmanned aerial vehicles (UAVs), currently has openings for embedded software engineers, mobile engineers with Apple iOS skills and field operations engineers.[40]

We foresee other kinds of jobs surfacing in the UAV industry as well. Companies that need UAVs to inspect pipelines and facilities will most likely wish to outsource these tasks to service providers. Those companies will need people who can design how the UAVs will operate and develop the applications that control, monitor and inventory the equipment; technicians to ensure connectivity between UAVs and the network and to integrate drone data into the company's systems; and dispatchers and field service agents to repair or replace parts or to investigate when a UAV spots broken equipment or intruders.

Supporting users of industrial products and services

Companies offering IIoT tools will strive to make them convenient and simple to use. Think of advances in wearable technology such as Google Glass and user interfaces as found in Metaio GmbH's augmented reality software, which combines mobility and industrial information.[41] But there will be times when putting intelligent equipment and services to work requires technical know-how. Companies will need process engineers to integrate these services into their operations and to find ways to improve worker and customer productivity. Data science and quantitative analysis skills will also be critical for those working with incoming data.

Mastering new ways of working

Users of the IIoT products and services will not only find new work to do; they will also have to do work differently. Think about equipment operators: their jobs take on more sophistication and skill when they move from driving equipment in the field to operating UAVs and robotic equipment from a hub and service center.

At Rio Tinto's operations center in Perth, Australia, skilled equipment operators sit in a remote command center and work with data analysts and engineers to orchestrate the actions of huge drills, excavators, earth movers and dump trucks. Operators share common screen views of the mine and its environs and carry out their work in response to changing conditions like weather, truck breakdowns or major equipment moves. Analysts, using data generated by sensing equipment in mines around the world, make recommendations to operators in the center about how to perform their jobs. The center has already demonstrated impressive results: increased efficiency and reliability, decreased variability, and better identification of performance issues.[42]

Advances in robot technology will further change how people do their work. Today's robots are generally used to perform hazardous, highly repetitive and unpleasant tasks. Many robots will continue serving in these ways. However, a new breed of robots is being designed to team up with people and work safely with them. For example, a robot could modulate its physical behavior to avoid causing injuries or learn tasks without the need for programming. The ABB Dual Arm concept robot (formerly known as FRIDA, for "Friendly Robot for Industrial Dual-Arm") can learn a worker's preferred way to carry out a certain task and then adapt its movements to help complete the task in that way. Rethink Robotics' Baxter not only interacts with humans but also learns from them. If Baxter is shown a step in a specific task, the robot can figure out how to perform the remaining steps in the task. These robots are well suited to working with people, doing basic, repetitive tasks supervised by workers.[43]

Connecting IT and OT

The Industrial Internet of Things brings together two separate technology families:

1. Enterprise IT for resource planning, customer relationship management and decision support systems.
2. Operations technology that monitors and controls field equipment, manufacturing and production processes.

These worlds will become one. However, the merger will take time because the technologies are owned by different business functions, operate under different technical standards and are served by different vendors.

Today's realities

- Software, sensors and controls running today's facilities and equipment are outdated and difficult to upgrade. Companies cannot readily incorporate new features and improvements.
- Limited integration between internal systems (managerial apps, plant data sources) and external partners creates data silos.
- Aging operating systems and vulnerable operational technologies pose security risks because they cannot be easily retired or replaced.
- Limited embedded computing or intelligence control at the device, product or plant level.

Tomorrow's vision

- Sensors, communications and other operational technologies are working together with information technologies, most likely meshing in the cloud.
- Standard, fast software development techniques are used to create intelligent industrial products.
- A common data model and sensing and control architecture that supports the flow of insights and action throughout an organization and its ecosystem of partners.
- The IIoT infrastructure is trustworthy and resilient to inevitable compromise.

Seven steps for moving forward

Offering product-service hybrids, exploiting intelligent technologies and transforming the workforce will require up-front preparation. Executives can get ready by taking these steps:

1 Think boldly about value.

Begin piloting a variety of new services that benefit key stakeholders: customers, original equipment manufacturers (OEMs) and dealers. Ask, "What product-service hybrids beyond remote monitoring and predictive asset maintenance resonate with our customers and our customers' customers? What product, service and value can we deliver to clients? How prepared are we to accelerate our move toward a services-and-solutions business model? How do we develop and add the talent we need to be successful?"

2 Think about tomorrow's partner ecosystem.

Companies will work with partners and suppliers to create and deliver services as well as reach potential new customers. Think of the partnering taking place between farm equipment, fertilizer and seed companies, weather services, and the suppliers needed to provide IT, telecom, sensors, analytics, and other products and services. Ask, "Which companies are also trying to reach my customers and my customers' customers? What other products and services will talk to ours, and who will make, operate and service them? What capabilities and information does my company have that they need? How can we use this ecosystem to extend the reach and scope of our products and services through the Industrial Internet of Things?"

3 Start now to design and develop your platform.

Investigate the pros and cons of new technologies. Develop the architecture and frameworks that will accommodate sensor networks, industrial analytics and an ecosystem of intelligent machine applications. Ask, "How will the architecture be designed: open or closed to outside developers, customers and third parties such as telecommunications firms and solution providers? What Industrial Internet platform will help us deliver and successfully operate these new services across multiple channels?"

4 Closely study the financials.

Consider all the financial angles in advance. Ask, "What financial models should we use to evaluate return on investment? How do we manage the costs of transitioning from a product to a product-service mix? How will different adoption scenarios affect our costs, pricing and margins? What revenues will be cannibalized as we move to services?"

5 Sell your sales channel on promoting new digital products and services.

Assess whether your company's sales or dealer network has the right incentives and training to support your growth strategy. Ask, "How can we convince our dealers that they will benefit from selling services as well as products? Where might channel conflict erupt when services can be sold directly online, and how should we manage such conflict?" Your marketing and your customer support and service operations need to be prepared for the sales push as well.

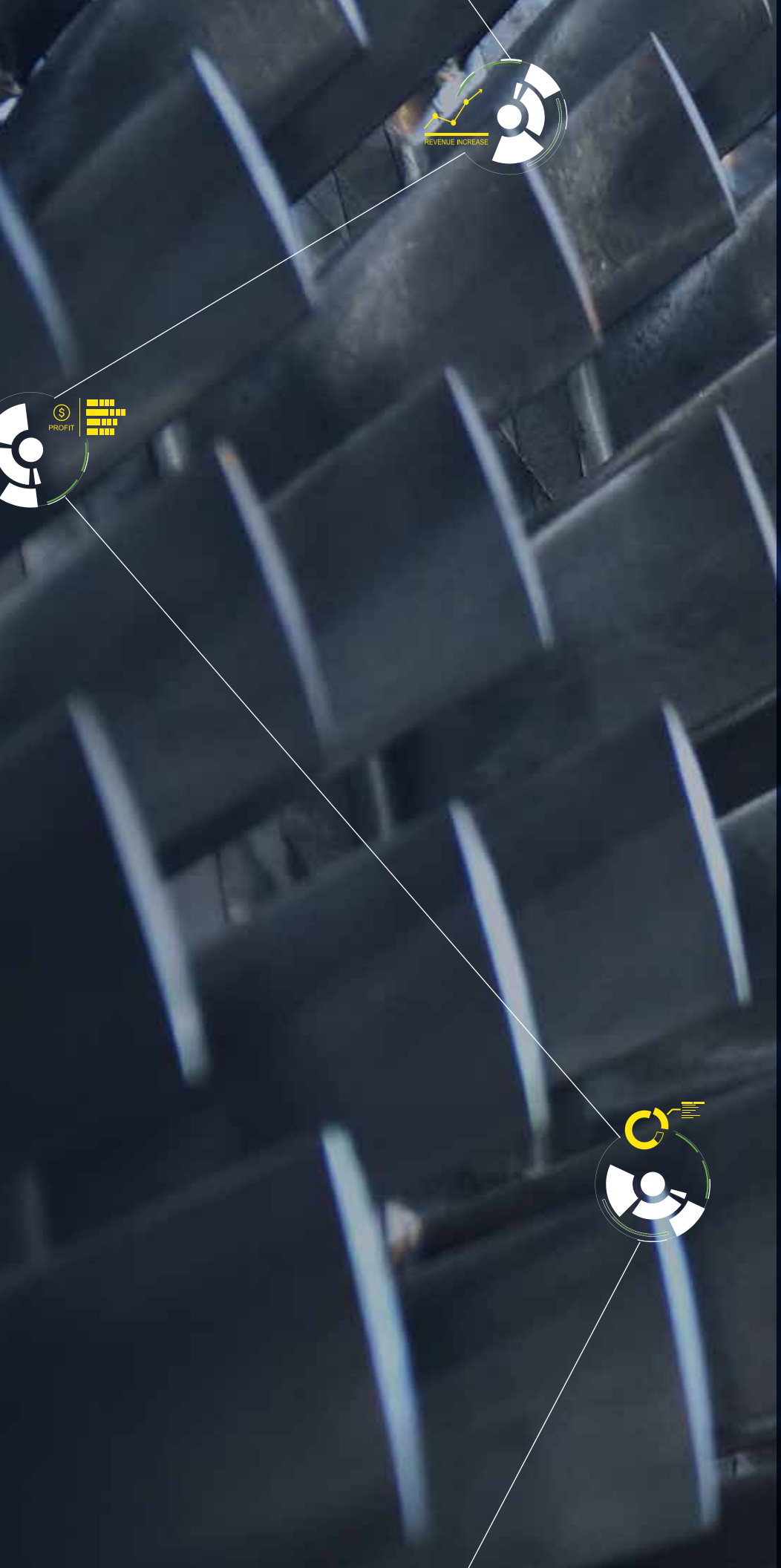
6 Clarify legal rights, obligations and secure access to information about your installed base.

Consider what data governance and protections you must establish to deliver new digital services. Ask, "Who has permission to use data generated by a given piece of machinery—our company or the owner of the equipment? How can we persuade owners to give us access? How do local laws affect what data is considered sensitive or protected in different countries where we operate?" See "Fostering confidence in the Industrial Internet of Things" (Page 13).

7 Put people at the center of executing your strategy.

Think about how to augment your workforce with smart machines. Ask, "How can we provide data so that experts and nonexperts alike can easily work with it? How can we raise worker productivity and empower people with the new Industrial Internet of Things' technologies? What are the skills that are needed to run innovative businesses, and with whom do we partner to obtain that talent?"

The Industrial Internet of Things is bringing new growth opportunities to companies that prepare themselves now. It is still early; there are technology challenges and important hurdles to overcome, particularly in connectivity and security. Not all products can or need to be connected and intelligent right away. But amid the new, an old truth remains: business customers need products and services that create more value for them than those on offer today. The emerging Industrial Internet will unleash new energy into the world of industrial products and services. To be a viable stakeholder as well as partner in the digitally contestable future—and thus generate new revenues—companies will need to make the necessary changes. The time to push is now.



Biographies

Paul Daugherty is Accenture's chief technology officer and also leads Accenture's Technology Innovation & Ecosystem groups. He is based in New York City.

Email paul.r.daugherty@accenture.com
Follow him on Twitter: @pauldaugh.

Prith Banerjee is the managing director of Global Technology Research & Development at Accenture. He is based in San Francisco.

Email prithviraj.banerjee@accenture.com
Follow him on Twitter: @prithbanerjee.

Walid Negm is a global R&D director with Accenture Technology Labs and leads Accenture's Industrial Internet Strategic Innovation Initiative. He is based in Arlington, Virginia.

Email walid.negm@accenture.com
Follow him on Twitter: @walidnegm.

Allan E. Alter is a senior research fellow at the Accenture Institute for High Performance. He is based in Boston.

Email allan.e.alter@accenture.com
Follow him on Twitter: @allanealter.

Acknowledgments

The authors wish to thank the following for their contributions: Edy Liongosari, Dev Shyam and Dadong Wan of Accenture Technology Labs; Jeanne G. Harris, David Light and Vikram Dalal of the Accenture Institute for High Performance; Laurie A. Henneborn and Karen E. Swanson of Accenture Research; Mark P. McDonald of Accenture Strategy; Frank Riemensperger of Accenture Germany; Eric Schaeffer, Ralf Russ and Juha Turunen of Accenture Products; and Omar Abbosh and Michael Grady of Accenture Resources.

Notes

1. Copyright Oxford Economics Ltd. Global Industry Databank, accessed on June 12 2014. https://www.oxfordeconomics.com/forecasts-and-models/industries/data-and-forecasts/global-industry-databank/overview.

2. David Floyer, "Defining and Sizing the Industrial Internet," Wikibon, June 27, 2013; Peter C. Evans and Marco Annunziata, "General Electric: Industrial Internet, Pushing the Boundaries of Minds and Machines," November 2012.

3. "Industry 4.0: Huge potential for value creation waiting to be tapped," Deutsche Bank Research, May 23, 2014.

4. G. P. Sullivan, R. Pugh, A. P. Melendez and W. D. Hunt, "Operations & Maintenance Best Practices: A Guide to Achieving Operational Efficiency, Release 3.0," Pacific Northwest National Laboratory, U.S. Department of Energy, August 2010.

5. Press release, "Accenture to Help Thames Water Prove the Benefits of Smart Monitoring Capabilities," March 6, 2014.

6. Scott MacDonald and Whitney Rockley, "The Industrial Internet of Things," McRock Capital.

7. James Wilson, "Miners tap into rich seam of `internet of things,'" Financial Times, July 16, 2014.

8. Apple iOS 8 Preview, health; Clint Boulton, "Apple's New Health Focus Comes at Propitious Time," The Wall Street Journal. CIO Journal, June 10, 2014.

9. 2014 Accenture Technology Vision.

10. Accenture, "Remaking customer markets: Unlocking growth with digital," 2013.

11. Rajan Varadarajan, Manjit S. Yadav and Venkatesh Shankar, "First-mover advantage in an Internet-enabled market environment: conceptual framework and propositions," Journal of the Academy of Marketing Science (2008) 36:293–308; Fernando Suarez and Gianvito Lanzolla, "The Half-Truth of First-Mover Advantage," Harvard Business Review, April 2005.

12. Accenture, "Remaking customer markets: Unlocking growth with digital," 2013.

13. Michelin solutions press release, July 11, 2013; Dipti Kumar, "Step on the Pedal of Cloud Services," CruxialCIO.com, September 17, 2013.

14. Daimler Car2go website.

15. "ERP Services & IoT Implications," Pierre Audoin Consultants, May 2014.

16. 365FarmNet.com.

17. Jacob Bunge, "Big Data Comes to the Farm, Sowing Mistrust: Seed Makers Barrel Into Technology Business," The Wall Street Journal, February 25, 2014.

18. Presentation by Venkatesh Prasad and Ford Motor Company exhibit at O'Reilly Solid Conference, May 21-22, 2014. OpenXC night vision project page, Ford OpenXC platform website.

19. "Manufacturing Transformation: Achieving competitive advantage in a changing global marketplace," Oxford Economics, June 10, 2013.

20. Dean Takahashi, "Spansion goes battery-less with tiny 'Internet of things' chips," Venturebeat.com, June 5, 2014.

21. Larry Downes and Paul Nunes, "Big Bang Disruption: Strategy in the Age of Devastating Innovation," Penguin Group US. Kindle Edition.

22. James Carbone, "Expect Sensor Prices to Fall," Digikey.com, December 18, 2013; Paula Doe, "Sharply Falling MEMS Prices Spur Rising Demand," Semi.org, July 6, 2010.

23. Gartner, "Gartner Says the Internet of Things Installed Base Will Grow to 26 Billion Units By 2020," December 12, 2013.

24. ZF Friedrichshafen AG, "TraXon – The New, Modular Transmission," www.ZF.com; "ZF's new modular TraXon Truck Transmission leads innovation," Primemovermag.com.au, August 15, 2012.

25. Daniel Terdiman, "How GE got on track toward the smartest locomotives ever," CNet.com, June 21, 2014.

26. Wayne Grayson, "Caterpillar pushes dealers missing out on billions in sales each year to increase use of telematics data," Equipment World, May 21, 2014.

27. G. C. Skipper, "Predictive maintenance and condition-based monitoring," ConstructionEquipment.com, February 22, 2013.

28. vRad.com future of radiology microsite.

29. Opower website; "Demand Response Programs Will Reach Nearly $10 Billion in Annual Revenue by 2023," Navigant Research, June 5, 2014.

30. Volvo Construction Equipment website, www.volvoce.com.

31. Chris Kanaracus, "SAP, BMW Research Project Will Connect Drivers with Real-time Offers and Services," PCWorld, February 26, 2014; BMW Group Research and Technology Testimonial (English), www.sap-customers.com.

32. Michael Belfiore, "We Could Build a Solar-Powered Roadway. But Will We?," PopularMechanics.com, June 11, 2014.

33. Patrick Waurzyniak, "Connecting the Digital World with the Factory Floor," Manufacturing Media Engineering, April 1, 2014.

34. "Chemicals and Petrochemicals." OSIsoft website, osisoft.com.

35. "Predix." GE Software website.

36. "ThingWorx." PTC website, PTC.com.

37. Don Clark, "New Tech Group Joins Crowded Field to Set Rules for 'Internet of Things,'" The Wall Street Journal, July 8, 2014; Quentin Hardy, "Intel, Qualcomm and Others Compete for 'Internet of Things' Standard," The New York Times Bits Blog, July 8, 2014.

38. Accenture analysis of Industrial Internet job openings on June 12, 2014.

39. GE.jobs.com, June 12, 2014.

40. Jobs at Skycatch, https://angel.co/skycatch/jobs, June 12, 2014.

41. Metaio website.

42. Robert H. Thomas, Alex Kass and Ladan Davarzani, "From looking digital to being digital: The impact of technology on the future of work," Accenture 2014. Accenture did not participate in the creation of the Perth operations center and is not involved in running the center.

43. Robert J. Thomas, Alex Kass and Ladan Davarzani, "Fast and furious: How digital technologies are changing the way we work," Accenture Outlook Journal, 2013, No. 3.

44. Robert N. Charette, "This Car Runs on Code," IEEE Spectrum, February 1, 2009.

45. Accenture Institute of High Performance research using data and statistics from the Federal Aviation Administration and the Bureau of Transportation Statistics of the U.S. Department of Transportation, the U.S. Bureau of Labor Statistics and Airlines for America (formerly known as the Air Transport Association of America, Inc.).

46. Taleris website, "Etihad Airways and Taleris Implement New Technology to Predict Aircraft Maintenance Faults, Reduce Flight Delays," BusinessWire, June 18, 2013; "Brains for Planes: Etihad Taps Big Data to Keep Planes on Time," GE Reports, June 18, 2013.

47. The World Economic Forum report "Global Risks 2014;" Jeremy Wagstaff, "All at sea: global shipping fleet exposed to hacking threat," April 23, 2014.

About Accenture

Accenture is a global management consulting, technology services and outsourcing company, with more than 336,000 people serving clients in more than 120 countries. Combining unparalleled experience, comprehensive capabilities across all industries and business functions, and extensive research on the world's most successful companies, Accenture collaborates with clients to help them become high-performance businesses and governments. The company generated net revenues of US$30.0 billion for the fiscal year ended Aug. 31, 2014. Its home page is www.accenture.com.

About The Accenture Institute for High Performance

The Accenture Institute for High Performance develops and publishes practical insights into critical management issues and global economic trends. Its worldwide team of researchers connects with Accenture's consulting, technology and outsourcing leaders to demonstrate how organizations become and remain high performers through original, rigorous research and analysis. For more information, please visit http://www.accenture.com/us-en/research/institute-high-performance/Pages/institute-high-performance-index.aspx.

About Accenture Technology Labs

Accenture Technology Labs, the dedicated technology research and development (R&D) organization within Accenture, has been turning technology innovation into business results for more than 20 years. Our R&D team explores new and emerging technologies to create a vision of how technology will shape the future and invent the next wave of cutting-edge business solutions. Working closely with Accenture's global network of specialists, Accenture Technology Labs help clients innovate to achieve high performance. The Labs are located in Silicon Valley, California; Sophia Antipolis, France; Arlington, Virginia; Beijing, China and Bangalore, India. For more information, please visit www.accenture.com/technologylabs.