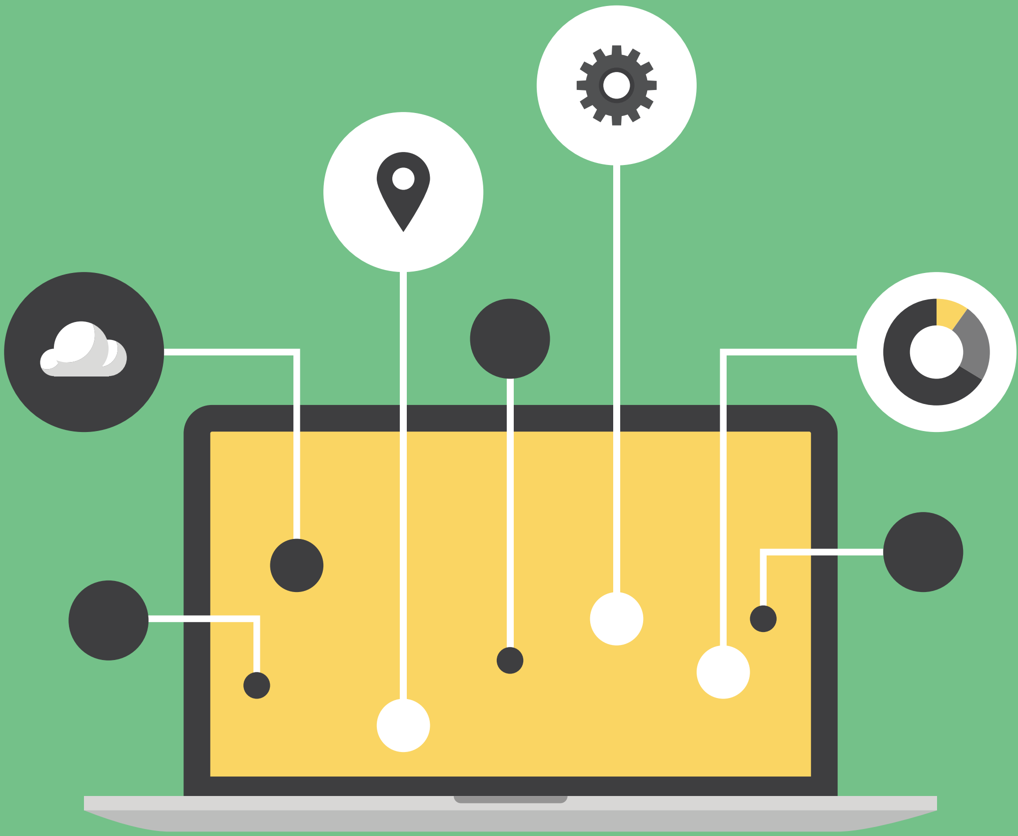

Industry 4.0

The Industrial Internet of Things

Alasdair Gilchrist

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Printed on acid-free paper

To my beautiful wife and daughter,
Rattiya and Arrisara, with all my love

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About the Author

Alasdair Gilchrist has spent his career (25 years) as a professional technician, manager, and director in the fields of IT, data communications, and mobile telecoms. He therefore has knowledge in a wide range of technologies, and he can relate to readers coming from a technical perspective as well as being conversant on best business practices, strategies, governance, and compliance. He likes to write articles and books in the business or technology fields where he feels his expertise is of value. Alasdair is a freelance consultant and technical author based in Thailand.

About the Technical Reviewer

Ahmed Bakir is the founder and lead developer at devAtelier LLC (www.devatelier.com), a San Diego-based mobile development firm. After spending several years writing software for embedded systems, he started developing apps out of coffee shops for fun. Once the word got out, he began taking on clients and quit his day job to work on apps full time. Since then, he has been involved in the development of over 20 mobile projects, and has seen several enter the top 25 of the App Store, including one that reached number one in its category (Video Scheduler). His clients have ranged from scrappy startups to large corporations, such as Citrix. In his downtime, Ahmed can be found on the road, exploring new places, speaking about mobile development, and still working out of coffee shops.

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Introduction

Industry 4.0 and the Industrial Internet of Things (IIoT) has become one of the most talked about industrial business concepts in recent years. However, Industry 4.0 and the IIoT are often presented at a high level by consultants who are presenting from a business perspective to executive clients, which means the underlying technical complexity is irrelevant. Consultants focus on business models and operational efficiency, which is very attractive, where financial gains and new business models are readily understandable to their clients. Unfortunately, these presentations often impress and invigorate executives, who see the business benefits but fail to reveal to the client the technical abstraction of the lower-layer complexity that underpin the Industrial Internet.

In this book, we strive to address this failure and although we start with a high-level view of the potential gains of IIoT business incentives and models, and describe successful use-cases, we move forward to understand the technical issues required to build an IIoT network. The purpose is to provide business and technology participants with the information required in deploying and delivering an IIoT network.

Therefore, the structure of the book is that the initial chapters deal with new and innovative business models that arise from the IIoT as these are hugely attractive to business executives. Subsequent chapters address the underpinning technology that makes IIoT possible. As a result, we address the way we can build real-world IIoT networks using a variety of technologies and protocols. However, technology and protocol convergence isn't everything; sometimes we need a mediation service or platform to glue everything together. So for that reason we discuss in the middle chapters protocols, software patterns, and middleware IIoT platforms and how they provide the glue or the looking glass that enables us to connect or visualize our IIoT network.

Finally, we move forward from generic IIoT concepts and principle to Industry 4.0, which relates to industry, and there we see a focus on manufacturing. Industry 4.0 relates to industry in the context of manufacturing, so these chapters consider how we can transform industry and reindustrialize our nations.

CHAPTER 1

Introduction to the Industrial Internet

GE (General Electric) coined the name "Industrial Internet" as their term for the Industrial Internet of Things, and others such as Cisco termed it the Internet of Everything and others called it Internet 4.0 or other variants. However, it is important to differentiate the vertical IoT strategies (see Figure 1-1), such as the consumer, commercial, and industrial forms of the Internet from the broader horizontal concept of the Internet of Things (IoT), as they have very different target audiences, technical requirements, and strategies. For example, the consumer market has the highest market visibility with smart homes, personal connectivity via fitness monitors, entertainment integrated devices as well as personal in-car monitors. Similarly, the commercial market has high marketability as they have services that encompass financial and investment products such as banking, insurance, financial services, and ecommerce, which focus on consumer history, performance, and value. Enterprise IoT on the other hand is a vertical that includes small-, medium-, and large-scale businesses. However this book focuses on the largest vertical

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of them all, the Industrial Internet of Things, which encompasses a vast amount of disciplines such as energy production, manufacturing, agriculture, health care, retail, transportation, logistics, aviation, space travel and many more.

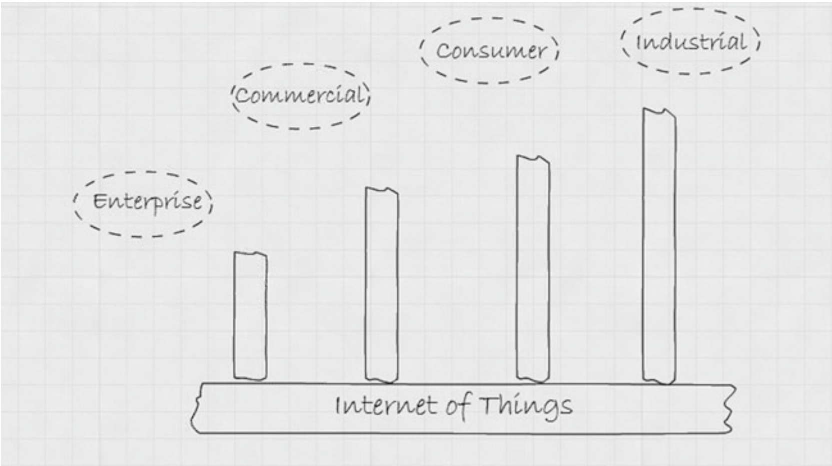

Figure 1-1. Horizontal and vertical aspects of the Internet of Things

In this book to avoid confusion we will follow GE's lead and use the name Industrial Internet of Things (IIoT) as a generic term except where we are dealing with conceptually and strategically different paradigms, in which case it will be explicitly referred to by its name, such as Industry 4.0.

Many industrial leaders forecast that the Industrial Internet will deliver unprecedented levels of growth and productivity over the next decade. Business leaders, governments, academics, and technology vendors are feverishly working together in order to try to harness and realize this huge potential.

From a financial perspective, one market research report forecasts growth of $151.01 billion U.S. by 2020, at a CAGR of 8.03% between 2015 and 2020. However, in practical terms, businesses also see that industrial growth can be realized through utilizing the potential of the Internet. An example of this is that manufacturers and governments are now seeing the opportunity to reindustrialize and bring back onshore, industry, and manufacturing, which had previously been sent abroad. By encouraging reindustrialization, governments hope to increase value-add from manufacturing to boost their GDPs.

The potential development of the Industrial Internet is not without precedence, as over the last 15 years the business-to-consumer (B2C) sector via the Internet trading in retail, media, and financial services has witnessed stellar growth. The success of B2C is evident by the dominance of web-scale giants born on the Internet, such as Amazon, Netflix, eBay, and PayPal. The hope is that the next decade will bring the same growth and success to industry, which in this context covers manufacturing, agriculture, energy, aviation, transportation, and logistics. The importance of this is undeniable as industry produces two-thirds of the global GDP, so the stakes are high.

The Industrial Internet, however, is still in its infancy. Despite the Internet being available for the last 15 years, industrial leaders have been hesitant to commit. Their hesitance is a result of them being unsure as to how it would affect existing industries, value chains, business models, workforces, and ultimately productivity and products. Furthermore, in a survey of industry business leaders, 87% claimed in January 2015 that they still did not have a clear understanding of the business models or the technologies.

This is of course to be expected as the Industrial Internet is so often described at such a high level it often decouples the complexities of the technologies that underpin it to an irrelevance. For example, in industrial businesses, they have had sensors and devices producing data to control operations for decades. Similarly, they have had machine-to-machine (M2M) communications and collaboration for a decade at least so the core technologies of the Industrial Internet of Things are nothing new. For example, industry has also not been slow in collecting, analyzing, and hoarding vast quantities of data for historical, predictive, and prescriptive information. Therefore the question industrial business leaders often ask is, "why would connecting my M2M architecture to the Internet provide me with greater value?"

What Is the Industrial Internet?

To explain why businesses should adopt the Industrial Internet, we need to first consider what the IIoT actual is all about. The Industrial Internet provides a way to get better visibility and insight into the company's operations and assets through integration of machine sensors, middleware, software, and backend cloud compute and storage systems. Therefore, it provides a method of transforming business operational processes by using as feedback the results gained from interrogating large data sets through advanced analytics. The business gains are achieved through operational efficiency gains and accelerated productivity, which results in reduced unplanned downtime and optimized efficiency, and thereby profits.

Although the technologies and techniques used in existing machine-to-machine (M2M) technologies in today's industrial environments may look similar to the IIoT, the scale of operation is vastly different. For example, with Big Data in IIoT systems, huge data streams can be analyzed online using cloud-hosted advanced analytics at wire speed. Additionally, vast quantities of data can be stored in distributed cloud storage systems for future analytics performed in batch formats. These massive batch job analytics can glean information and statistics, from data that would never previously been possible because of the relatively tiny sampling pools or simply due to more powerful or refined algorithms. Process engineers can then use the results of the analytics to optimize operations and provide the information that the executives can transform to knowledge, in order to boost productivity and efficiency and reduce operational costs.

The Power of 1%

However, an interesting point with regard to the Industrial Internet is what is termed the power of 1%. What this relates to is that operational cost/inefficiency savings in most industries only requires Industrial Internet savings of 1% to make significant gains. For example, in aviation, the fuel savings of 1% per annum relates to saving $30 billion. Similarly, 1% fuel savings for the gas-fired generators in a power station returns operational savings of $66 billion. Furthermore, in the Oil and Gas industry, the reduction of 1% in capital spending on equipment per annum would return around $90 billion. The same holds true in the agriculture, transportation, and health care industries. Therefore, we can see that in most industries, a modest improvement of 1% would contribute significantly to the return on investment of the capital and operational expenses incurred by deploying the Industrial Internet. However, which technologies and capital expenses are required when initiating an IIoT strategy?

Key IIoT Technologies

The Industrial Internet is a coming together of several key technologies in order to produce a system greater than the sum of its parts. The latest advances in sensor technologies, for example, produce not just more data generated by a component but a different type of data, instead of just being precise (i.e., this temperature is 37.354 degrees). sensors can have self-awareness and can even predict their remaining useful life. Therefore, the sensor can produce data that is not just precise, but predictive. Similarly, machine sensors through their controllers can be self-aware, self-predict and self-compare. For example, they can compare their present configuration and environment settings with preconfigured optimal data and thresholds. This provides for self-diagnostics.

Sensor technology has reduced dramatically in recent years in cost and size. This made the instrumentation of machines, processes, and even people financial and technically feasible.

Big Data and advanced analytics as we have seen are another key driver and enabler for the IIoT as they provide for historical, predictive, and prescriptive analysis, which can provide insight into what is actually happening inside a machine or a process. Combined with these new breed of self-aware and self-predicting components analytics can provide accurate predictive maintenance schedules for machinery and assets, keeping them in productive service longer and reducing the inefficiencies and costs of unnecessary maintenance. This has been accelerated by the advent of cloud computing over the last decade whereby service providers like AWS provide the vast compute, storage, and networking capabilities required for effective Big Data at low cost and on a pay-what-you-use basis. However, some risk-adverse companies may prefer to maintain a private cloud, either on their own data centers or in a private cloud.

Why Industrial Internet and Why Now?

To comprehend why the Industrial Internet is happening today, when its technologies have been around for a while, we need to look at legacy system capabilities and inefficiencies.

One assumption is that the complexity of industrial systems has outpaced the human operator's ability to recognize and address the efficiencies, thus making it harder to achieve improvements through traditional means. This can result in machines operating well below their capabilities and these factors alone are creating the operational incentives to apply new solutions.

Furthermore, IT systems can now support widespread instrumentation, monitoring, and analytics due to a fall in the costs of compute, bandwidth, storage, and sensors. This means it's possible to monitor industrial machines on a larger scale. Cloud computing addresses the issues with remote data storage; for example, the cost and capacity required to store big data sets. In addition, cloud providers are deploying and making available analytic tools that can process massive amounts of information. These technologies are maturing and becoming more widely available, and this appears to be a key point. The technologies have been around for a while and have been adopted by IT—cloud adaptation and SaaS are prime examples of this. However, it is only recently that industrial business leaders have witnessed the stability and maturity of solutions, tools, and applications within these IT sectors reach a level of confidence and lessen concerns.

Similarly, the maturity and subsequent growth in networks and evolving low-power radio wireless wide area networks (WWAN) solutions have enabled remote monitoring and control of assets, which previously were simply not economical or reliable enough. Now these wireless radio networks have reached a price point and a level of maturity and reliability that works in an industrial environment. Together these changes are creating exciting new opportunities when applied to industrial businesses, machines, fleets, and networks.

The decline in the cost of compute, storage, and networks is a result of the cloud-computing model, which allows companies to gather and analyze much larger amounts of data than ever before. This alone makes the Industrial Internet an attractive alternative to the exclusive M2M paradigm.

However, the Industrial Internet has its own issues, which may well act as severe countermeasures to adoption. These are termed *catalysts* and *precursors* to a successful Industrial Internet deployment.

Catalysts and Precursors of the IIoT

Unfortunately, there are several things an IIoT candidate business simply must have in place before embarking on a serious deployment, discussed in the following sections.

Adequately Skilled and Trained Staff

This is imperative if you expect to benefit from serious analytics work as you will certainly need skilled data scientists, process engineers, and electro-mechanical engineers. Securing talent with the correct skills is proving to be a daunting task as colleges and universities seem to be behind the curve and are still pushing school leavers into careers as programmers rather than data scientists. This doesn't seem to be changing anytime soon. This is despite the huge demand for data scientists and electro-mechanical engineers predicted over the next decade. The harsh financial reality is that the better the data analytical skills, the more likely the company can produce the algorithms required to distil information from their vast data lakes. However, this is not just any information but information that returns true value, aligned to the business strategy and goals. That requires data scientists with expert business knowledge regarding the company strategy and short-medium-long term goals. This is why there is a new C-suite position called the Chief Data Officer.

Commitment to Innovation

A company adopting IIOT has to make a commitment to innovation, as well as taking a long-term perspective to the IIoT project's return on investments. Funding will be required for the capital outlay for sensors, devices, machines, and systems. Funding and patience will be required as performing the data capture and configuring the analytics' parameters and algorithms might not result in immediate results; success may take some time to realize. After all, statistical analysis does not always return the results that you may be looking for. It is important to ask the correct questions. Data scientists can look at the company strategy and align the analysis—the questions of data pools—to return results that align with the company objectives.

A Strong Security Team Skilled in Mitigating Vulnerabilities in Industrial and IT Networks

This is vital, as the IIoT is a confluence of many technologies and that can create security gaps unless there is a deep understanding of the interfaces and protocols deployed. Risk assessments should reveal the most important assets and the highest risk assets and strategic plans developed to mitigate the risk. For example, in a traditional industrial production factory the machines that produce the products such as lathes that operate on programmable templates contain all the intellectual and design knowledge to construct the product. Additionally, security teams should enforce policy and procedures across the entire supply chain.

Innovation and the IIoT

Proponents of the Industrial Internet refer to it as being the third wave of innovation. This is in regard to the first wave of innovation being the industrial revolution and the second wave the Internet revolution. The common belief is that the third wave of innovation, the Industrial Internet revolution, is well under way. However, if it is, we are still in its infancy as the full potential of the digital Internet technology has yet to be realized broadly across the industrial technology sectors. We are beginning to see intelligent devices and intelligent systems interfacing with industrial machines, processes, and the cloud, but not on an industry-wide scale. Certainly, there is not the level of standardization of protocols, interfaces, and application that will undoubtedly be required to create an IIoT value chain. As an example of this, there is currently a plethora of communication and radio protocols and technologies, and this has come about as requirements are so diverse.

In short, no one protocol or technology can meet all use-case requirements. The existence of diverse protocols and technologies makes system integration within an organization complex but with external business partners, the level of complexity can make integrating systems impractical. Remember that even the largest companies in the world do not have the resources to run their own value chains. Therefore, until interfaces, protocols, and applications are brought under some level of standardization, interconnecting with partners will be a potentially costly, inefficient, and possibly an insecure option.

Intelligent Devices

We are witnessing innovation with the development of intelligent devices, which can be new products or refitted and upgraded machinery. The innovation is currently directed toward enabling intelligent devices. This is anything that we connect with instrumentation, for example, sensors, actuators, engines, machines, components, even the human body, among a myriad of other possible items. This is because it is easy and cost effective to add instrumentation to just about any object about which we wish to gather information.

The whole point of intelligent devices in the Industrial Internet context is to harvest raw data and then manage the data flow, from device to the data store, to the analytic systems, to the data scientists, to the process, and then back to the device. This is the data flow cycle, where data flows from intelligent devices, through the gathering and analytical apparatus before perhaps returning as control feedback into the device. It is within this cycle where data scientists can extract prime value from the information.

Key Opportunities and Benefits

Not unexpectedly, when asked which key benefits most IIoT adopters want from the Industrial Internet, they say increased profits, increased revenue flows, and lower operational expenditures, in that order. Fortunately, using Big Data to reap the benefits of analytics to improve operational processes appears to be akin to picking the low hanging fruit; it's easily obtainable. Typically, most industrial companies head straight for the predictive maintenance tactic as this ploy returns the quickest results and return on investment.

Some examples of this are the success experienced by Thames Water, the largest fresh-drinking water and water-waste recycler in the UK. It uses the IIoT for remote asset management and predictive maintenance. By using a strategy of sensors, remote communication, and Big Data analytics, Thames Water can anticipate equipment failures and respond quicker to any critical situation that may arise due to inclement weather.

However, other industries have other tactical priorities when deploying IIoT, one being health and safety. Here we have seen some innovative projects from using drones and autonomous vehicles to inspect Oil and Gas lines in inhospitable areas to using autonomous mining equipment. Indeed Schlumberger is currently using an autonomous underwater vehicle to inspect sub-sea conditions. The unmanned vehicle travels around the ocean floor and monitors conditions for anything up to a year powered only by wave motion, which makes deployment in remote ocean locations possible, as they are both autonomous and self-sufficient requiring no local team support.

Submersible ROV (remote operational vehicles) previously had to be lowered and supported via a umbilical cord from a mother ship on the surface that supplied power and control signals. However, with autonomous ROVs, support vessels no longer have to stay in the vicinity as the ROVs are self powered. Furthermore there is no umbilica3l cord that is susceptible to snagging on obstacles on the seabed.

It is not just traditional industry that can benefit from the Industrial Internet of Things. Health care is another area that has its own unique perspective and targets. In health care, the desire is to improve customer care and quality service. The best metric for a health care company to be judged is how long their patients survive in their tender care, so this is their focus—improving patient care. This is necessary, as hospital errors are still a leading cause of preventable death. Hospitals can utilize miniaturized sensors, such as Google and Dexcoms' initiative to develop disposable, miniaturized glucose monitors that can be read via a wrist band that is connected to the cloud. Hospitals can improve patient care via nonintrusive data collection, Big Data analytics, and intelligent systems.

The improvements to health care come through not just the medical care staff but the initiatives of medical equipment manufacturers to miniaturize and integrate their equipment with the goal of achieving more wearable, reliable, integrated, and effective monitoring and analysis equipment.

By making medical equipment smaller, multi-functional, and usable, efficiency is achievable through connecting intelligent devices to a patient's treatment plan in order to deliver medication to the patient through smart drug delivery systems, which is more accurate and reliable. Similarly, distributing intelligent devices over a network allows information to be shared among devices. This allows patient sensor data to be analyzed more intelligently, as well as monitored and processed quicker so that devices trigger an alarm only if there is collaborative data from other monitoring sensors that the patient's health is in danger.

Therefore, for the early adopters of the Industrial Internet, we can see that each has leveraged benefit in their own right, using innovation and analytics to solve unique problems of their particular industry.

The Why Behind the Buy

The IIoT has brought about a new strategy, which has arisen in industry, especially within manufacturing, and it is based on the producer focusing on what the customer actually wants rather than the product they buy. An example of this is why a customer would buy a commercial jet airliner. Is it because he wants one, or is it because he needs it to transport hundreds of his customers around the globe?

Traditionally, manufacturers set about producing the best cost-effective products they could to sell on the open market. Of course, this took them into conflict with other producers, which required them to find ways to add value to their products. This value-add could be based on quality, price, quantity, or perceived value for the money. However, these strategies rarely worked for long, as the competitor having a low barrier to entry simply followed successful differentiation tactics. For example, competitors could match quantity and up their lot size to match or do better. Worse, if the price was the differentiator, the competitor could lower their prices, which results in what is termed a race to the bottom.

Selling Light, Not Light Bulbs

What the customer ultimately wants the goods for is to provide a service (provide air transportation in the previous example), but it could also be to produce light in the case of a light bulb. This got manufacturers looking at the problem from a different perspective; what if instead of selling light bulbs, you sold light?

This out-of-the-box thinking produced what is known as the *outcome economy,* where manufacturers actually charged for the use of the product rather than the product itself. The manufacturer is selling the quantifiable use of the product. A more practical example is truck tires. A logistics company doesn't want to be buying tires for every truck in its fleet up front, not knowing how long they might last, so they are always looking for discounts and rebates. However, in the outcome economy, the logistic company only pays for the mileage and wear it uses on the tires, each month in arrears. This is a wonderful deal for them, but how does it work for the tire manufacturer? (We must stress a differentiator here—this is not rental.)

Well, it appears it works very well, due to the IIoT. This is feasible because each tire is fitted with an array of sensors to record miles and wear and tear and report this back via a wireless Internet link to the manufacturer. Each month the tire manufacturer invoices the logistics company for the wear of the tires. Both parties are happy, as they are getting what they originally wanted, just in an indirect way. Originally, the logistics company needed tires but was unwilling to pay anything over the minimum upfront as they assumed all the risk. However, now they get the product with less risk, as they pay in arrears and get the service they want. The tire manufacturer actually gets more for the tires, albeit spread over the lifetime of the tire, but they do also have additional services they can now potentially monetize. For example, the producer can supply data to the customer on how the vehicle was driven, by reporting on shock events recorded by the sensors or excessive speed. This service can help the customer, for example in the case of a logistics company to train their drivers to drive more economically, saving the company money on fuel bills.

Another example of the outcome economy is with Rolls Royce jet engines. In this example, a major airline does not buy jet engines; instead, it buys reliability from Rolls Royce's TotalCare. The customer pays fees to ensure reliable jet engines with no service or breakdowns. In return, Rolls Royce supplies the engines and accepts all the maintenance and support responsibilities. Again, in this scenario Rolls Royce uses thousands of sensors to monitor the engines every second of their working life, building up huge amounts of predictive data, so that it knows when a component's service is degrading. By collecting and storing all those vast quantities of data, Rolls Royce can create a "digital twin" of the physical engine. Both the digital and its physical twin are virtual clones so engineers don't have to open the engine to service components that are subsequently found to be fine, they know that already without touching or taking the engine out of service.

This concept of the "digital twin" is very important in manufacturing and in the Industrial Internet as it allows Big Data analytics to determine recommendations that can be tested on a virtual twin machine and then processed before being put into production.

The Digital and Human Workforce

Today, industrial environment robots are commonplace and are deployed to work tirelessly on mundane or particularly dirty, dangerous, or heavy-lifting tasks. Humans on the other hand are employed to do the cognitive, intricate, and delicate work that only the marvelous dexterity of a human hand can achieve. An example of this is in manufacturing, in a car assembly plant. Robots at one station lift heavy items into place while a human is involved in tasks like connecting the electrical wiring loom to all the electronics. Similarly, in smartphone manufacturing, humans do all the work, as placing all those delicate miniature components onto the printed circuit board requires precision handling and placement that only a human can do (at present).

However, researchers believe this will change in the next decade, as robots get more dexterous and intelligent. Indeed some researchers support a view of the future for industry in which humans have not been replaced by robots but humans working with robots.

The logic is sound, in that humans and robots complement each other in the workplace. Humans have cognitive skills and are capable of precision handling and delicate maneuverings of tiny items or performing skills that require dexterity and a sense of touch. Robots on the other hand are great at doing repeatable tasks ad nauseam but with tremendous speed, strength, reliability, and efficiency. The problem is that industrial robots are not something you want to stand too close to. Indeed most are equipped with sensors to detect the presence of humans and to slow down or even pause what they are doing for the sake of safety.

However, the future will bring another class of robot, which will be able to work alongside humans in harmony and most importantly safely. And perhaps that is not so far-fetched when we consider the augmented reality solutions that are already in place today, which looked like science fiction only a few years ago.

The future will be robots and humans working side by side going by the latest research in IIoT. For example, robots are microcosms of the Industrial Internet, in so much as they have three qualities—sensing, processing data, and acting. Therefore, robots—basically machines that are programmable to replace human labor—are a perfect technological match for the IIoT. Consequently, as sensor technology advances and software improves, robots will become more intelligent and should be able to understand the world around them. After all, that is not so far away as we already have autonomous cars and drones. Expect robots to be appearing in supermarkets and malls near you soon.

References

https://www.ge.com/digital/industrial-internet

https://www.accenture.com/us-en/labs-insight-industrial-internet-of-things.aspx

http://www.forbes.com/sites/bernardmarr/2015/06/01/how-big-data-drives-success-at-rolls-royce/#206a7e173ac0

http://zwcblog.org/2014/08/08/selling-light-not-light-bulbs/

http://news.mit.edu/2015/giving-robots-more-nimble-grasp-0804