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The Internet of Things: Are you ready for what's coming?

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Abstract Are you ready for what's coming? As senior managers look to connect products, processes, and services to the growing field of the Internet of Things (IoT), this is an important preliminary question. Leveraging the IoT for firm benefit involves revisiting certain ideas that may have gone unquestioned for a long time. In this article, we begin by reviewing the complexity of the IoT, the complexities of an increasingly interconnected environment, and the increasing need to develop partnerships in order to create innovative solutions. We then offer practical insights from a case in which three actors with reciprocal specialties cooperated to create an IoT solution in the form of a connected appliance. While a shared spirit of optimism prevailed throughout the endeavor, reaching the finish line meant jumping a few hurdles along the way. Finally, we describe a number of fundamental issues related to business models, partnership strategy, data ownership, and technology diffusion that every enterprise should address before diving headfirst into the Internet of Things.

1. Lost in the woods

Are you ready for what's coming? As senior managers look to connect products, processes, and services to the growing field of the Internet of Things (IoT), this is an important preliminary question. Analysts—including Gartner (2015) and McKinsey (Manyika et al., 2015)—have predicted significant growth in the number of connected devices and areas of application, creating value for both private consumers and businesses. Connected devices are currently attracting a significant amount of attention among practitioners as well as researchers. IoT is often spoken of with the same reverence that the World Wide Web enjoyed in the late 1990s and cloud computing just a few years ago. However, as the promise of a hyperconnected future in which everything is connected to everything else appears to be drawing ever closer, we appear to become less and less certain regarding just what this future will look like. Estimates for the number of connected devices range from 25 to 50 billion by the year 2020

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(Lee & Lee, 2015; Weinberg, Milne, Andonova, & Hajjat, 2015). While the hefty margin of error might provoke a smirk or be dismissed as the result of pure guesswork, it is also symptomatic of a deeper, more serious issue. What can be gained by directly connecting products to the internet that cannot already be attained with the current range of gadgets and contraptions? What are the consequences and critical issues of a transition to a connected world? Are firms obligated to incorporate another feature into their products 'just because,' or is there an actual rationale somewhere behind the hype?

Leveraging the IoT for firm benefit involves revisiting certain ideas that may have gone unquestioned for a long time. As Erik Brynjolfsson and Andrew McAffee (2014) outline in their book *The Second Machine Age*, radical innovations such as electricity and computers were slow to yield proper dividends. It took many years for people to realize how to use the new technology to their advantage, and those who got there first enjoyed a significant competitive advantage while the competition scrambled to mimic their approach. While it is not our intention to overinflate the significance of the IoT by making direct comparisons to the introduction of electricity or the proliferation of computers, we can make a direct comparison concerning the initial confusion and inability to see the full potential of a new innovation. Researchers and practitioners are still in the midst of making sense of the IoT. The attachment to existing norms, value chains, and business models casts long shadows that prevent proper exploitation of products that can continually disclose how, where, and when they are used. Realizing the idealistic notion of a smart product is as much about exploring motives and expectations as it is about resolving technical issues.

In this article, we begin by briefly reviewing what has been written about the IoT and the immense complexity of seamlessly integrating products, people, places, and processes that will require both high volume and high customization. We then proceed to outline value creation and the increasing necessity to form partnerships in order to develop intricate solutions that extend well beyond the product itself. Next, we present practical insights from three enterprises that pooled their know-how of product development, communication infrastructure, and information management to furnish an appliance with online capabilities. Finally, we offer a number of fundamental issues related to business models, partnership strategy, data ownership, and technology diffusion that every enterprise should address before diving headfirst into the IoT.

2. The Internet of Things

We will briefly review two essential aspects of the IoT: the technical advances in remote connectivity itself and the potential business consequences of digitizing products.

2.1. It has been a long time coming

Despite the massive amount of attention given to the IoT over the past couple of years, connected products are essentially old news as large and expensive industrial equipment has been supervised remotely for many years (Wünderlich et al., 2015). The novelty associated with IoT stems from its potential for widespread application as technical barriers associated with automated surveillance have been gradually eroding, drastically decreasing the associated costs in its wake. The requisite technical equipment, such as computers and sensors, has gotten smaller and more power efficient. The rates for data traffic have decreased as an infrastructure of wireless, high-capacity networks has expanded at breakneck speed. The ability to create interfaces between network types (middleware) has improved, making it possible to accommodate multiple standards and formats and provide seamless connectivity.

The IoT's coming of age may be attributed to a generic technical development where smartphones and tablets have served to propel miniaturization of components so that more and more capacity may be crammed into devices that weigh ounces rather than pounds. However, there are also less noticeable drivers for high capacity with a small footprint. Companies involved with logistics and warehousing have a comparatively long history of assigning a digital identity to physical objects (e.g., via Radio Frequency Identification tags) (Atzori, Iera, & Morabito, 2010). In doing so, they have been able to cultivate long and winding logistical chains while still providing quality assurance at a low cost. In addition, firms involved in product development pay earnest attention to connectivity and remote access. A constant threat of new entrants coupled with the modest return on investment from incremental product development spurs even the more confident enterprises to diversify their offering beyond the product itself. The race is on to find new additions and ways to compete based on experience and expertise rather than merely retail price.

While technology evangelists claim that everything will be connected in the near future, it is more accurate to say simply that everything can be connected. For instance, recent advances in low-power wide area network (LPWAN) technology serve to

address one of the remaining barriers—power supply (LoRa® Alliance, 2015). LPWAN enables the construction of cheap, highly mobile sensors that can last at least 10 years on a single battery. As the technology is intended specifically for IoT applications, sensors are adapted to facilitate the relatively sparse transfer of data over long distances—enough for essential information but not for images or other forms of multimedia. With LPWAN technology, one could cover a small city with hundreds of sensors and provide network coverage using five or six base stations rather than the 50 or 60 you would need with conventional wireless technology. The ability to connect entire cities and provide real-time data provides opportunities into which we can only begin to speculate. Authorities can monitor traffic conditions and air quality in the interest of public safety. Local commerce can see how and when shoppers roam and advertise their goods and services accordingly. One by one, the technical barriers are crumbling. The IoT is growing more mature and its applications more prolific. The only real limitations that remain are the ones held firmly in place by our lack of imagination.

2.2. Digitizing business models: Rewards and risks

Digital technology is not only powering the internet and our social media accounts, but is increasingly becoming an integral part of all products and processes. Digitization and digital innovation can create opportunities for product manufacturers. By supplementing a product like a vehicle or an appliance with sensors and communicative abilities, one is able to attain detailed information regarding position, condition, and usage. In a recent article, Michael Porter and James Heppelmann (2014) shone a light on how connected products affect competitive capabilities. They saw enormous potential for industry incumbents to strengthen their positions by expanding their presence in the value chain with product-service hybrid offerings in the form of comprehensive solutions. In their view, digitization is a means to erect higher barriers to entry for newcomers to the market as incumbents can form more intimate service-oriented relationships with customers.

However, just as it may create new barriers, digitization can also tear them down and make room for new entrants. This digital disruption is highly visible in the news and media industries where newspapers have experienced a figurative mass-extinction and many of the survivors struggle to remain afloat (Nylén & Holmström, 2015). The collapse of Kodak provides an especially vivid and cautionary tale of how digitization can topple large enterprises and disrupt industries that have been stable for decades. Hence, it would be both one-sided and myopic to consider digitization as either a force for good or ill. Rather, it should be likened to a force of nature that can propel those who plan ahead, or devastate those who ignore its potency.

3. Value creation

A development from a detached product to a digitized, connected product may serve several purposes. From a supplier's perspective, a connected product can provide continuous access to data regarding modes of application, component wear and tear, the relative appeal of different features, and more. This, in turn, can provide invaluable input into the refinement of existing products, as well as encourage future development based on hard data rather than guesswork and limited observations.

From a marketing perspective, a firm's priority is to enhance the appeal of its products for present and prospective customers. This is done by showing how a product contributes to a greater business context, that the firm understands the product as well as its environment, and that the firm is willing to support customers in their day-to-day operations. Product-based services such as scheduled maintenance contracts are a well-established way for manufacturers to provide added value to customers (Oliva & Kallenberg, 2003). Connected products enable firms to go even further and provide a dynamic product and service environment in which maintenance can be performed based on actual need rather than when it is statistically assumed that it should be done. Furthermore, a connected product may receive software updates at regular intervals to ensure that it is always operating at optimal efficiency. Hence, connected products provide a solid base for long-term business-to-business relationships as parties operate based on real-time data and proactive service.

In order to design, implement, and support a connected product, core competencies such as product development and/or marketing will need to be supplemented with skills in wireless communication and management of the large amounts of data that will be generated. Realizing any kind of connected product requires at least three distinct functional roles (Burkitt, 2014): (1) an *engager* develops products that are desirable for customers and is equipped with sensors that convert real-world events into bits and bytes; (2) an *enabler* provides the remote connectivity needed to ensure a robust connection between the product and a

back office system; and (3) an *enhancer* filters, aggregates, and analyzes the data that is continuously generated and applies it to develop useful services. In due time, it may well be that these three skill sets become a natural part of all product developing enterprises. However, in the short term, there is a significant risk of delivering low-grade services if a single actor tries to cut corners and offer a connected product prematurely. Product developers will need to cultivate access to external competencies via value networks, ecosystems, or partnerships in order to provide a fully developed, connected offering that provides value to customers as well as one's own brand. In many cases, creating value using the IoT will be a complicated and interconnected process involving multiple parties and perspectives. However, the potential payoff is significant, as a connected product can provide valuable information regarding location, status, and usage—insights that in turn can be used to enhance efficiency in logistics, efficacy in service and maintenance, and innovation in new product development. Furthermore, a connected product that offers continuous access to user data creates a new dimension through which customer behavior can be better understood and long-term relationships developed.

4. Illustrating our point

During the first half of 2015, we had the opportunity to observe as three distinct enterprises—WashCo, LinkCo, and InterfaceCo—pooled their expertise to develop an IoT solution for laundry equipment intended for large-scale use in laundromats, hotels, and apartment buildings with shared laundry rooms. WashCo is a global enterprise active in several distinct industries. In this endeavor, staff from WashCo's professional laundry systems division participated with the explicit intent to develop a connected washing machine. LinkCo's expertise revolves around secure connectivity and cloud services, and InterfaceCo is an expert in data filtering and interface design. The three firms partnered together in an attempt to combine their different areas of expertise into a scalable IoT solution.

At the onset of the project, there were no established solutions or standards for collecting, analyzing, and utilizing data in WashCo's operational processes or customer offerings. First and foremost, the project goal was to create the necessary knowledge and shared understanding for how connected products can serve both supplier and customer. A second aspect of the project was to develop the participating firms' understanding of the infrastructure needed to realize solutions in keeping with the IoT. Hence, the endeavor addressed technical- and business-oriented issues in order to tackle both the rationale for connected products and the skill set needed to bring this idea to fruition.

4.1. Connected products and connected actors

During an initial 2-day workshop where representatives from all three parties participated (we also attended the event as part of our research), there was some initial confusion regarding the extent and aim of the venture. Was the aim to fully automate all aspects of service notifications and error messages? If so, how should messages be routed and distributed to local service contractors? Could such an endeavor even be implemented in a service organization that is both complex and largely outsourced to external contractors? The initial conversations were ambitious, with WashCo keen to establish what it perceived as a competitive advantage and both LinkCo and InterfaceCo eager to demonstrate their respective technical proficiencies. At times, the discussions were borderline utopian, with connected products treated as a silver bullet that would save money, increase market share, and enhance aftermarket control. However, by the end of the second day, a first road map of ideas started to take form and the ambition for the first iteration was to establish a solid foundation that could be expanded to other products, other markets, and other partners.

A core concern for creating sustainable IoT solutions is the issue of scalability in terms of both connected products as well as related services. In order to connect entire product lines, a firm needs an infrastructure that is able to accommodate hundreds if not thousands of connected products. WashCo had previously conducted its own test installations with connected products but was not encouraged by the results. For example, a single connected washing machine could generate dozens and dozens of error messages all referring to a single problem that was not immediately corrected. If one were to extrapolate this level of redundant messaging to an entire product line, the amount of work needed to sort through the mess would be prohibitive to say the least—not to mention inconsistent with the idea of IoT as an enabler of efficiency. On the other hand, scalability is the bread and butter of both LinkCo and InterfaceCo. Both firms are proficient in creating systems that are flexible enough to be adapted for different users and scalable in order to accommodate a steadily increasing number of

items—either connected devices or work orders related to said devices. Hence, while a large enterprise like WashCo is often able to resolve most of its challenges using in-house capabilities, in this instance the issue of scalability was deemed sufficiently problematic and warranted taking on external expertise.

WashCo's history of conducting the bulk of development in house provides a complete contrast to both LinkCo and InterfaceCo, which are both accustomed to collaborating with big and small customers with a large amount of freedom under responsibility. Even though both firms have a long history of co-creating solutions with different clients, they have been allowed to retain ownership of their respective output and have successfully marketed similar solutions to different customers—albeit with a suitable amount of customization.

Furthermore, both firms are accustomed to collaborating with external actors active in different markets. LinkCo is the more active in this respect, having positioned its offering as a platform through which different partners deliver digital services to customers in several industries (e.g., logistics and public transportation). Given the input from LinkCo and InterfaceCo, the project yielded the technical preconditions needed to incorporate product-centric services to WashCo's washing machines. However, while WashCo was keen to work with external partners to establish an infrastructure for its own products, it was also very keen to keep control of the end result. The idea of inviting external parties to create services for its products or even have access to data was entirely alien to WashCo and would signify a significant break from existing traditions and practices. Time will tell how much pressure is exerted to convince WashCo to loosen the grip on its products and invite some form of ecosystem to form around its washing machines.

4.2. Potential benefits from a connected product

The venture yielded a proof of concept that demonstrates how data are transmitted from a connected washing machine to a back office system and subsequently presented to different users (e.g., simple status updates for everyday users, comprehensive reports for technicians). While remote connectivity amounts to little more than an incremental innovation to the product itself, it holds significant potential to virtually all activities surrounding its usage.

One of the primary concerns for WashCo was the issue of product service and maintenance. There are several distinct issues that serve to impede efficiency in existing service processes. First, customers who contact the customer service call center rarely provide sufficient information for technicians to identify the problem correctly as error codes are not very intuitive. The general lack of information regarding the nature of the problem (or even the type of washing machine) breeds inefficiency as the technician does not have a clear picture of what tools or spare parts are required to get the job done. Direct machine access could remedy many of these problems as the technician would then be in a better position to diagnose the problem prior to arrival. Second, in addition to identifying the problem, WashCo pointed to difficulties in locating the product itself. When dealing with washing machines housed in apartment buildings or laundromats, any address can house several laundry rooms, and any laundry room can house several washing machines. Unless provided with exact information by the customer, the repair technician can waste a lot of time identifying the faulty machine. Again, direct machine access would alleviate this problem as each machine features its own unique ID. Furthermore, in the proof of concept developed in this venture, the communications unit used to connect the washing machine to the internet featured a GPS transponder, offering accurate positioning within a few yards. Third, in addition to purely service-related issues, WashCo has had significant trouble keeping track of its products after delivery. By its own estimates, roughly 60% of products delivered are subsequently moved to another location without notification. More accurate information would not only enhance service tasks, but it would also help WashCo assess the need for service personnel as well as sales representatives within a given geographical area. Overall, access to better and more comprehensive information could facilitate significant improvements at all levels of the service process.

In addition to service and repairs, connected products have the potential to enable additional benefits related to future offerings. At present, product development is based on past experience and the best guess of the product development team. However, connected products have the potential to provide data on actual use and essentially replace guesswork with hard facts. It may well be that several product features are hardly ever used in which case they could be phased out in favor of a more streamlined product that is cheaper to manufacture and easier to use. Moreover, continuous access to the status and location of a washing machine enables new business models based on selling solutions rather than products. In a solution-based contract, the customer does not purchase the machine, but instead pays a monthly fee for carefree use of a washing machine. This type

of arrangement is attractive to both supplier and customer as a fixed monthly expense is considerably more predictable than the intermittent spikes that characterize retail products. Ongoing contracts also have the welcome side effect of encouraging more stable relationships with customers, which allows suppliers to demonstrate properties that are not reflected in the bottom line price tag (e.g., quality, service commitment).

In addition to the service organization and product manufacturer, a connected washing machine can also bring benefits to the customer. Aforementioned issues and inefficiencies in the service process often manifest in the form of nonfunctional equipment. For the proprietor of a laundromat, that means decreased revenue. For a landlord, it means complaints from frustrated tenants. Shortening repair times—or even avoiding breakdowns via preemptive maintenance—goes a long way toward realizing the commitment business owners have toward to their respective customers. The prospect of carefree usage where any and all problems are automatically dealt with provides a powerful incentive to position washing machines—or any other product—as a guarantor of quality.

As IoT has the significant potential to create tangible as well as intangible benefits for several distinct stakeholders, it is important to identify potential value propositions at an early stage. We summarize the value propositions of a connected washing machine in Table 1.

4.3. The finished proof of concept

During the course of the collaborative venture, LinkCo, InterfaceCo, and WashCo developed a proof of concept that included communication between the appliance and back office system. Furthermore, the data were subsequently presented via a web-based user interface. The proof of concept was closely based on the existing protocols that were used in all WashCo washing machines—the obvious difference being that existing appliances had not been designed with any kind of remote connectivity in mind. The effort of extending existing appliance design and communication protocols to permit remote connectivity required close collaboration between WashCo and LinkCo over the course of several months. While the linkage between appliance and back office system was an important first step, it was not sufficient, as the raw data would appear incomprehensible to all but bona fide experts. Hence, the subsequent web-based interface, developed by InterfaceCo, was just as important in order to filter and present information that was intelligible and relevant. Figure 1 provides a basic outline of the solution architecture.

For the purpose of this proof of concept, the washing machine was supplemented with an external unit that acted as a bridge between the wired interface used to access the washing machine and the wireless interface used to access the back office system. The external unit also encrypted the data in order to prevent unauthorized access. While security may at first glance not appear to be a serious issue for a connected appliance, it was a serious concern for WashCo. In theory, a connected product not only enables services but also invites tampering that could result in disabled safety features.

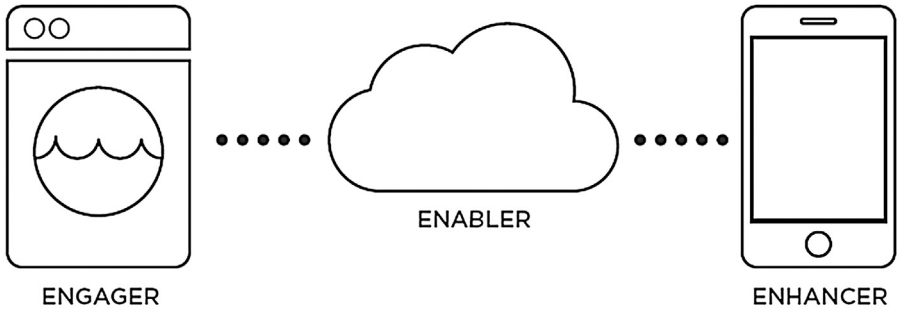
The developed proof of concept was tested successfully in a lab environment and considered very promising by all parties. This was a significant first step in developing an IoT-infrastructure that carries relevance beyond the actors involved in this venture. The next step for the partnership was to further develop the proof of concept into a full-fledged prototype ready for testing in the field, which was well underway by the summer of 2016. Initial results were very promising and WashCo has voiced serious interest in moving forward with developing this kind of functionality for a wider range of products, effectively raising the level of

Table 1. Potential benefits of a connected washing machine

Manufacturer	Service staff	Customer

• Long-term customer relationship
  ○ Full-service contracts
  ○ Transition from product to solution
• Continuous access to data from the field
  ○ Enhanced product design
  ○ Enhanced component design
	• Accurate machine localization
	• Precise information
	  ○ Appropriate spare parts
	  ○ Reduced number of visits per repair job
	• Opportunity to restructure service organization
	  ○ Improved service prediction
	  ○ Ability to better match service staff and service needs in a given area
		• Quick and efficient service
		• Security
		  ○ Working machines
		  ○ Assistance when needed
		• Less downtime
		  ○ Increased reliability

Figure 1. Outline of solution architecture



ambition from connected products to connected environments.

5. Self-study questions: What have we learned?

The IoT occupies the focal point of several distinct phenomena, including digitization, service-orientation, and value co-creation. As such, its complexity is not derived from any single source. Instead, there is a need to balance a plethora of different concerns and be mindful of a whole system of moving parts rather than one's own little corner of the market. Based on our study of a co-created proof of concept for a connected product, we are prepared to present a number of fundamental questions important for any firm to address prior to embarking on its own IoT project.

5.1. Could your product be a platform?

A connected product offers potential for value-adding activities and business opportunities even after it has been sold and delivered to a customer. Current research on IoT (e.g., Ostrom et al., 2015; Porter & Heppelmann, 2014) as well as platform research (e.g., Thomas, Autio, & Gann, 2015) suggests that any connected product can serve as a platform for services. A connected product offers opportunities for providing combinations of product and services in solutions that are tailored to each market or perhaps even each individual customer. While services are traditionally associated with labor intensity and continuous costs, services associated with connected products are digital in nature. They require little in the way of maintenance and can be reproduced at virtually no cost. Furthermore, a more comprehensive offering, where the product is directly connected to different services, has the dual advantage of tying a firm closer to the customer and raising the barriers to entry for competitors. Hence, complementing a product with services provides a clear and tangible means of highlighting the long-term value of a product over its competition.

5.2. Automate or informate?

If one is to consider IoT as a tool for one's business, then it is definitely a scalpel and not a club. Successful application requires one first to know what one is looking to achieve. We have known for 30+ years that any application of information technology can serve two distinct roles: automate or informate (Zuboff, 1985). *Automate* describes a direct replacement of manual labor with a machine. The ability to automate tasks is of course highly attractive as it either reduces labor costs or frees up employees to perform other tasks. With tasks that cannot be automated, information technology offers the ability to *informate*, to provide employees with faster and more accurate information so that they can perform to the best of their abilities. As connected devices are poised to produce a continuous stream of data, the manner in which we handle information makes the distinction between automate and informate arguably greater today than ever before. Massive quantities of data will require advanced routines for sorting and filtering that need to be maintained all day, every day. That kind of task is dependent on purposeful back office systems that automatically process data and sort out that which is anomalous rather than considering all data as equally important. However, evaluating and addressing the anomalies is something that requires human eyes and attention. Deviation from the norm may be a result of any number of reasons, including scheduled maintenance or signal interference due to geographical distance. Human judgment is (so far) infinitely better able to appraise a situation and provide a suitable response. Hence, automate or

informate is not a paradigmic choice in design philosophy. Firms that embrace the IoT will need to do both, and think carefully to determine what mix of computer efficiency and human judgment fits their specific needs.

5.3. What are you looking for?

It is widely presumed that data has inherent value. Indeed, one could argue that the underlying premise for big data is that massive amounts of data will somehow be useful to someone (Bendle & Wang, 2016; McAfee & Brynjolfsson, 2012). If that is indeed the case, then connected products are essentially a license to print money. Hundreds, thousands, or even millions of products that are connected all day, every day will yield enormous quantities of data before too long. At that point, one may well wonder just how bits and bytes transform into cents and dollars. The answer is that they do not—at least, not as easily as one might be led to believe. Value stems from the ability to analyze vast amounts of data and select critical indicators that are hidden deep within. Even if you are an expert in your own field, managing data requires expertise in data aggregation, filtering, analysis, and finding correlations in data generated from a large number of users. If those things were easy, we would have dozens of Googles instead of just one. So, ask yourself what you are looking for—and who can help you find it—before the data starts piling up. Far too many start IoT projects without capacity or ideas on what to do with the data and for what purpose data will be collected.

5.4. Share or charge?

IoT enables the collection of massive amounts of data related to product use, and with the right set of skills useful insights from analyzing said data can be extracted. The next question is: How does that fit with the firm's current business model? Is this still primarily a product-based firm that is chiefly concerned with retail volume? If that is the case, then sharing useful information at no extra charge to the customer may well be a way to strengthen the brand and compete based on quality rather than retail price. Another approach is to sell information in the form of services that refine data derived from product use and thus cultivate new revenue streams and business areas. The latter option bears some resemblance to servitization (Oliva & Kallenberg, 2003) but differs in that services form a distinct business model that is separate from the product. In other words, while servitization replaces retail product, digital services offer a complement to the product regardless of whether the product is servitized or not. The appeal of alternate revenue streams could arguably be very tempting for manufacturers of products with a lengthy lifespan. Even if a customer only buys a new washing machine, truck, or digger every 10 or 15 years, there are significant gains to be made by continually selling services during the product's entire lifespan. Any IoT initiative thus needs a long-term idea for how it fits with current business practices: Is this a new business area or a way to strengthen the appeal of your products?

5.5. Who owns the data?

The issue of ownership related to physical assets is relatively straightforward. If someone buys a product, then they own it. If a product is rented or leased, then the supplier retains ownership but the customer has the right to use it during a stipulated period of time. However, the issue of who owns data generated by a connected product is a more complex issue (Weinberg et al., 2015). On the one hand, data is generated based on actions taken by the user and as such could be considered his or her property. On the other hand, the data is generated, gathered, analyzed, and presented courtesy of servers and systems owned by another party—in many cases the manufacturer of the product. One could argue that the (useful) information provided based on the analysis is the property of the supplier. As IoT gradually diffuses into more and more areas of application, there is no one-size-fits-all approach to data ownership, but rather a plethora of caveats and considerations that are unique to different industries, markets, and regions. For the time being, you may have to learn to live with the idea that every contract will have a separate section on data ownership.

5.6. Horizontal or vertical?

As connected products require a broader skill set than nonconnected ones, one may anticipate a significant number of co-created solutions in which several parties provide different components to the overall system (Burkitt, 2014). The idea makes sense from a strictly functional perspective—each actor contributes his/her own expertise and adds an essential piece to the overall puzzle. However, things can go from harmonious to conflicted when zooming out from the individual case and considering the respective business interests of each actor. The technical infrastructure needed to enable IoT-solutions, from localized sensors to centralized back office systems, is often generic and can be adapted to a wide range of applications with

relative ease. It is therefore in the interest of technology-oriented firms to market their offerings as widely as possible. We describe this as horizontal diffusion as an actor tries to leverage his/her own knowledge of a particular technology to as many customers as possible, regardless of industry or market. Conversely, product manufacturers are more likely to dwell within specific industries and have cultivated skills related to a specific range of applications. The barriers to moving outside this range of applications are likely to be prohibitive; for example, a manufacturer of kitchen appliances cannot easily move into home entertainment or gardening equipment. Hence, we may describe them as interested in vertical diffusion, looking to establish a firmer presence in the same industry and possibly expand to other geographical regions or markets. Vertical and horizontal ambitions may well happily co-exist in one specific point in time, but the contradiction in business logics becomes apparent as soon as we look ahead or review our history. As much as connected products require a complex set of technical skills, one may find that negotiating mutually beneficial agreements between partners is equally challenging. Hence, managers must be aware of how IoT affects their own business model, but also take notice of the business logic pursued by their partners.

5.7. Are you ready to go big?

At its core, the challenge of realizing IoT is closely intertwined with the idea of scalability. Certain related phenomena such as big data are possibilities that are enabled via large quantities of connected products, but they are not an intrinsic part of IoT itself. However, one cannot escape the simple need to keep track of one's connected products in an efficient manner in order to avoid chaos (Miorandi, Sicari, De Pellegrini, & Chlamtac, 2012). Even if manufacturers (wisely) start out small and merely launch a trial run of 100 connected devices, scalability will have to be a prime concern from day one. If not, they run the risk of scaling up the workload by the same factor that they scale up connected products. Any practical—and commercially viable—application of IoT will need to be able to monitor 100 units or 100,000 units with roughly the same amount of staff. For this to occur, a significant amount of data needs to be filtered out at the local level, forwarding only relevant key indicators to the respective back office systems. The cloud metaphor often applied to internet-based computing needs to be complemented with consideration of how data is processed by individual devices or machines. A connected device needs to be capable of dealing with the localized 'mists' of data that form around smart devices and transmit only that which is relevant.

6. Conclusion

The IoT is a subject of increased interest and enthusiasm, and much of it is warranted. Connected devices and products offer new possibilities for everything from preemptive maintenance to new services and business models. The IoT is not a homogeneous concept or paradigm, but rather a buffet of possibilities from which each actor can peruse and assemble an approach that is right for their strategic interests and business requirements. In this article, we draw upon existing research as well as observations from the field and present a number of fundamental questions that each and every actor looking to implement the IoT needs to address before making any decisions or investing a single cent. The results of the collaborative venture involving WashCo, LinkCo, and InterfaceCo demonstrate that a financially sustainable solution needs to have the full support of all participants in order to enable the right preconditions for value creation. Although unique skill sets are part of the rationale behind business ecosystems, these in and of themselves are not sufficient. Unless complemented by suitable forms of communication, coordination, and trust between parties, disparate skill sets are just as likely to create confusion and conflict as they are to yield synergies. In order to prepare for what is coming, managers need to consider their digital strategy in relation to their own business and the ecosystem of partners, as well as emerging technology.

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