

MACIEJ KRANZ

BUILDING

THE

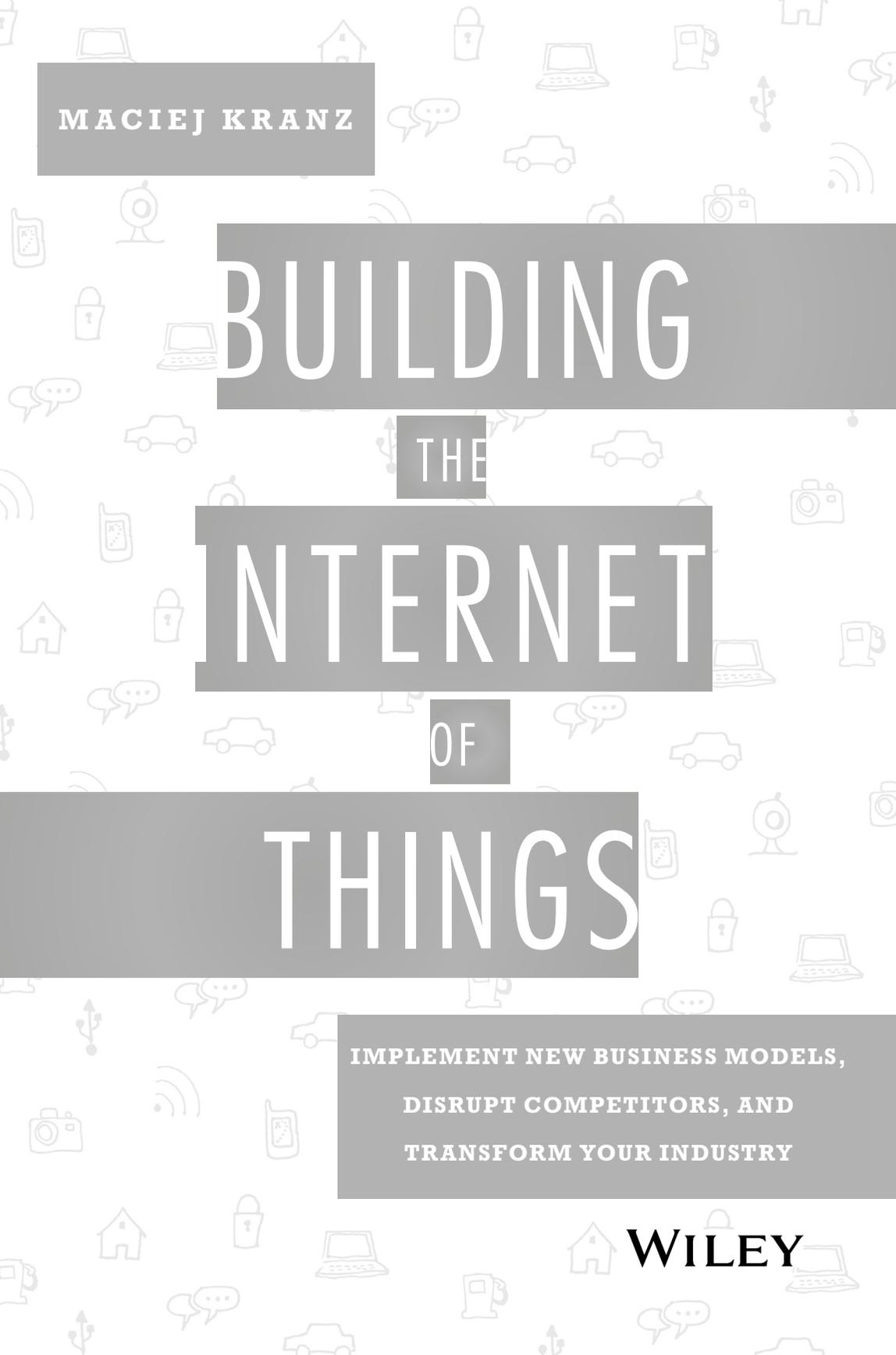
INTERNET

OF

THINGS

IMPLEMENT NEW BUSINESS MODELS,
DISRUPT COMPETITORS,
TRANSFORM YOUR INDUSTRY

WILEY



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To my wife Kasia

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Foreword

We are inundated with hype around Internet of Things (IoT) today. There is a need for a book like this—a practical guide that separates the hype from reality—to direct us to what’s practical and immediately valuable about IoT and how we can start today and derive tangible benefits tomorrow.

Today’s reality is that in a world of more than 7 billion people, there are 70 million who are joining the middle class annually. This growing middle class generates \$8 trillion in consumer spending, and their demands require manufacturing companies to be more productive, more sustainable, more flexible, and more cost competitive. Manufacturers must also ensure global compliance and effectively manage enterprise risks while improving the connectivity across their business enterprises.

The Internet of Things will significantly impact and change how global companies conduct business. IoT technologies will transform the manufacturing environment; it will change more in the next 10 years than it has in the past 50 years. Cisco estimates there is \$3.9 trillion of value in manufacturing alone for IoT, one of the largest sectors to benefit from this technology.

The convergence of information technology (IT) and operations technology (OT) has brought us to an inflection point for realizing a vision that we call The Connected Enterprise. The foundation of this vision is our belief that the future of manufacturing is based on standard unmodified Ethernet and open systems. The combination of information in the two worlds of IT and OT—seamlessly and securely connecting

production data with business data and information—results in transformational benefits. And IoT accelerates The Connected Enterprise.

Manufacturers still have a long way to go to realize the full benefits of The Connected Enterprise and the fast-emerging IoT. In a January 2015 *Industry Week* survey of 581 manufacturing executives and managers, fewer than 28 percent said their plant floor was Internet-enabled. Only 8 percent of larger companies with sales over \$1 billion described their organization as “completely ready” to benefit from the new IoT technologies. Thus, we need to accelerate the adoption of IoT technologies.

IoT starts with smart assets that are securely networked over an open, standard network (Ethernet). We realize the full value of IoT by complementing smart, networked assets with contemporary technologies such as scalable computing, information management, analytics, and mobility, to create high-value outcomes such as zero downtime and reduced energy consumption. The Connected Enterprise accelerated by IoT technologies delivers unprecedented benefits in productivity, sustainability, and global competitiveness.

Rockwell Automation is proud to be an early pioneer of IoT since 2005. Working with Cisco, we knew that this new technology would lead the industry through a major transformation, and we are committed to leading this transformation together. Through innovative collaboration on products, services, and educational initiatives, we are helping companies achieve successful convergence.

Our collaboration adopted a phased approach. In Phase 1, we initiated joint product development. So far, we have developed more than 50 products together. We joined forces to drive network migration to Ethernet/IP. We actively engaged with the standards bodies to chart the migration plans, combining the best of both IT and OT worlds.

In Phase 2, we worked on joint architectures—first a converged plant-wide Ethernet (CPwE), then more recently the Secure Industrial Network. In Phase 3, we moved to building joint solutions. Subsequent phases enabled new business models (CAPEX to OPEX), including pay-for-production performance approaches. Now we are working together to address the skilled workforce gap with joint certification programs. The history of our engagements alone present a good set of lessons learned for anyone working through the adoption of IoT.

Over the past 11 years of working with Maciej Kranz, Rockwell Automation and Cisco have successfully deployed joint products, architectures, and solutions to over 10,000 customers globally. In this book, Maciej has taken the lessons learned from our IoT journey and shares them with readers from all industries. Maciej, one of the pioneers of IoT, has masterfully captured best practices and combined them with practical guidelines to help readers begin their own IoT journeys.

Our customers continue to be inundated with IoT discussions. This practical guide helps differentiate the excitement from reality and provides pragmatic advice on starting your own journey along with advice on planning for the future. I recommend business and technical managers from every industry read this book to understand how to achieve faster innovation and higher productivity from a successful implementation of IoT.

Keith Nosbusch
Chairman, Rockwell Automation

PART

1

A Secure and
Transformative
IoT Now

1

Beyond the Hype—All You Actually Need to Know About IoT for Business

Like it or not, the Internet of Things (IoT) will change your organization unlike anything before. It will change your organization more than business process reengineering (BPR), Six Sigma, lean manufacturing, agile computing, or any of the other business concepts that periodically pop up, experience success, and are forgotten when the next big thing arrives. Granted, to date most of IoT deployments have been incremental and evolutionary, streamlining an existing process here, cutting some costs or improving productivity there. That, however, is about to change as IoT ramps up, as standards are adopted, and as security is bolstered—all of which and more are in the works. So please don't misunderstand me. The Internet of Things certainly will be a big thing—an enormously big thing, actually. But it isn't *just* the next big thing. IoT is the future—your industry's future, your organization's future, and probably your personal future. Welcome to the future. It's spelled I-o-T. All this may seem like hype now, but it will prove in the end to be quite understated; IoT is very, very real.

You still are skeptical. The hype around IoT certainly has become deafening and distracting. Over the past few years, however, I have traveled more than a million miles meeting with people around the world to discuss IoT. Some of those people have actually done stunning things with IoT and wanted to show these off for me. Others were struggling with a problem IoT should be able to solve and wanted to know how their peers were doing it. Full disclosure: not every business problem, it turns out, lends itself to an IoT solution.

OK, so are there problems I wouldn't recommend an IoT solution for? Not many come to mind immediately. If you insist, for starters there is the connected home. At the Consumer Electronics Show in Las Vegas you can see home appliances from washing machines to coffee makers connected to the Internet and to each other. The problem: while I see value in connecting individual home devices to the Internet, the business case for connecting all appliances and devices to each other in the mainstream home is just not there yet. There are a few emerging use cases, for example, home security and elder care where specialized devices in the home have to be interconnected, but an immediate IoT payoff is still some distance away.

In truth, most of the current implementations of IoT are in the business-to-business (B2B) area and are focused on improved efficiency and productivity around existing processes. As I said, IoT gains are incremental at this point. The real payoff from IoT comes down to automating existing processes that have a large labor or time component and streamlining the related process in one way or another. The resulting improvements, despite having measureable business impact, are mostly evolutionary. Similarly, you, too, after reading this book, should focus first on streamlining and improving your existing processes, which will deliver your fast paybacks and set you on the path toward more revolutionary applications, new business models, and incremental revenue streams. For example, you might use IoT to automate a data collection process you now do manually or remotely monitor something that otherwise requires a person to actually visit. Such solutions are already well proven and documented. I do, however, expect that down the road many breakthroughs in IoT will also come from the B2B2C (business to business to consumer) domain, but today they are just starting to emerge, pioneered by early adopters: processes like mass customization, food safety, and even autonomous car or drone transportation/delivery (see Figure 1.1).

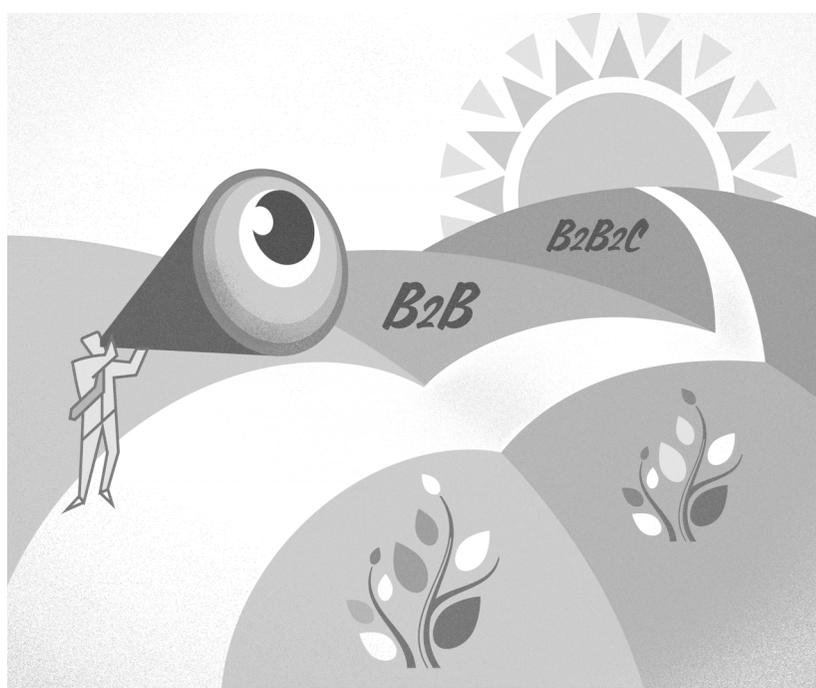


Figure 1.1 B2B and B2B2C Domains

In the meantime, manufacturing around the world, including in North America, is having a renaissance of sorts, and IoT is part of the reason. By converging previously siloed sensors, machines, cells, and zones, IoT-driven factory automation helps enterprises integrate production and business systems and then bring everything online over a single network. Organizations are gaining flexibility to quickly adapt to changes, whether for new product introductions, planned product line changeovers, or other adjustments. Each affected zone, from the enterprise to the plant floor to the loading dock, receives real-time alerts about changes through networked mobile devices, video monitors, and human-machine interfaces. The real-time information also links back to the entire supply chain, so each step in the manufacturing value chain, from supply through production to distribution, can respond as quickly as needed.

These represent evolutionary improvements that together deliver real business value. Similar gains are being achieved in transportation,

utilities, agriculture, building automation, education, retail, health care, sports, and entertainment—even the military. Companies in these industries are taking first steps on their IoT journeys starting with low-hanging fruit. Still, the process improvements are real and the paybacks, the ROI, add up to serious money in the bank, as I will demonstrate in Chapters 3 and 4.

So this isn't theory. It's real, and it's working today. What a better example than a legendary American motorcycle manufacturer, Harley-Davidson Motor Company. The company was facing intense global competition while its core market was aging and new younger buyers wanted a different type of motorcycle.¹ It needed to get agile, to be able to respond to changes fast, and to be more efficient and productive. IoT gave Harley-Davidson the capabilities it needed. Here's how.

Harley-Davidson faced the familiar litany of problems encountered by many American businesses, especially large and market-leading companies or those with ambitions to be so in their industry. Labor was too costly. Production was not aligned with IT operations. Islands of incompatible data were everywhere. "You name it, we suffered from it," one former Harley manager told me.

So the company pulled together key people from both IT and operations (known as operational technology, or OT). In every industry and most businesses, IT and OT are notoriously uncooperative, almost as if IT, as the book title says, was from Venus and OT from Mars. We're not talking about a mass revolution here: more like a couple of people from different groups who got together by themselves and started actually talking to each other. Later they pulled in a few others and sat together in a room until they formed a unified team willing to communicate with each other and with other Harley-Davidson business units to gain the efficiencies IoT could deliver. The company converged its multiple networks into a single network and began consolidating data islands. As of this writing, one Harley-Davidson factory is fully IoT-enabled. The results are impressive. "What used to take a painfully long time to triage and troubleshoot now can be accomplished in a single morning," the manager said, an order of magnitude improvement. That alone led to increased productivity, efficiency, flexibility, and agility. The results have been so astonishing that other Harley-Davidson factories are clamoring to be the next adopters of IoT.

Moreover, those are just the operational results. Harley-Davidson's strategic business outcomes from the IoT-induced changes are equally impressive:

- Eighty percent faster decision making due to workforce enablement
- Dramatic reductions in costs and set-up time
- Continuous asset management, enabling even better decision making
- 6.8 percent increase in production throughput due to asset tagging
- Ten to 25 times improvement in build-to-order (BTO) cycle times (18 months reduced to two weeks)
- Seven to 12 percent increase in IoT automation-driven equipment utilization

All of this led to a profitability increase between 3 and 4 percent. And that was just one factory!

Harley-Davidson bet its future survival on IoT and, from its first IoT-enabled factory, it began paying off big (see Figure 1.2). This same future attracts what I refer to as Generation IoT everywhere.

Generation IoT Drives Business Survival in the 21st Century

If you look at the last 25 years of the tech industry, you'll see that change has been constant. Every three to seven years, organizations had to reinvent themselves. Companies that missed one technology transition could possibly recover if they scrambled to catch up. Those that missed two, however, most likely perished. Interestingly, according to The Boston Consulting Group, when you look at the roster of S&P 500 companies from 50 years ago, only 19 percent are still in existence.² The rest have perished.

As the S&P 500's mortality shows, we're so used to change that we barely notice it occurring. Remember tape recorders, CDs, VHS tapes, and answering machines? The advent of each changed society in substantive ways. When I asked my children about CDs and VHS tapes, I got blank stares. What about home telephones? I recently met a teenager who didn't recognize a telephone busy signal when she heard it; she had never experienced the phenomenon. When it was explained, she was baffled.

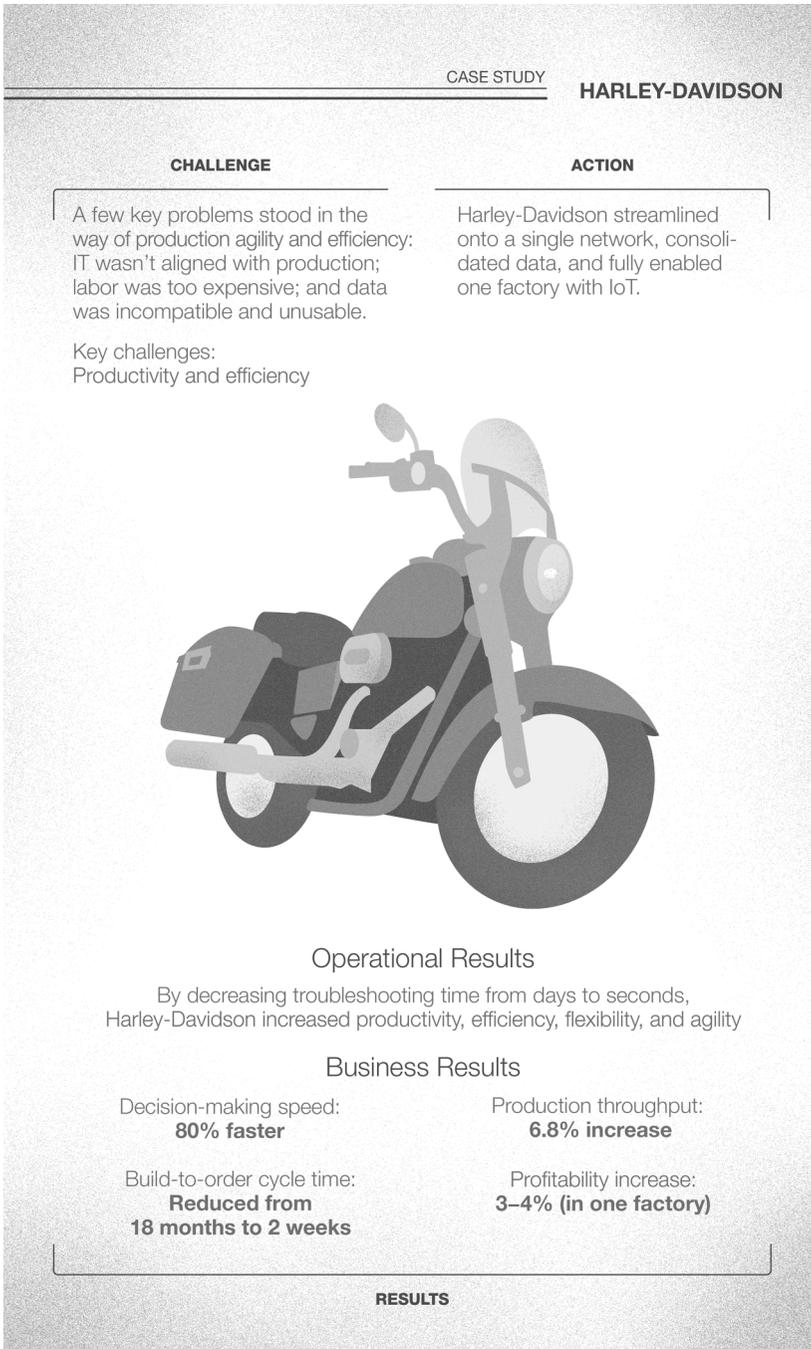


Figure 1.2 Harley-Davidson Case

Everyone has voicemail and call waiting, she insisted. Tape recorders, CDs, VHS tapes, and answering machines are maybe 30 years old, and yet they're not only obsolete but also now forgotten. Their replacements are now integrated into your smartphone. Society and business keep moving forward.

This is as good a point as any to tell you about me, your author. Obviously I'm a father with a bunch of kids, but what's important to you is my experience with IoT. My IoT journey started 12 years ago as a manager at Cisco when several of us flew to Cleveland and started working on industrial Ethernet switches together with Rockwell Automation. It was a challenging assignment for our team, encompassing a completely new set of requirements, certifications, and accommodating so many ruggedized systems versions, but we got things to work. A few years later, we decided that the time was right for Cisco to focus on the industrial networking segment, and we created the Connected Industries Group, which I ran. We also decided to adopt the IoT term to describe the phenomenon of everything connecting to everything. Anyway, this is how I started.

From there our plan for IoT was to expand our ruggedized infrastructure portfolio, develop vertical solutions expertise, build a partner ecosystem to augment our own skills—even then we realized that IoT would be bigger than any one organization could do on its own—and offer a platform for real-time analytics and vertical applications. We also evangelized IoT to the rest of the industry with the goal of getting them excited about its potential so that together we could turn the IoT vision into a huge market opportunity for everybody. Judging from the latest independent industry projections of billions of connected devices in just a few years and trillions in revenue, it has worked out pretty well to date. The important part, however, is that we have started to deliver on that promise. Now, if you haven't done so already, I hope that after reading this book you will join us as well by introducing your organization to IoT and participate in the IoT economy.

Today, the pace of change is more than a constant; it's the new status quo. The Millennials now entering the workforce know only unrelenting change. To them it's a way of life, one that will likely continue for the rest of their lives. But no matter our actual age, we are all part of a generation poised to encounter revolutionary change. That's why I call what we're experiencing in every business segment Generation IoT.

So how does your business survive in this environment? How do you avoid the mortality we've seen among the S&P 500? That's what this book is about—understanding this emerging change that has just begun to sweep over us and finding a strategy that will ensure your business and your career not only survive but thrive. The winners in this new era will recognize the changes occurring around us and be willing to adjust and re-learn, over and over again. They are Generation IoT.

So how do we spot these winners? You belong to Generation IoT if you embrace open standards, open collaboration, open communications, and open, flexible business models and you're willing to assemble a comprehensive partner ecosystem to build and deploy agile, flexible business solutions. The losers, however, will insistently stick to the old ways of doing business or try to do it all themselves. We've seen them many times in the past. They run their operations on proprietary or semi-standard technologies and adopt business models that lock in customers, ultimately destroying whatever value they initially delivered.

Need another example of IoT-led transformation? How about Ford Motor Company, a major U.S. automaker? It hasn't been long since the company together with its peers was on the ropes during the financial crises. Today, Ford has smartened up and changed processes. Of its 40 vehicle assembly plants, 25 now use IoT technology to speed communications within and between them. Plants around the world are now connected to the Ford enterprise network. Moreover, its next-generation automated vehicle scheduling system manages production in real time, handling more than 2 million variations. As a result, Ford is selling more cars than ever before. Thank you, IoT.

First Step on IoT Security Journey

The ability to deal effectively with security threats is the number 1 make-or-break factor for IoT adoption. Without it, companies will be reluctant to implement IoT and thus not benefit from the growing number of powerful use cases emerging across all industries.

The industry recognizes the challenge and is making it the top priority. IoT security is starting to be integrated into the very fabric

of both industry and public infrastructure, including fundamental areas such as transportation and logistics, power grids, water supplies, and public safety. However, much more needs to be done. We still lack skills, education, and awareness. Many companies continue to be in denial, still relying on a discredited physical separation approach to securing their plants and infrastructure. The OT and IT divide prevents the companies from implementing modern and proven security best practices.

So how should organizations start to approach IoT security? According to Verizon's "2015 Data Breach Investigations Report," most security breaches exploit well-known vulnerabilities where companies have not applied available fixes. The first step, therefore, is to implement existing best practices by following these three sets of guidelines:

- **Adopt** a single policy-based security architecture built on an open, unified approach with automated, risk-based self-defense and self-healing capabilities.
- **Converge** around standards. Vendors and enterprises alike need to leverage IT industry standards and best practices in OT and to fill in the gaps between industry-specific and horizontal standards organizations.
- **Collaborate.** OT, IT, information security teams (CiSO), together with vendors and consultants, must work together on common architectures, incorporating not only OT requirements into the IT provider's product portfolio but also supporting form-factors, up-time requirements, and integration with legacy industrial protocols. Security isn't your differentiation; it's your foundation. Therefore, let's learn and share together.

Yes, IoT is different than IT in many ways: it is more distributed, more heterogeneous, and more dynamic. There are many new IoT scenarios that require brand new approaches to security. We will explore them in more detail in Chapter 9. But the first step on the IoT security journey is to leverage 30+ years of experience and best practices that IT security systems give us. So let's not reinvent the wheel.

A Revolutionary Economic Opportunity

Many of us view IoT as the next stage of the Internet/Web that uses the Internet protocol-based (IP-based) distributed cloud to connect anything to anything. According to Vernon Turner, senior vice president of enterprise systems and IDC Fellow for The Internet of Things, “Think of IoT as a network of uniquely identifiable things that communicate using IP connectivity without human interaction.” Pretty straightforward, huh? Some people, including me, extend this definition into what some call the *Internet of Everything (IoE)*, a term first coined by Cisco, or even to the digitization of smart assets. IoE brings together the people, processes, data, and things that make networked connections more relevant by turning information into actions. For the purposes of simplicity and clarity, this book refers to both IoE and IoT as IoT—in effect, treating the two terms as synonymous.

Here’s an easy way to think of what’s going on: The first stage of the Internet connected people to networks, data, each other, and processes. With IoT, we’re now connecting anything with anything—or, if you prefer, everything with everything. In short, anything that can be digitized can be part of IoT. The business impact of IoT makes it revolutionary; when everything can communicate with everything else, it essentially redefines and creates new business value chains (see Figure 1.3).

First, as Turner points out, IoT disrupts traditional value chains. This forces companies to rethink and retool everything they do, including product design, production, marketing, and after-sales service, while using analytics combined with security. That’s essentially what happened at Harley-Davidson. From there, smart connected products expand traditional B2B channels and effectively demolish line-of-business (LOB) boundaries.

A decade ago, visionaries talked about mass customization—the ability to customize mass-produced products to each individual buyer’s specifications. A few tried, but it proved very difficult to implement efficiently. The process had too much latency (delay), which added cost and slowed the results. However, IoT makes strategies like mass customization far more practical and cost efficient. Latency isn’t a problem. Information can be shared in real time between every element in the supply chain. Buyers can click on the components they want. Suppliers and logistics providers

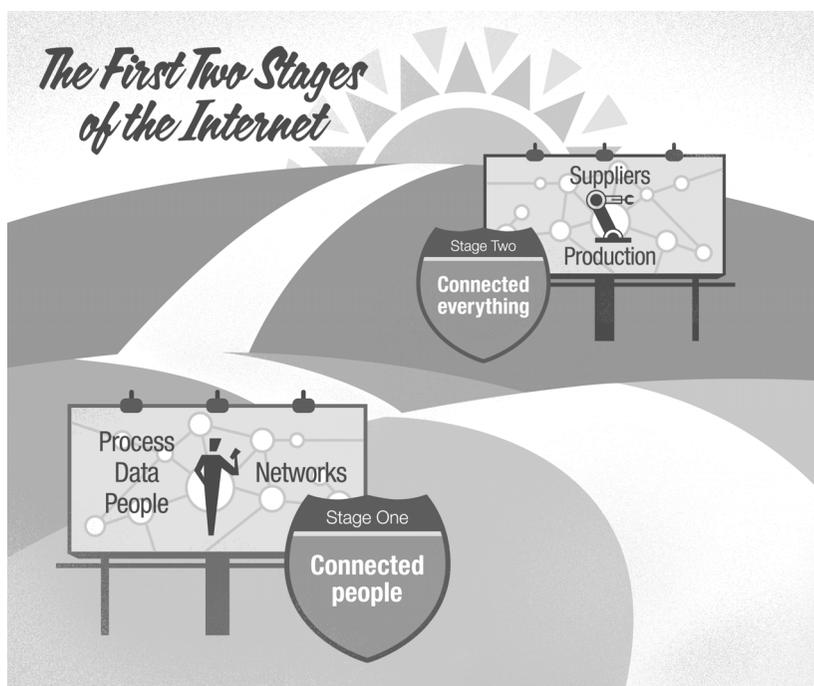


Figure 1.3 First Two Stages of the Internet

can see what components are being ordered, and with rapid systems retooling adjust their schedules appropriately—on the fly, if necessary. With the information flowing, the various players can ensure the desired components are at the production line when that customer’s order is being assembled, whether it’s a car or a three-piece suit. Customers order a car or a suit or anything else, specify the desired components, and have it built or assembled as ordered. Daihatsu Motor Company is already using 3D printers to offer its car buyers 10 colors and 15 base patterns to create their own “effect skins” for the car exterior. Each order rolls off the assembly line customized to that individual buyer. And it’s no big deal. With IoT, mass customization is starting to happen.

Now imagine what’s possible when you can connect anything with anything—production lines with parts and components, production lines with suppliers, products with service providers, logistics operations with transportation companies—and you can do it in near-real time. Designers could create products people really want and use, marketers could sell those products the way people want them, and service and support teams

would know where potential problems are and address them before things break. Costs could be contained, and customer satisfaction would soar.

Or imagine if products you put out in the field could link back to you, signaling when a part starts to fail or a configuration isn't working correctly. You could effectively eliminate unplanned downtime. What could product managers do when they learned that customers were using the company's product in new ways the marketing teams didn't even imagine? The possibilities and opportunities are endless. Admittedly, not all of these concepts and value propositions are available at scale today, but there are plenty of mature, fast paybacks you can implement now.

At the same time, there is no magic here. That's right; *no* magic is at play, none, nada. We're talking about the same digitally connected world we know now, just more so. Essentially, we're using the cloud as we know it, plus an intelligent infrastructure within which every device is digitized and addressable over a common IP network. Yes, there are a few new innovations—such as fog computing, a form of cloud computing at the edge of the network for real-time data processing; blockchain technology, essentially a secure distributed log; and machine learning, the technology behind real-time predictive analytics—but none of these is magic either. These are concepts that industry is focusing on and implementing (if you can't wait to learn more about them, we will cover them in more detail in Chapter 10); nothing exotic, nothing magical.

IoT Background—A Brief History

For many people, the first time they heard about IoT was in the business media or at a business conference. But IoT isn't actually new. It has been around for years, in various forms. Banks run large, distributed automated teller machine (ATM) networks. Retailers operate large point-of-sale (POS) networks, as well as extensive deployments of radio-frequency identification (RFID) tags to track the movement of millions of inventory items. Manufacturers connect thousands of devices to monitor and manage production in machine-to-machine (M2M) networks. Utilities deploy connected sensors and meters to enable everything from customer billing to maintenance troubleshooting. Each network could amount to tens of thousands of connected devices.