SERVICE SYSTEMS AND INNOVATIONS IN BUSINESS AND SOCIETY COLLECTION

Jim Spohrer and Haluk Demirkan, *Editors*

People, Processes, Services, and Things

Using Services Innovation to Enable the Internet of Everything

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Bil Dry
Carlos Pignataro

BUSINESS EXPERT PRESS

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To my father, my favorite librarian, wish this book could have made it to your shelf; to my mother, with heartfelt gratitude. To my wife Angela, and to our "three little birds each by my doorstep," Hala, Leila, and Zayd, thank you for your love and patience.

— Hazim

To my wife, Silvija, for all her patience and understanding along the way …

— Bil

To Sofía, Luca, and Verónica, with all my <3! /smiles and waves/

— Carlos

Abstract

People, Processes, Services, and Things: Using Services Innovation to Enable the Internet of Everything guides the reader through the technological advances, business needs, and societal shifts that drive the Internet of Everything (IoE). It continues by explaining the differences and relationships between the Internet of Things (IoT) and IoE. IoE offers many benefits to industries and organizations that embrace it, but there are real adoption and success barriers to address and overcome. This book discusses those barriers and offers solutions. In many cases, services are the solution because they drive IoE application and impact. The business and technical services need to deliver IoE and realize the promised benefits that are discussed in this book. Discussions include assisting candidate IoE customers to assess and rank priority gaps in business process insight, strategies to connected *things*, and ways to wrangle and transform data streams of new *things* into actionable information. The last section of this book discusses IoE applications and use cases. It includes in-depth use cases on manufacturing process changes and retail store operational improvements from customer queue management to augmented reality along with changes in security considerations, design practices, and operating procedures to ensure malicious intent does not disrupt the emerging and growing IoE networks. Knowledge of leading practices and organizational values and sensitivities are keys to successful IoE transformations. This book concludes with a complete checklist of considerations for IoE transformation success.

Keywords

augmented reality, cloud, data analysis, data at rest, data in motion, fog computing, innovation, Internet, Internet of Everything, IoE, Internet of Things, people, processes, service innovation, services

Contents

Foreword

I lead a software platform and applications group here at Cisco. Not long ago, my kids asked me what was the Internet of Everything (IoE)? "You know, Dad… What's IoE?" I told them to imagine a world where everything they owned, everything they cared about, could not only chatter but also engage them in meaningful conversation.

Today we connect to the Internet for all kinds of experiences, but if you just connect everything to the Internet you only receive a partial benefit. Real value and memorable experiences happen when things engage with people to share relevant data and influence behaviors and outcomes; when you unlock and connect the data that drives the value.

Two years ago, I was really skeptical of the IoE, but with 25 billion devices connected to the Internet today and 50 billion projected by 2020, there is real business value that can be unlocked. Business processes that matter—whether it facilities management or manufacturing—will be connected, instrumented, and mined for information to drive new value. It is likely this value growth will ramp in a nonlinear fashion.

In the past, IT delivered results to the "carpeted floor"—in the office where the company's decision makers were. Their real business happens in the field. Neither IT nor the Internet has ever served highly distributed industrial operations. The IoE changes that.

Train derailments can be catastrophic. There are thousands of couplings and miles of track. Imagine if they were all Internet connected, reporting and replying to measurement and operating status. We now have modular, hardened routers, and switches with embeddable compute logic to monitor, interrogate, and compute the status of "things" so the rail operators can actively engage and assess the track they oversee. Suddenly, every sensor is now a communicator that delivers actionable information instead of just raw telemetry data. This is data in motion; this is data that now matters!

Similarly, the Oil and Gas Industry does not just need video telephony. It needs platform sensors that register and respond to real time flow deviations and then open collaboration sessions with remote experts to share live platform video feeds, sensor data trends, and as-built specifications to diagnose and solve the problem at hand without the delay and cost of helicopter travel.

Cloud and fog layers accelerate the value IoE brings. The computation and storage capabilities of the cloud deliver the brains of IoE while the Fog layer offers persistence reliability and localized processing to normalize the data offered by intermittent sensors. The Internet links these two layers providing a central nervous system conveying sensor data and returning actionable instructions. Combined, we can now deliver business process as a contextually aware, accommodating service today. I expect the power of IoE will empower us to deliver entire Industries as a Service in the future.

Pankaj Srivastava
Vice President, Software Platforms Group
Cisco Systems, Inc.

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Innovation is a collaborative exercise. Hats off to all the thinkers and doers, too many to list, who are pioneering the Internet of Everything.

We would also like to thank our reviewers for their valuable feedback, insight, and advice.

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- Nicola Villa, Managing Director and Global Lead, Analytics, Cisco Consulting Services, Cisco Systems

CHAPTER 1

Defining the Internet of Everything

Once Upon a Time There Was the Internet

A computer network is defined as a set of data communication systems interconnecting computer systems, and the Internet is defined as a network or a collection of interconnected networks. The Internet (with a capital I) is the largest internet in the world. The Internet is the global system of interconnected computer networks, linking devices worldwide and connecting public, private, academic, governmental, and corporative networks. A visualization of the Internet can be seen in Figure 1.1.

The technical foundations of the Internet leverage a core set of protocols designed with the guiding principle of maximizing interoperability. The Internet Protocol (IP) standardized at the Internet Engineering Task Force (IETF) is at the center of these core protocols and is responsible for end-to-end interoperable communications. At an infrastructure level, the Internet is comprised of hardware devices (e.g., routers, switches, access devices) and internetworking software. Layered over this infrastructure, we find a rich diverse set of services, which have made the Internet a valuable platform and, in turn, created a vibrant ecosystem. These services provide value by connecting computers that exchange information, and these new capabilities have created a deep social impact akin to an *information revolution*. The greatest impact of the Internet is not technological but social.

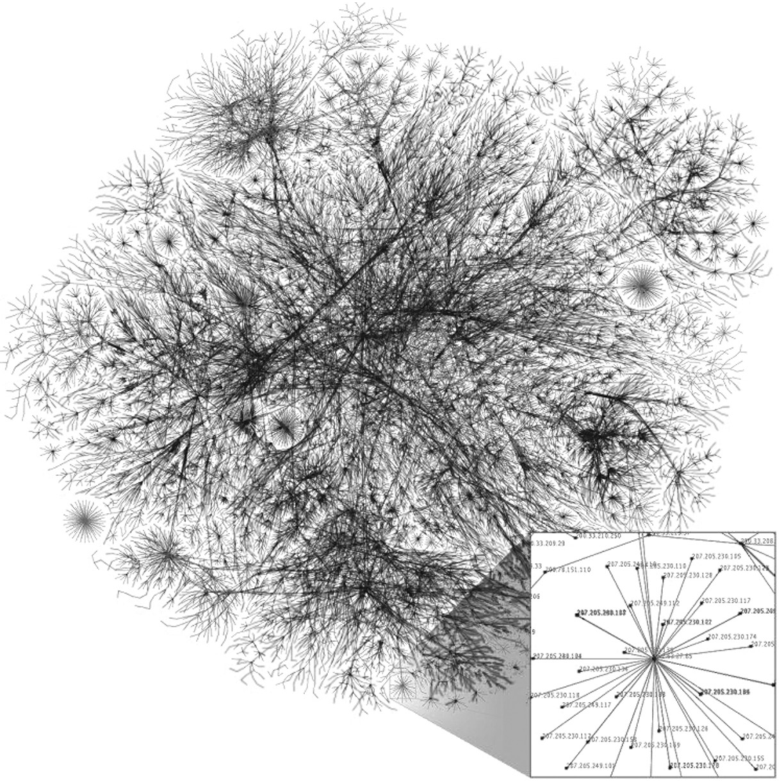

Figure 1.1 Visualization of the Internet

Source: The Opte Project by Barrett Lyon, http://www.opte.org/

Phases in the Evolution of the Internet

Looking at the evolution of the Internet, we can identify four very distinct phases or waves. Furthermore, each phase has a significantly more profound effect on business and society.

- In the first phase, the goal is to achieve *networked connectivity*, and consequently, digitizing the access to information.
  A couple of decades ago, just getting connected to the online world was miraculous enough. The World Wide Web (WWW) flourished, and the distance and time to access information dramatically shrank. People look for information online, send e-mails, and search the Web.

- The second phase is characterized as the *networked economy*, in which business processes are digitized. People buy products online. During the networked economy phase, e-commerce is developed, analytics finds a new anchor point, and the supply chain is digitally connected providing additional digital consolidation.
- In the third phase, *networked emerging experiences*, interactions are digitized. These digitized experiences belong to both the business and personal realms. This phase is dominated by digitally enabled social media and collaboration. Furthermore, widespread access to digital mobility compounds the effects of this phase where digital video for personal interactions is pervasive. People connect digitally with each other.
- The fourth phase, which we are entering, is referred to as the *Internet of Everything* (IoE). In this phase the whole world is digitized! We are entering a phase that unlocks an unprecedented value for businesses, governments, and society in general.

Figure 1.2 depicts these four waves and their growing impact on the world.

Each of these four phases builds on the previous one, and the technological and social advances of the past few decades have led to IoE.

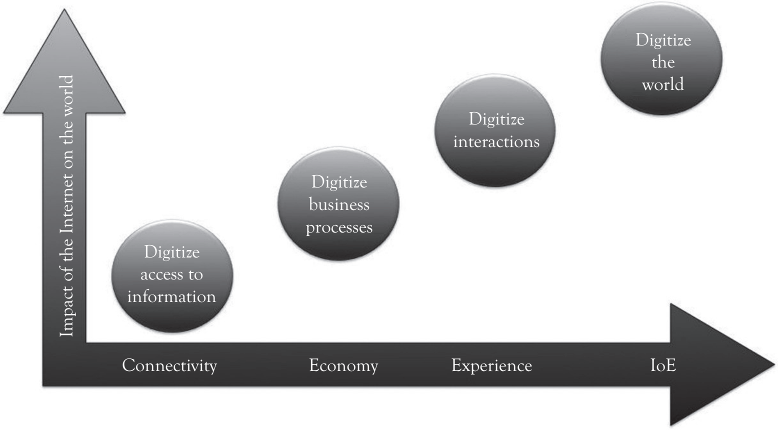

Figure 1.2 Four phases in the evolution of the Internet

The IoE creates an incredibly unprecedented opportunity for connected services—an exciting new world.

And Then There Is the Internet of Things

As we have mentioned, the growth of the Internet is occurring in accelerated waves. The acceleration is often explained as following Metcalf's Law, or the *network effect*, which explains that the value of a network grows exponentially with the number of endpoints being connected (or proportionately to the square of the number of users). In other words, the more *things* and people connect, the larger the value of the network.

On depicting the size of the Internet as the number of devices connected, we can see that the milestones of 1,000 devices, one million devices, one billion devices, and 10 billion devices were reached, respectively, in the years 1984, 1992, 2008, and 2011. Figure 1.3 shows a logarithmic graph that helps visualize this exponential growth.

An even more significant milestone is that at some point near 2008, there were more *things* connected to the Internet than people in the world. Even more importantly, the slope of the growth is much steeper, with a rapid adoption rate of the digitally connected infrastructure. While the world population is growing linearly with a small slope, the *Internet of Things* (IoT) is growing exponentially, to soon reach a higher average of multiple Internet-connected devices per person. In other words, the adoption of the digital infrastructure is much faster—multiple orders of

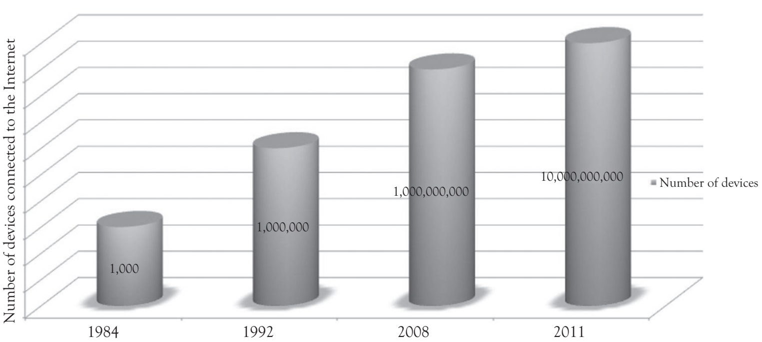

Figure 1.3 Growth in the number of devices in the Internet

magnitude faster—than anything seen before by humankind, including telephony and electricity.

The beginning of the fourth phase is about connecting the vast majority of objects (or *things*) that were previously unconnected. These things, as we will exemplify via use cases later in this book, are rich in variety and diversity. They include a robot in an industrial factory or a drone, a home meter, a traffic light, a pair of glasses, and a car. In the IoT, millions of new devices, sensors, actuators, and, in general, *things* are being regularly connected to the Internet. Furthermore, there is a shift in the endpoint landscape—from individual devices like computers, to things, smart objects,* and digital clusters such as the multitude of connected devices within a single car. Consequently, the IoT creates a network of networks, recursively.

From a couple of million things that were connected to the Internet in the year 2000, technology transitions and trends such as mobility, embedded computing, and cloud have started *connecting the unconnected*, such that at the writing of this book there were about 10 billion things connected to IoT. And still, most *things* are unconnected.

The IoT Reference Architecture

During the IoT World Forum Conference in October 2014, Cisco, in collaboration with Intel and IBM, announced an IoT Reference Model as shown in Figure 1.4.

The model breaks down the idea of data capture, data management, and data analysis into smaller subcomponents. It identifies the various technologies, their hardware and software components, how they relate to each other, and the boundaries and interfaces among the various layers. Understanding the interfaces and the boundaries facilitates a multivendor environment and ease of interoperability among the various layers.

This model describes interconnecting the *things* at the bottom layer (the edge). The things are any *operational* devices or elements: A temperature or pressure sensor in a factory, a security camera at a retail store,

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* A smart object can report any or all of its included sensor readings in context to its current task. A Wi-Fi-enabled programmable thermostat is an example of a smart object.

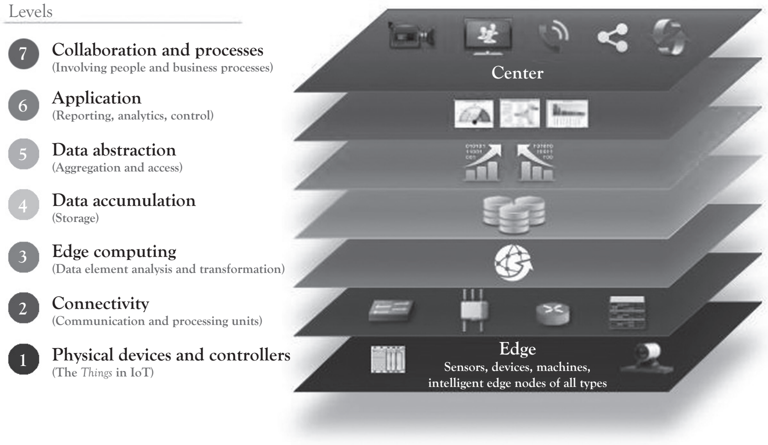

Figure 1.4 IoT World Forum reference model

a wearable activity monitoring device, a cell phone, or any other device used by an internal process or by a customer or channel partner to conduct business or interact with others. The next layer provides connectivity among all these sensors or edge devices using a gateway or a connectivity layer that links *local* devices together. The model then introduces the concept of edge-computing.

At the edge-computing layer, users acquire specific data from the edge devices based on a set of rules and then have the ability to conduct local analysis and produce results that can be translated into actions locally and without having to immediately transmit data upstream for further analysis. This does not imply that this is an analysis layer as much as it is a local action layer facilitating real-time action based on data in motion. If a particular process is approaching a threshold of some sort, this layer will give us an early alert before the data is processed at the upper analytics layers, at the same time it will send an *action* toward the lower layers to capture additional data to improve our sample or detect trends with a higher degree of accuracy (Figure 1.5).

The upper layers are concerned with managing the data from operations and processing and delivering it for analysis to the *analytics* entity for gleaning insights. The term *process* in this context is mainly concerned with the process data that has been integrated into business software like enterprise resource planning or customer relationship management to name a couple.

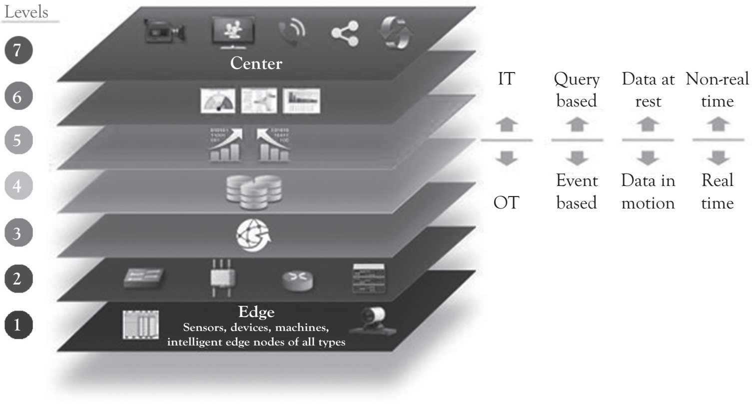

Figure 1.5 Data-in-motion and data-at-rest

This discussion is a short introduction to the reference model. It will be helpful when we present, later in this book, detailed use cases about two industries implementing IoE capabilities to gain deeper insight into their current processes so that they can introduce data-driven changes to enhance the efficiency of their operations and improve their business outcomes.

The Internet of Everything

So far, we have looked at the Internet through two different lenses: The Internet as an interconnection of devices and *things* and as a platform for human collaboration. While these two views are accurate, there is an additional ingredient of *dynamism*. There are two fundamental elements that complete the forward-looking story: First, people and things are interconnected to realize various processes. And in those workflows, there are significant amounts of data created. For example, the year 2012 created more information than the past 5,000 years combined. The Internet is ubiquitous.

These two additional items, *process* and *data*, complete the value picture of the Internet. Because of this, in May 2011, the United Nations called the Internet a "Fundamental Human Right."*

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* Olivarez-Giles (2011).

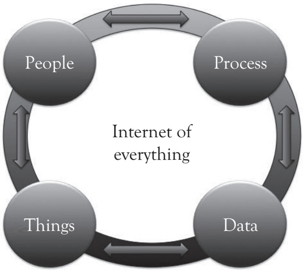

Figure 1.6 Internet of Everything

IoE, which is the next phase of the Internet, is about connecting people, process, data, and things in new ways to unlock untapped value (Figure 1.6).

IoE, driving the next wave of dramatic growth of the Internet, will come from the confluence of people, process, data, and things. In a way, IoE can be thought of as a network of networks creating new connections that never existed before (e.g., a car, a traffic light, and a doctor) and spawning new opportunities as well as new risks. With increased processing power, decentralized architectures, context awareness, and real-time analytics, new services are constantly created. When these new capabilities are applied to the multidimensional platform, that is, IoE, they have the potential to dramatically increase global corporate profits, create new businesses, and invent brand new services. The IoE makes networked connections more relevant than ever.

IoE Connection Types

IoE connects both machines and people. This diversity creates the following IoE connection types:

- Machine-to-machine (M2M)
- Machine-to-person (M2P)
- Person-to-person (P2P)

The M2M communication, called the *Internet of Things* or the IoT, connects data sent and received to and from machines and *things*. In this context, the word *machines* not only includes computers, but also includes sensors, robots, actuators, drones, light bulbs, TVs, wind turbines, trains, mobile devices, and in general machines previously unconnected.

In the M2P communication, information is transferred from a machine to a person (or vice versa). This not only includes traditional Internet workflows such as downloading a web page, but also includes less traditional ones such as a human interacting with a remote point-of-sale machine at a kiosk. If a person retrieves information from a database or from a big data repository, something we call data and analytics also falls in this category.

Finally, P2P communication is often referred to as *collaboration*. Increasingly, P2P communication happens virtually (in instant messenger, voice, video, or a combination) as well as personally. These yet-to-be-invented collaboration means that connecting people together over the Internet is a key component of IoE. Figure 1.7 visually depicts these three connection types.

These connection types are not mutually exclusive. Most commonly, people will interact with things and other people on a single interactive process workflow. Furthermore, the business value increases when more connection types are used for a given interaction. Consequently, the highest value for IoE, where new business models, services, and innovation happen, is at the intersection of M2M, M2P, and P2P connection modes.

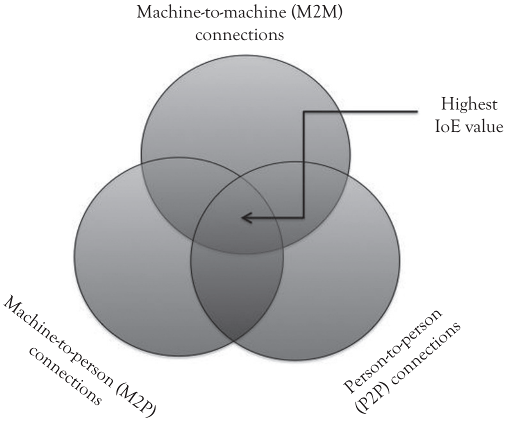

Figure 1.7 IoE connection types

IoT Versus IoE

One common source of confusion is the distinction between IoT and IoE.

In IoT, devices and things (i.e., sensors, robots, drones, etc.) are connected to the Internet and networked wirelessly or wired with standardized protocols, in particular the IP (see the section titled "The Internet Protocol"). IoE covers much more than merely *things*. IoE makes connections between things, people, data, and processes, and leverages analytics to make connections between apparently unrelated pieces of information. Information and analytics are the intelligence behind IoE.

In other words, IoT is a part of IoE; IoT is the subset that focuses on connections between machines. IoE, on the other hand, focuses on heterogenic connections among things, people, data, and processes (Figure 1.8).

The New Currency of Value

The IoE brings together four elements from the Internet as we know it today: people, process, data, and things. These four elements brought together create new networked-connections and unlock unprecedented value.

It is anticipated that the majority of the value created comes from new, seemingly unrelated connections being made of all the new elements connected to the Internet.

One of the corollaries of adding connections to the Internet is the explosion in the amount of data. New people, things, and processes

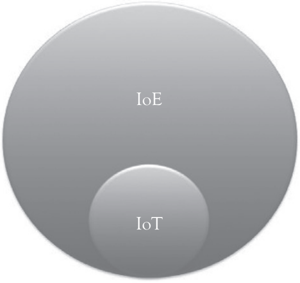

Figure 1.8 IoE versus IoT

contribute massive amounts of data. This data, by way of analytics, gets turned into information (capturing the most useful pieces of data), which in turn gets correlated with other pieces of information to create insight. There is a clear distinction between the raw data, the captured and prioritized information, and the correlated insight. However, that is not the end of the IoE workflow. For this data to ultimately be of value, it needs to be turned into actions. Data and insight-driven actions create new capabilities and richer experiences (Figure 1.9).

Consequently, in IoE, the value (business monetizable value) is about sifting through immense amounts of data, realizing actions from prioritizing information, and correlating it into insights.

The main corollary is that what matters to IoE is the outcome of these connections. The connections themselves and the additional data generated, as well as the improved visibility, are a means to an end. The actions, business outcomes, better decisions, and new opportunities are the goals.

An Architecture for the IoE

IoE presents a completely new paradigm. As such, many of the commonly used architectural tenets and assumptions will not suffice or might not even be adaptable. At the core of this paradigm shift is the scaling element of an IoE. This section explores some key architectural building blocks supporting the IoE.

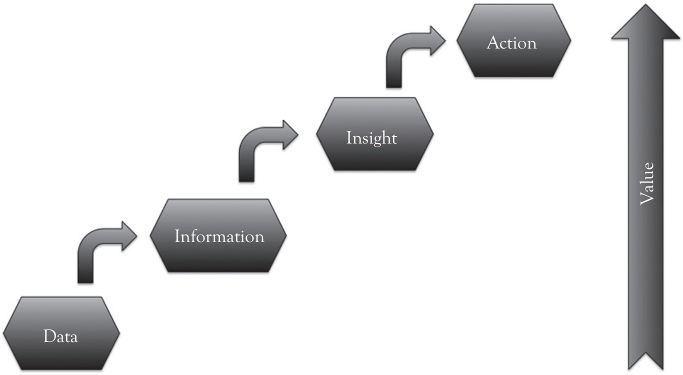

Figure 1.9 Turning data into action

Data

We have already seen a glimpse of the massive implications of the explosion of data as we connect previously unconnected *things*. Furthermore, data is the key ingredient to capitalize on the value of IoE, and data analytics is the engine to extract this value, it is paramount to understand what architectures can scale to leverage this data.

The requirements for data analytics of IoE are related to understanding big data. Connecting the unconnected brings new volumes of data. For example, 30 minutes of flight create 10 terabytes (10,000 gigabytes) of data by a jet engine. The world generates over two exabytes (over 2,000,000,000 gigabytes) of data daily.

And it is really more than just the amount of data. IoE brings diversity and variety in the sources of the data (e.g., data created by humans is structured differently than machine-generated or sensor-created data).

If we are to categorize the IoE data, we can find the following classes:

- Based on the structure of the data:
    - Structured data, such as including clear semantics (e.g., XML)
    - Unstructured data, without associated format and schema
- Based on the dynamisms of the data:
    - Data at rest, for example, in a data center
    - Data in motion, flowing as part of a business or industrial process

The speed or velocity of the generation of data as well as the need for results and actions calls for the creation of what is termed real-time analytics. Basically, the processing of data into action needs to take seconds, or even small fractions of second in some industries, instead of weeks.

Fog Computing

As we continue introducing new concepts and defining new terms, the one that follows is the most important ones in the context of IoE.

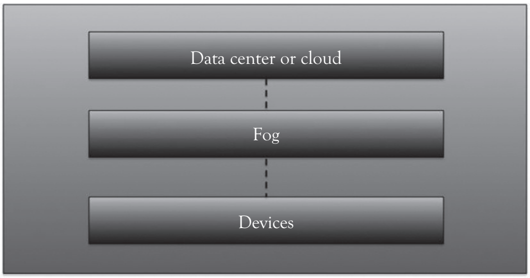

Figure 1.10 IoT computing model

Traditional computing follows a centralized approach, in which data is moved to a data center, in a client-server model, to be processed. In an IoE world, the amount and velocity of the data does not allow for all data to be moved to a central location and then analytics be performed on it. For IoE, there is an intermediate layer between the end devices and the data center or cloud, and that layer is termed fog. The distributed IoT computing model can be seen in Figure 1.10.

The term fog implies that it is like a cloud but closer to the edge. It is an expansion of the cloud paradigm, extending the architecture into the physical world. In the fog layer, some processing (e.g., analytics) is performed to provide actions close to the edge without having to send all the volumes of data to the cloud. The traditional data processing of Store→Analyze→Act→Notify is replaced by Analyze→Act→Notify→Store.

Fog computing was highlighted in *The Wall Street Journal* of May 19, 2014, as the "Tech's Future."*

The Internet Protocol

The final architectural building block is an interoperable protocol to provide connectivity, by way of location and identification. IP serves this role, and it can be seen in two versions coexisting in the Internet: the historical (legacy) IP version 4 (IPv4) and the current IP version 6 (IPv6).

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* http://www.wsj.com/articles/SB10001424052702304908304579566662320279406

Among many other things, IPv6 provides much enhanced and improved scalability, which is why it is the protocol of choice for IoT and IoE. For example, while IPv4 addresses are 32 bits, IPv6 addresses are 128 bits. While this book does not dive deep into the technical underpinnings of the IPs, curious readers can refer to the Internet request for comments 6272, “Internet Protocols for the Smart Grid.”

CHAPTER 2

Benefits and Challenges of IoE

Connecting and mining information from unconnected and untapped *things* instigates positive changes in business processes and outcomes.

New opportunities can be captured as they are created by two main changes: networking the previously unconnected data and utilizing previously unused data. The value and growth of IoE is created with these two capabilities: connectivity and data.

Many benefits of IoE are somewhat obvious and directly relate to being connected. For example, if a water *smart* meter is installed for reading water usage, then company technicians do not have to physically inspect the meter to record the reading; the water usage can be continuously measured. However, the benefits clearly do not stop there, and in fact, second, third, or higher order correlations make for innovative value creation.

Generalizing the example, we can say that outages detection, usage trending and baselining, seasonal adjustments, and fault remediation are some of the improved areas in the utilities sector.

These benefits do not come without a set of unique challenges. Going further with the water meter example, the readings of the meter can be tampered with in ways that were considered impossible before, thereby creating a security challenge. Additionally, if every sensor is suddenly sending data, there is the challenge of managing the new volumes of data.

Clearly, IoE imposes a different order of things and consequently brings additional challenges, which are further explored in the following sections.

Scale of Service Creation

The exponential growth in connectedness creates many different types of scaling challenges. The first one is scaling the massive volume of data. As we discussed in Chapter 1, processing needs to shift closer to the edges for decisions and actions to be taken before transmitting all the data, which often seems impractical. Scaling is a challenge when it comes to the number of connections as well as the amounts of data.

However, there are additional dimensions to the scaling challenges. That is, the diversity in the types of new services and dynamism in the rates at which they can be created, spawned, and instantiated.

Predictability and Reliability

Internet users expect a website to be available always. When we factor in the Internet of Things (IoT) and a number of sensors and things being connected, the playing field rapidly expands. Sensors are often battery powered and expected to last for years or even decades. Consequently, they are often in sleep mode, waking up intermittently. Traditional ways of managing devices cannot be applied to sensors and *things*.

Because it is expected that more and more things will be intermittently available, multiple standards development organizations are creating new protocols and methods to enable their management. This work is happening at multiple layers of the stack. They include wireless communications, long and short-range communications, mobile networks and devices, and various approaches to maximize different variables in the trade-off of power consumption, range of distance, and transfer rate. As a consequence, there is a proliferation of new communication protocols that optimize various scenarios, such as minimizing power consumption in favor of data rates and communication ranges. Certainly, reliability decreases as we increase the number of devices and data rates. But order-of-magnitude improvements are still being made.

Furthermore, many cases and scenarios necessitate reliable management, including centralized controllers. For example, home and building automation, health care, and smart metering require management access to *things*. While there are a number of candidate protocols, different criteria result in various communication protocol design principles. There are multiple ongoing efforts for standardization of IoT in several industry forums, including, in particular, connectivity for most scenarios.

User Experience

Users demand a certain quality of experience. However, traditional devices are not the only means by which users access connected value. Mobility is increasingly becoming the mainstream (and sometimes even the only) media. Similar user experience is expected no matter whether the user is accessing a service via his or her mobile phone, at a connected kiosk in a public area, at a smart endpoint (such as a smart automatic teller machine [ATM] or a connected point of sale [PoS] terminal), or say from his or her car.

It is both a challenge and an opportunity to provide a consistent user experience across a user's devices and interfaces. On one hand, it might appear to be problematic to ensure a seamless user experience. However, when looking at it from both a user-center design as well as from *simplification* perspectives, a new viewpoint arises:

- It is the differentiator that provides a seamless interface across the platforms.
- Designing for the less detailed platform will bring simplicity to the more detailed and capable platforms and interfaces.
- A portable design can play to each interface's and platform's capability.

In particular, combining these three factors, we can see how, for example, designing for a mobile platform can result in a much better user experience in a desktop interface, a kiosk, or a TV.

Complexity

Tied to the previous element of user experience, the additional volumes of connected devices and data cannot directly translate to the user experience in increased complexity. In fact, the most successful services have *simplicity* as a core design principle. Designing with simplicity is different than managing complexity—and the former is the result of successfully conquering the complexity challenge.

Management

The increase in the number of devices and *things* connecting to the Internet brings multiple challenges. One of the most immediate ones is how to provide a scalable, secure, and real-time management layer for all these *things*. For example, how do we perform inventory management and essentially account for them? How to provide fault management for a new type of element connected to the Internet, one that, as we have seen, could turn itself off to conserve energy? If a sensor is not responding, is it *sleeping* or is it broken?

On taking a different perspective, the quality of data collected and retrieved from the *thing* population is a key concern.Often, this raw device data is incomplete with missing or partial data fills. As this raw data is acquired via device push or system pull, the IoE system must process, interpolate, predict, fill, and flag missing and manufactured values. Metadata describing the omission marking scheme and algorithms calculating simulated data fills are required by information processing systems so that they can signal the validity—and degree of uncertainly—of the statistics and recommendations they produce.

Data Integration and Reconciliation

As mentioned in the previous chapter, data is the source of the new currency. However, to make data usable, we need to integrate and reconcile varied data sources from previously unconnected and disparate systems. This is, again, a challenge as well as an opportunity.

To perform this data reconciliation, data virtualization systems should be created. The objective of data virtualization is to abstract the underlying data and provide a single unified view and application programming interfaces to the upstream consumers of the insights generated. In this way, the system not only provides data but also the right context for better decision making. Better decision-making is the monetizable improvement created by IoE.

Security

Security is probably the biggest, the least understood, and the most underestimated challenge. Yet, it is likely the most important.

Basically, IoT and the IoE greatly increase the attack surface and create new or increase existing attack vectors. A few reasons for this are as follows:

- Interconnected systems: IoE transforms separate closed systems into Internet Protocol (IP)-based networked systems.
- New devices: From the whole universe of new devices introduced by IoE, smart meters and wearables are just the beginning.
- New protocols: The IoT stack creates new capabilities and new attack vectors.

The impact on security is shown in Figure 2.1, where new opportunities create new threats because of the increased surface of attack.

Additionally, when cybersecurity exposure, threads, and attacks bleed into the physical world, the impact is compounded because it is no longer

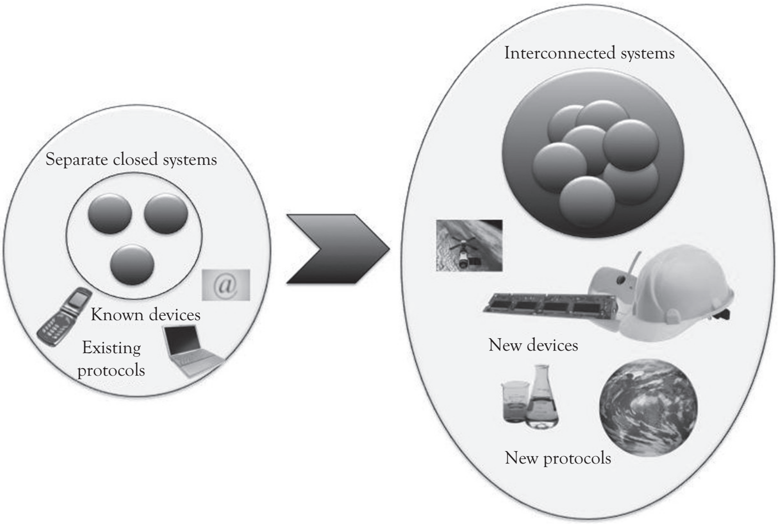

Figure 2.1 Increased surface of attack

just information theft and unwanted repurposing of software applications but an issue of the control and misuse of physical devices such as control valves and pumps that are now connected to the Internet.

New things need protection, and that is an opportunity. This opportunity is unchartered, and it tests the known boundaries of the security. Identity takes a new meaning with devices. When the Internet is attached to the real world, physical protection and anti-tampering become critically important. When a sensor is battery-powered for decades, its supplied cryptographic protocols must be equally resilient to protect the sensor from malicious attacks throughout its operating life.

CHAPTER 3

Drivers of IoE

There are multiple drivers of IoE. This section explores the key drivers of IoE in two different dimensions: business drivers and technology drivers.

Business Drivers

It is particularly critical to articulate the problems that we try to solve in IoE. IoE potential ideas need to have a return on investment ordering—ideas that deliver great impact on both topline as well as bottomline, leverage the new IoE data paradigm, and then those that result in connectedness.

Fundamentally, IoE business drivers fall into two key categories: revenue-generating drivers and expense-reducing drivers.

Many IoE business drivers address the key challenges mentioned in Chapter 2, including IoT security and a contextual, linked IoE experience such that the user feels the IoE system is reading his or her mind. Experience is king. IoE offers opportunity to create new methods for interacting with devices and with one another. Finding methods that truly delight customers unlocks IoE's business benefits. For example, multichannel experiences with HD video, mobility, digital signage, and social knowledge all together transform the customer experience at a sports stadium. When we overlay video analytics, the equation results in a much improved bidirectional engagement with the stadium operators, local sports teams, and even the night performers reaching out to interact with fans.

Some business drivers seek to satisfy customer demands by new ways of interacting. For example, finding new ways to seamlessly connect with customers with new engagement and interaction media in digital kiosks. New business opportunities open up when interacting differently with customers in health care environments or when leveraging new connections in, for example, an oil and gas rig.

IoE accelerates the pace of innovation. In addition to opening new markets and transforming the customer experience in multiple market verticals, IoE drives the massive and pervasive automation of business processes, because new *things* have more and easy-to-access digital connecting points which simplify the creation of automated processes. These newly automated processes and advances in predictive analytics expose data correlations unavailable prior to IoE. These new correlations and insights deliver significant productivity improvements across all industries—more connectedness and more data result in higher productivity improvement due to automation.

Technology Drivers

Technology transitions often predate market transitions, which in turn create business transitions. Consequently, understanding technology transitions give business and governments an edge to predict the forces that can disrupt the markets and create new businesses.

In particular, in the case of IoE, the key technology drivers with material market and business impact are as follows:

1. New devices types—including holistic intelligent solutions:
    - There is a fundamental shift in the endpoints that dominate the process edge and technical landscape.
    - This shift also ripples in the whole ecosystem. Developers shift from a focus on the endpoint (e.g., mobile phones) into a focus on the fog (e.g., industry focused system-based applications).
    - This fog layer precipitates from digitally enhanced devices—*things*—which incorporate embedded event processing, reasonably sized onboard data storage capabilities, and IP network connectivity.
2. Volumes and types of new data generated:
    - This technology trend gives way to a data virtualization layer.
    - To deal with the volumes and types of data, the platform becomes a data fabric, from which distributed applications can access data in a normalized way.

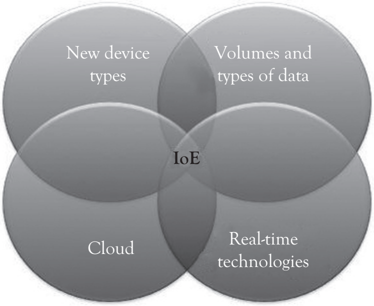

Figure 3.1 Technology drivers of IoE

- This trend dissolves the boundaries between the network and the data center or cloud.

3. Easy access to cloud technology:
    - This is made even easier when the cloud is extended to the edges via the fog.
4. Real-time nature of data interactions:
    - Data is processed in seconds or minutes instead of large overnight or week-long batch jobs.
    - The application of this analytics ranges from business intelligence to industrial automation.
    - Analytics applications are embedded and distributed.
    - Real-time analytics paradigm first acts and then stores (as compared with the traditional model that first stores, then analyzes, and later acts).

These four key technology drivers are depicted in Figure 3.1. All these technology trends are key drivers for value created with IoE.

CHAPTER 4

Barriers to IoE Adoption

So far, we have explored the definition of IoE, along with some of its benefits, challenges, and drivers.

In this chapter, we list some of the key barriers to adoption of IoE. The main intent is to understand these roadblocks and to explore how a services approach can deal with them.

Intrinsic Barriers

First, some of the barriers to adoption are fundamental and inherent resistance to new technologies. IoE is actually a set of new interrelated technologies, making this resistance and inertia much bigger. These include:

- Unmanaged data
- Increased security attack surface
- Physical security threats.

Transformation Barriers

Second, additional barriers to adoption stem from the application of IoE and the transformation of businesses, industries, and cities, and are transitional in nature. For example, these include:

- Information technology (IT) systems are not keeping pace
- Operational technology (OT) systems are managed by different administrative groups
- The integration of new technology with legacy systems is nontrivial

- The ability to update current processes to absorb new and emerging technologies is finite and reaches a saturation point.

Extrinsic Barriers

Lastly, there are specific barriers to adoption that predate IoE, yet continue to be relevant. For example, regulatory compliance and data sovereignty are two of the most important ones.

CHAPTER 5

Service Innovation for IoE

We have surveyed the societal and business opportunities ignited by IoE, as well as the barriers, that may hamper the adoption and expansion of IoE. Let us now focus on service and consulting industry's role in launching IoE and furthering its acceptance.

Navigating IoE Size and Scope with Services

A big area for new IoE services includes analysis of device or thing capabilities to deliver relevant, crisp information, while hiding complexity. As all device capabilities are relevant in some context, it behooves the manufacturer to make application-programming interface (API) as granular as possible. Granular (i.e., down to the particulars) APIs allow downstream partners and clients to customize their software applications interfacing with the device. Customizing enables application developers to interrogate specific indicators emitted by the device or thing and deliver the exact calculation or data point needed by the business to meet its objectives. However, IoE's tenet of more insight from more connected devices presents formidable challenges to device-heavy industries operating a vast array of legacy systems. Service organizations with detailed knowledge of industry processes and equipment operations bring a discerning order that forms the link between their clients and IoE business insights. These service organizations create this link by identifying all relevant equipment API attributes and then developing the algorithms that process those attributes and produce new business insights.

Service developers have a clear opportunity—a near mandate—to define heuristics for mining discreet attributes from devices and sensors. Accompanying every heuristic will be a framework for organizing the attributes according to the prevailing best practices for a particular development community. Defining and mapping device attributes at an atomic level allows multiple taxonomies to coexist. In turn, different standards bodies my ratify industry-specific device information maps based on these attributes to expedite rapid delivery of new products and applications.

Organizing IoE standards bodies into a tiered structure enables this mining and mapping to flourish. Attribute mining organizations will work with chip and system-on-a-chip manufacturers to create standard guidelines and decision trees for identifying device and interaction indicators and attributes. Interested product and system manufacturers may participate in mapping standards organization events to illuminate the needs of various industries to the chip and elemental component manufacturers. This ensures device attribute guidelines for selecting object features and interactions to expose via APIs are standardized with the needs of the implementers taken into consideration. Second-tier taxonomy standards bodies identify, group, and link devices into structured maps relevant to the industry or affinity group(s) they represent.

IoE services penetration and acceptance rates rise in inverse proportion to the perceived complexity of IoE systems design. IoE services providers and consultants wholly benefit by forming industry standards groups to identify and document common device interactions within and across a variety of industries. Taking advantage of previous representation and modeling efforts, these IoE systems standards bodies may use the Unified Modeling Language (UML) previously standardized by the Object Management Group. UML provides an industry-accepted method of organizing the capabilities of IoE systems into structural and behavioral relationships so that users can easily understand the functions within an IoE system and how these functions interact to deliver the desired features of the IoE system. More importantly, UML gives IoE systems architects the ability to clearly define sequence diagrams depicting the actions and reactions exchanged among *things* to accomplish a particular task. Figure 5.1 provides an example of UML activity diagram for consuming media content by detecting the participants, discerning their choice to possible group viewing.

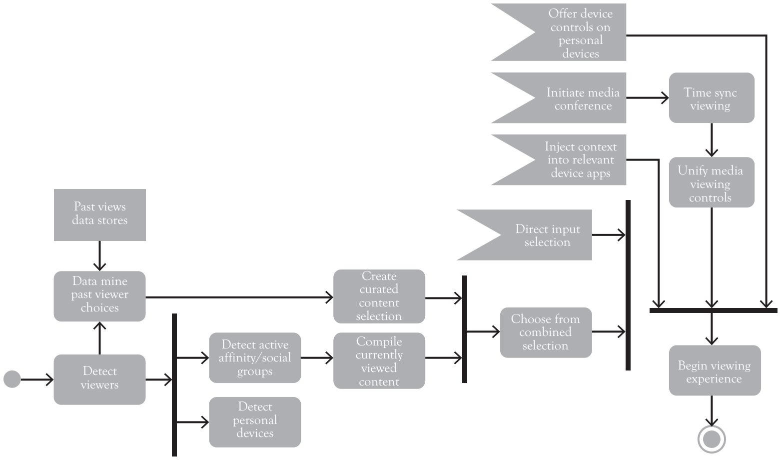

Figure 5.1 UML activity diagram showing IoE enhancing the media viewing experience

Transforming Data into Information and Actions Using Services

IoE service providers fill a crucial gap helping high-volume production manufacturers decide which attributes—more likely which combinations of attributes across disparate devices—constitute a trade secret or patentable idea. The attribute combinations must be protected. Service providers (SPs) may offer proven methods to secure and protect these attributes from their vendors. Vendors may poll and assess these attributes as a part of their as-a-service (aaS) maintenance offerings without infringing on their clients privacy if their device's software development kit (SDK) is sufficiently detailed and discreet.

Once the relevant device attributes are identified, IoE service providers and consultants may offer the next crucial step along the path to realize IoE business benefits. This step is device discovery and identification. Converting legacy systems with unique—often proprietary and many times orphaned—device addressing schemes onto an IP version 6 (IPv6) address assignment plan seems straightforward, but identifying the legacy device's capability to operate an IPv6 end system software stack and adapt the IPv6 numbering plan to the designed hierarchy of the legacy system is a complex exercise. Similarly, a legacy system may have design limitations that limit its native IPv6 capabilities, so a shim or translation gateway may need to be installed to act as a translator connecting the legacy system to an IoE network.

Manufacturers, health care delivery organizations, and retailers operating these legacy systems often do not have the resource time and, in some cases, the expertise to design and transform the legacy systems into an IoE device or endpoint. The IoE services consultant or provider brings along the advantage of the experience of transforming many legacy systems to IoE as well as the industry best practices for transformation architecture and project planning, learned from participation and contribution to the standards bodies discussed earlier.

Operationalizing IoE Using Services

Once the legacy device system's path to IoE communication is clear, IoE service providers must deliver capabilities to locate and identify all the devices which should participate in the legacy system within the enterprise's environment. Often, legacy systems are heterogeneous mixes of units with near identical functionality from several different manufacturers. Depending upon age, process criticality, and the overall industry demand for a particular unit, it may be impossible to replace a class of units with the legacy system. Uncommon device management interfaces or the unit's lack of a traditional computer management interface compound the problem of integrating the device and system into IoE. In this case, service providers and consultants must illuminate the limited capabilities of this device make and model to all their client stakeholders, overcome make and model feature limitation by verifying adaptation techniques to control, monitor, and manage the legacy device using IoE applications, and finally, demonstrate how this particular device will be operated as its containing system is connected to the IoE network.

Locating legacy devices presents several challenges including:

- Ferreting intermittent electrical communication paths to discern all the operating devices within the device or process. Legacy devices may operate repetitive tasks properly and be ignored until they fail. IoE data flows can prevent this using predictive analysis and live monitoring.

- Undetected component failures that prevent a device from sending or responding to management systems.
- Lack of bidirectional device communication links—devices are actuated but legacy systems do not receive or retrieve device action responses.
- Inaccurate inventory systems omit some number of actual operating devices or include devices that are physically missing or destroyed.
- As-built design documents are no longer accurate due to legacy device moves, adds, and changes throughout the system's operating life.

The IoE services provide opportunity to create heuristics, information gathering techniques, and means of data verification, which uncover all the devices within a legacy system.

To deliver the insight and responsiveness IoE can bring to process monitoring and automation, service providers must offer their clients complete service solutions that begin with the assessment of information sources and sinks. Using this information usage assessment, a follow-on service must quantify and illustrate the data availability and reliability needs between all information sources and sinks. Availability and reliability figures across all of the information flows in the IoE network dictate the architecture and construction methods employed to build the routing network to move requisite information from IoE sources to sinks.

IPv6 Routing Protocol for Low Power and Lossy Networks (RPL) addresses many of the needs for moving information between devices or emitters and consumers or users of information. Services role begins with the design of the RPL-based network and the bill of materials specification but expands to include the integration of new information sources and the deeper analysis made available by industry-specific statistics and data representation using these new information streams.

Emerging industry associations, such as the newly formed LoRa Alliance—launched at the 2015 Mobile World Congress—seek to establish standards and accompanying heuristics that ease the implementation of mass-scale low power devices. The alliance addresses low power wide area networks (LPWAN) via device communication classes for transmission and reception, as well as recommendations for communication topologies between devices and gateways. Beyond basic communication, the alliance focuses on security for communications within the device-gateway network and security for device-resident applications communicating with central network server applications.

Defining the IP network to transit all this information is not enough. Higher-level services must offer clients guidance for business process integration and application modification so the marked increase in data flow from device, process, and system telemetry does not overwhelm existing job functions and work streams.

Seizing the Opportunity to Define New Services

This section discusses new professional and consulting services to adapt and launch IoE technologies and practices into enterprises and service providers. The roll out of IoE also offers new tools, information, and contextual analyses to create new business-to-business (B2B), business-to-consumer (B2C), machine-to-consumer (M2C), and machine-to-machine (M2M) services. Many of these new services will be predictive—delivering people and machines the logical next step to improve and simplify their lives or deliver the exact part just in time to finish the task. The convergence of searches, enterprise chats, affinity networks, calendaring applications, and building management systems to preschedule meeting rooms based on digital conversation cues is an example of new IoE converged services.

Professional and consulting services organizations have a clear opportunity to assemble and deliver methodology to identify the need for new B2B, B2C, M2C, and M2M services and assist corporations and government entities to assemble the information sources and associated contextual linkages to deliver these new IoE services. IoE produces information that may be stored centrally or spread as a distributed data model delivered by a network. New services are required to monitor and mine this data into information and analysis using business activity monitors, complex event processors, and statistical analysis softwares. Given the variety of new data sources IoE introduces to the most plain-vanilla, homogeneous industries, service organizations must deliver teams with varied expertise and work experiences to assess the entity, sensor and process data, and discern likely contextual events and unexpected indicators from unusual and previously unavailable—or even previously dismissed—data sources.

Services to Wrangle and Direct All the IoE Data

Making more astute decisions by uncovering unexpected causalities and detecting new information flows typify the core benefits of IoE. But how does an operator swim through this new churning sea of data without drowning? Distributing data sources among multiple computation points in the network provides a scalable solution. Service and consulting providers greatly benefit their clients by guiding them through the process of distributing the computation and analysis functions at first tier device aggregation points. At these junction points, data is extracted, potentially stored, and interrogated by algorithms injected from centralized IoE management systems and local users.

Service teams must consider the following challenges and needs as they architect and design data management and presentation systems:

- How to account for and catalog all of the data sources emitted by a particular device or entity complex?
- Within the IoE deployment domain, how does one classify data as locally or globally significant or both?
- Where are the processors and consumers of the located relative to the data sources and data stores?
- As data sources emit new data, how often do data processors and consumers need updates?
- Is the emitted data consistently in the proper format for the data consumers and processors? If not, is it easier to enhance the parsing and extracting functions of the data processors and consumers or insert a multiview data presentation layer between data sources and data consumers?
- Is the data transient or historically valuable?
- For data with critical and or historical value, how is the resiliency of the containing data repositories ensured?

- Data transport networks are often costly, slow relative to software application needs and prone to bottlenecks due to oversubscription. How will the data management architecture mitigate these transport network issues to meet the needs of local and remote data processors and consumers?

Beyond technical consultation services to design a data management network that addresses these considerations, services delivery organizations have the opportunity to implement and operate telemetry systems as cloud services to ensure the data management service functions as desired.

Relevant domain expertise enables services providers to mine the data requests and resulting computations to determine if the resulting actions deliver the optimal process or product improvement. Data-driven actions, which result in discernable process or product improvement, constitute a premium value-added service in the IoE services providers' offerings that are built on the base IoE system design and deployment services. In many cases, the base IoE design and deployment services will commoditize as industry standards and best practices emerge for interconnecting disparate devices and systems.

Human initiated device linkages are only the first step in IoE. Complex event processing within the device will advance from contextual awareness and choice selection to judgment capabilities and *things* making the next best decision. This technology progression will shift the focus of the services consultants from alternatives assessment, architecture specifications, and action plans to desired outcomes and results verification because things will naturally form systems delivering outcomes as expected functions. An example is the video surveillance system in the local grocery store detecting significant pedestrian traffic in the frozen food section, which triggers the heating, ventilation and air-conditioning (HVAC) system to warm the freezer aisle and the freezer itself to increase the shelf lighting.

CHAPTER 6

IoE Privacy and Security

If there is any philosophical discussion in IoE, it is around privacy and security. There is a large amount of information generated and exchanged among the various entities, devices, or nodes in the Internet of Things (IoT) or the IoE value chain. As mentioned earlier, regardless of the industry or vertical market, in the IoT or IoE world, there is a stack of building blocks that generate information and send it up the stack for further processing. Consider the following diagram we introduced earlier in Chapter 1 (Figure 6.1).

Information is continuously being generated and exchanged among the layers of this life cycle, and in most cases, information crosses many boundaries, enterprises, clouds, and even the Internet as shown in Figure 6.2.

Therefore, there is a need for a solid security framework that addresses all aspects of security and privacy for every element and building block of the data life cycle or flow.

In the following subsections, we shed light on few areas of IoE security and privacy while generating questions and considerations for your specific scenario. Security and privacy measures need to be addressed during the design phase to reap effective results and minimize costs. Adding security measures to an IoE system can be very costly and possibly limit the systems intended performance.

Identifying and Authenticating Sensors or "*Things*"

As technology advances, the smaller and smaller *things* will be digitized, and the embedded memory and computing in these devices will shrink as well. This is why choosing the right hardware, middleware, and protocol to achieve all functionality, including security, needs to be a design consideration. As *things* power up, they need to connect to be identified or

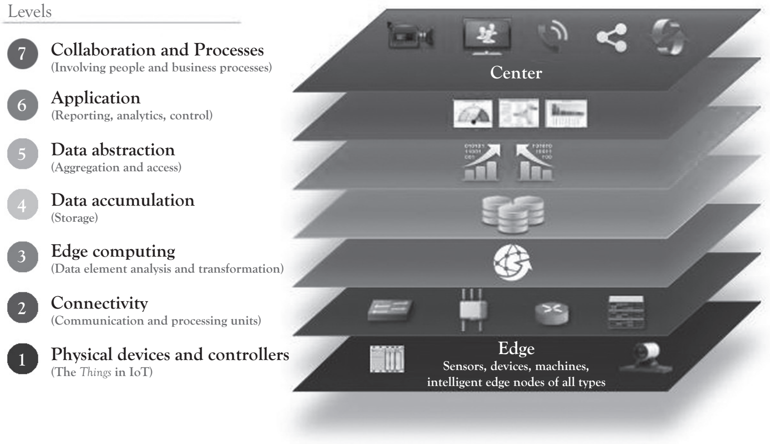

Figure 6.1 IoT World Forum reference model emerging markets

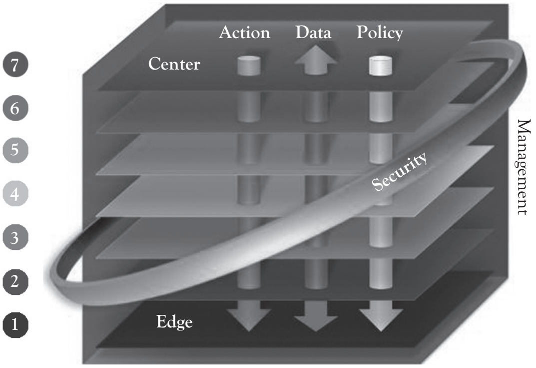

Figure 6.2 Information flow dictates security boundaries and models

registered by a *gateway* or an aggregation point of some sort. This simple process is sensitive and essential. Consider a health monitoring device worn by or attached to a heart patient, which ensures that the proper *handshake* between the health monitoring device and the next layer *node* or *element* is essential not only for identifying and authenticating the device but also for ensuring the data flow to and from the device for proper operation, monitoring, and control.

Identifying and authenticating *things* heavily depend on addressing and controlling protocols. IPv6 has scalable addressing space and a few built-in security features, and it has demonstrated effectiveness in domains like energy, for example, smart-grid. However, IPv6 may present computing and throughput issues as *things* have less computing power and memory. *Light-weight* protocols such as Constrained Application Protocol (CoAP), message queue telemetry transport (MQTT), and others have been used for IoT or IoE applications. These protocols are not without shortcomings depending on the solution you try to build. We encourage the reader to further investigate these protocols as they are beyond the scope of this book.

Situational and Contextual Security

Mass participation from individuals, devices, and *things* leads to additional or new privacy concerns. System access and system usage will become context-aware. It is not only enough to know the identity (who or what) and the access or participation mechanism (the how), but also the context in which they access or participate in the system (when, where, and possibly why).

The fact that someone or something has the required credentials to access or control a device or a record does not mean that the access needs to be granted *unconditionally* and without the proper context. Similarly, the fact that someone is executing a *legitimate* control command on a machine does not mean that the instruction needs to be executed without looking into the nature or context of the direction. Imagine a scenario where a specific *stress-test* command, normally executed during maintenance hours, was being sent to a *controller* during production hours. This type of behavior could be destructive, disruptive, or even dangerous to human operators. With contextual security, we examine where the command was executed from (e.g., internally or through remote access), we examine the credentials used to access the controller, we examine the *time of day* or the *time within the production cycle*, and we also attempt to correlate this *change management* records to see if this type of *command* was related to a particular maintenance cycle. This type of cybersecurity thinking emerged after the *Stuxnet* incident in the Iranian nuclear facilities where legitimate controller commands sent centrifuges to spin beyond their limits.

Now, imagine a physical access scenario where an employee works at a high-security area and has the required credentials and privileges to access that area. The employee goes to access the area at 7:00 p.m. She shows uses her credentials and gets access into the area, but it does not stop there. Behind the scene, some security application or system begins investigating that employee. The application is trying to build a real-time profile of the person, for example, match shift-hours with time of access, direct certain cameras to identify her using face-recognition, and then track her movement within the high-security area, query the human resources applications to determine if any recent security or safety incidents have been reported against her, and query the document management system (DMS) to determine if she has recently downloaded sensitive documents to her personal computer. In this case, it turns out that the employee left her cell phone behind and went back to retrieve it. As you can see from these examples, context-aware security is extremely important in this exploding world of data, devices, and things.

Data Sovereignty

As cloud services adoption becomes widespread, especially, by large and global enterprises, the data sovereignty concerns come into focus. Data sovereignty is about data residency. It is about regulations or business-agreements that require the data belonging to a group of clients residing in one entity or domain that cannot be stored or moved outside the borders of that entity or domain. This is especially important as data from *things* or sensors moves to the cloud for additional analysis. The cloud providers must insure that the data respects privacy regulations related to established and respected boundaries.

Who Owns the Data?

The issues of data ownership and data repurposing are common news topics. This goes beyond law enforcement agencies requesting or acquiring personal or private data. For social networking or search-engine companies, to capture data about search trends or *special* topics of national or group interest and selling it to marketing companies is one thing, but to zoom-in and *personalize* the data is another and that is where ethical problems arise.

Imagine that you use a very expensive and sensitive machine (call it Widget-Maker 2000 or WM2000). With widgets being an all-time high demand, your operations must go without interruption. The WM2000 machine-builder approaches your company about a new service called *predictive maintenance for continuance operations* (PMCO). The PMCO service captures approved data from your operations and from the WM2000 machine and then moves the data to a cloud-provider for aggregation, cleansing, and preparation for delivery to an analytics service provided by a super-computing company. Your company conducts a design phase to address all network and security scenarios and then decides to subscribe to the service, especially, after you have seen firsthand that the PMCO was able to predict a few maintenance issues or outages before they occurred. Now, several hundred, of data from your company's WM2000 machines is flowing into the cloud and stored or archived by the machine-builder. The machine-builder now wants to perform additional analysis (usage, fatigue, stress, etc.) on the WM2000 as a machine regardless of the customer and type of widget it is making. In essence, he plans to combine data from your operations with data from all the customers that own the WM2000 in order for him to study the behavior of the WM2000 and improve the product. Now, you have a dilemma. Who owns the data? You programmed and tuned the WM2000 to produce a high-quality widget, now your data (your secret sauce, your market differentiator) is going to be used in some calculation to improve the life of the WM2000 machine for you and your competitors. It is not an easy question to answer.

Requiring your solution provider to *expire* (no longer retain) your production WM2000 data immediately after using it for your specific analysis is one way of dealing with this. Another way would be to try and clean or sanitize the data locally (at your operations) and remove process-specific data from it. But that requires a deep-level understanding of the controllers and control protocols of the machine.

In conclusion, we encourage you to consider the value of the data produced by the things you digitize, the computing power of your things, and the entities or groups that need to receive, process, and analyze data from your things. Taking these three areas into account will direct your security and privacy design decisions as you construct your IoE systems.

CHAPTER 7

The Changing World: Where IoE Is Making the Biggest Difference

We hope that by now you are able to see how IoE will help you run a more effective business, predict your customer or client behaviors, and automate time and people intensive processes, just to name a few. As you can imagine, this value is realized through a carefully selected and orchestrated ecosystem of elements that produce data, capture all or relevant pieces, and manipulate, correlate, and analyze them to deduce actionable knowledge. The previous sentence is the long way of saying "IoE is about getting knowledge out of information" and, subsequently, of saying "knowledge is power."

The simplified diagram (Figure 7.1) from International Data Corporation (IDC) gives a very good picture of the stages of data workflow and how data changes from being *information* created at the *process* or *procedure* level all the way to becoming actionable knowledge.

This rapidly changing world we live in is (and has been for few years) experiencing an explosion of information, and now it is the time to capture and use this information to understand or explain why we did certain things and what we plan to do about certain other things in the future. In the next few sections and chapters, we plan to touch on the preceding statements with real-world examples.

A Shift Toward Insight-Driven Operations

As we bring together all the pieces needed to deliver the highest value from IoE, we must consume and process massive amounts of data from

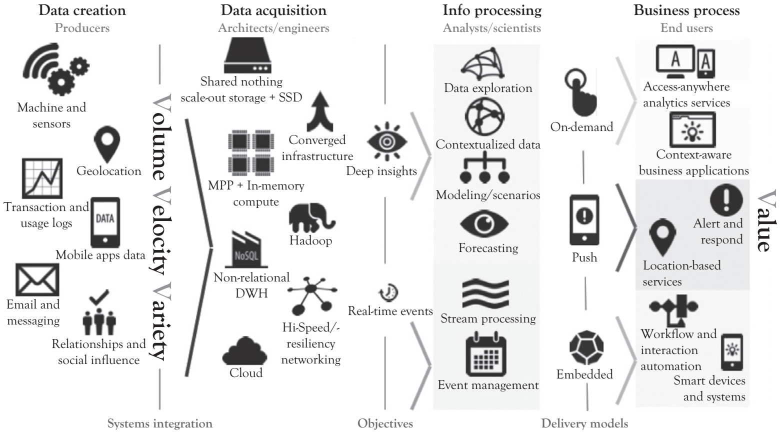

Figure 7.1 Data workflow

Source: IDC Big Data Predictions 2014

an exponentially growing number of data sources. Often the desired IoE analytics come from secondary and tertiary systems, which require the IoE operator to capture, store, and deliver data to a data management system that manipulates it and makes it available (transmit it) to other systems for further processing, correlation, and analysis. In this case, *data manipulation* defines data to be processed and presented in a certain way depending on the systems that will perform the final analysis and, subsequently, display results (aka visualization tools). Alongside data manipulation, please note that we also mentioned *data capture* and *data transmission*. In the emerging world of IoE, these two concepts are proving to be the most challenging and will be the focus of innovation and research. A simple data capture and transmission scenario is shown in Figure 7.2.

Regardless of the market segment or vertical, capturing data related to a particular process or transaction, in most times, may require capturing data related to several other processes and transactions, storing it, and then transmitting it to the data processing engines location for further analysis. Aside from the complexity and expense associated with data transmission, it is inefficient and consumes significant network and computing resources.

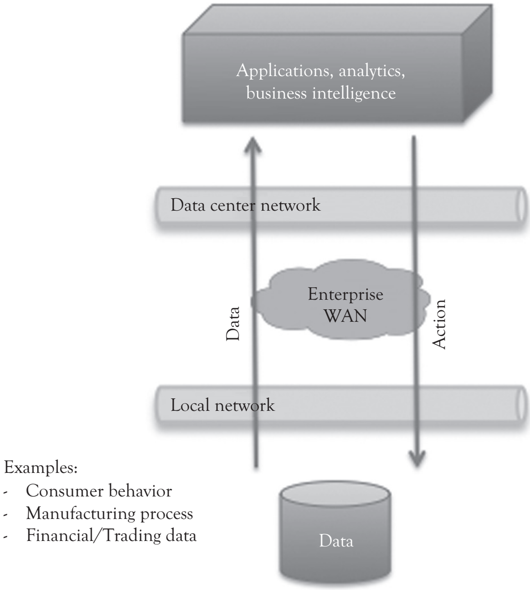

Figure 7.2 Simple data capture and transmission scenario

Putting Insight into Action

Imagine that we capture data from a drilling operation of an oil rig with only satellite connectivity. We are talking about hundreds of sensors generating gigabytes of data to be analyzed at the same time. We have to rely on data collected by conventional procedures from pumps, valves, temperature gauges, and the drill-bit itself, stored into historian-type databases, and transmitted to the company's data center for further analysis. What we see is the emergence of technologies that facilitate the capture of only the data we need from the process or transaction of interest and then transmitting it to the data center for further analysis. This is only a fraction of the data mentioned in the previous example.

In the example, we capture historical data from various sources and send it to a central place for analysis. The data is processed as a batch and the results are possibly presented as a day's, a week's, or a month's operation activities. In the second example or method, the data is collected and processed in real time and as close as possible to the source. A deeper understanding of the business process, the data needed, and the results will help you in architecting your data management and analytics building block (e.g., storage, computing, relational or nonrelational databases, etc.). See Figure 7.3 for an example of data shared outside the boundaries of the enterprise.

Now that we have examined the *data capture* types and requirements, let us give some thought to *data transmission*. Capturing data from various levels of operations and transmitting it to a centralized place for processing is not as easy as it sounds. As you probably deduced from our previous *satellite transmission* example, there are a few important things that need to be considered beyond just the transmission medium. Consider, for example, data security. We have been speaking generically so far, but consider the example of a financial institution or a health care provider capturing customer data or consumer behavior data and transmitting it to a service provider network with a high-performance computing cluster provided by a *cloud service* in order to be analyzed. Also, consider an example of capturing manufacturing data from your manufacturing floor (or shop floor) where you have your production control systems. This type of environment is usually isolated and controlled even to employees of the same company whose jobs directly relate to manufacturing process. Manufacturers hesitate to allow open communication

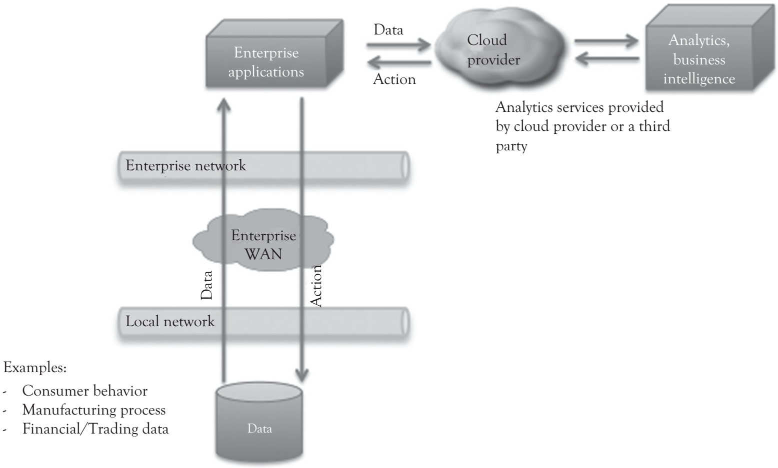

Figure 7.3 Example of data shared outside the boundaries of the enterprise

in their control systems, as any security breach will have data safety and security consequences.

The next chapter focuses on IoE use cases where early adopters in manufacturing and retail spaces partnered with device makers, IT hardware or software providers, and leading consulting firms to improve business insights and results using IoE enabling technologies.

CHAPTER 8

IoE Use Cases

Scenarios and Use Cases

IoE promises industries a higher degree of efficiency and profitability using insights obtained from data about our customers or simply from our *operations*. New data acquisitions and analysis technologies are making it easier for a large number of industries to adopt the IoE implementations to improve operations. The IoE concepts—whether they are called IoE or not—have already made a difference in various vertical or industries. The list is long, but we have attempted to briefly highlight six main categories.

Discrete Manufacturing

The manufacturing sector is expected to hugely benefit from the IoE technology adoption. There are several types of manufacturing categories and it is probably not fair to group them all into a single category, but we will generalize this time for the purpose of our discussion. The adoption of IoE promises significant benefits related to improving efficiency, productivity, availability, and reducing energy consumption. In addition, as the various processes get interconnected, the ability to capture process-specific data in realtime (or close to it) will help manufacturers to better react to market conditions including customer demand and supply chain issues.We will give manufacturing an in-depth focus in the next chapter.

Oil and Gas

Similar to manufacturing, oil and gas (O&G) industries will benefit from IoE technology adoption. O&G companies are one of these types:

- Upstream companies, which are concerned with exploration and extraction of crude oil and natural gas.

- Downstream company includes companies that refine and distribute processed products. Marathon Oil is an example of this category.
- Midstream company is not a common category since it is sometimes included with downstream, but it mainly involves storing and transporting crude oil or natural gas.
- Fully integrated, or as one of our clients describes his company, from the well to the wheel. Exxon Mobile, Shell Oil, Chevron, and British Petroleum are common examples.

As you can imagine, when we talk about O&G adoption of IoE technologies and processes, we deal with oil rigs, refineries, pipelines, tankers, gas stations, and so on. For each of these, there is a lot to be gained from connecting, correlating, and automating the various processes. In recent projects, we have seen our customers deploy new connectivity models to improve the communication infrastructure and then subsequently move toward advanced remote monitoring and operations for effective field collaboration. With the availability of information comes the next step of gleaning insights and business intelligence using advanced analytics technologies.

Health Care

Like O&G, the health care sector has many categories and subsectors, but we will quickly cover the main challenges experienced by all health care categories.

Health care executives are encountering new challenges in providing quality health care, innovative technology solutions, energy savings, and a magnitude of regulations and reporting standards. In addition to these is the excitement around wearable technologies and how they will change the world of health care. You can then imagine the challenges that health care executives face today. The wearable devices provide new markets for proactive personal health care as well as extended care monitoring. But they also come with major privacy and security challenges.

Transportation

IoE's benefits to transportation are of no exception. Transportation is a vast world covering multiple areas—fleet management, connected vehicle programs, and positive train control (PTC) to name a few. PTC is a set of functionalities for monitoring and controlling trains in an attempt to increase safety. As you can imagine, a number of sensors (speed, location, safety parameters, etc.) will be providing information to a centralized control system that issues commands to the equipment on the train to ensure that the train is traveling safely. Fleet management technologies have been in action for quite some time now providing companies with safety, efficiency, locations, and maintenance information.

Energy

When we talk about technological advances and the value of IoE, the energy sector immediately comes to mind. The past five years showed a significant advancement in what we call the smartgrid. The main benefit of the smart grid is the information it provides to utility companies about the grid itself and about the consumers of its electricity services. It will also help utility companies in detecting failures and allow self-healing without human intervention. The information provided by the grid will also help to predict and adjust various load patterns.

A true IoE implantation is the energy sector in the advanced metering infrastructure (AMI), which is an integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities and customers. "Customer systems include in-home displays, home area networks, energy management systems, and other customer-side-of-the-meter equipment that enable smart grid functions in homes, offices, and factories."*

Retail

With the advancement of communications and e-commerce technologies and processes, the retail sector has been experiencing several shifts and

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* SmartGrid.gov (2015).

adjustments. At the same time, retail is benefiting from new technologies that bring retails closer to their customers by providing them with a shopping experience and improving loyalty. As we discuss retail in more detail in the following section, we will touch on the major advances in IoE as related to the retail industry. One might argue that there are significant differences within the various retail specialties (e.g., apparel versus grocery chains versus electronics), but at the end of the day the mission is one. The retailers want more information about their customers to be able to have the right product in the right place at the right time and nothing can deliver this better than the frame work and technologies provided by IoE adoption.

CHAPTER 9

Use Case in Depth—How Will Manufacturing Benefit from IoE

Manufacturing is booming. Economic upturn along with rising consumer wealth, low energy cost, and consumers' healthy appetite for big-ticket items will create a manufacturing boom. The new-order manufacturing index reported its highest levels since 2004 (August 2014 data). As we already guessed, the automotive industry has led the pack and is expected to grow few more percentage points in 2015. In a recent Cisco economic research data, the manufacturing industry proved to benefit the most from the adoption of IoE technologies and practices.

The manufacturing sector has been going through a *modernization* phase. With modernization, the idea is to bring few necessary technologies and architectures commonly used in the *carpeted space* or *nonmanufacturing space* onto the shop floor or to the production environment, without compromising availability and security of production systems. Technologies and solutions like wireless, video, and VoIP have been used to improve communication and collaboration and subsequently improve productivity. Not to forget that manufacturers had to adopt Internet Protocol (IP) and Ethernet infrastructure topologies to facilitate communication among various production, control, and safety systems in the manufacturing environment. The following sections give the reader additional information about the evolution of the manufacturing space and the use cases or processes that saw the highest degree of improvement and efficiency.

The Manufacturing Environment

The *process* (whatever it is we are trying to build) usually dictates how you design the production environment and how you deploy or use the various *automation* technologies. Automation comes with the ability to improve productivity as well as the ability to collect data from the various production steps and use the data to understand the production process and all factors and parameters that affect it. But for the majority of cases, the production environments remained isolated from the rest of the enterprise, and the ability to correlate data among the various manufacturing cells, plants, or both was limited. Therefore, the need to open up communication arose and subjected the production environments to security and availability concerns.

A framework to synchronize the vocabulary and design practices among manufacturers, machine-builders, and the system integrators (SIs) or main automation contractors (MACs) was necessary. Various organizations stepped up to provide that framework or reference model. The International Society of Automation (ISA) was one of the first to publish a series of recommendations for integrating the *control systems* with the *business*. What ISA attempts to do is not only related to technology integration but also related to integration of operational and organizational processes. The ISA approach was to partition or subdivide the manufacturing environment or production environment into functional categories with various requirements and challenges and relate them to the upper layers of the hierarchy. The upper layers are usually the rest of the business, or what we commonly call the *enterprise network*.

Figure 9.1 presents a simplification of the ISA95 or the Purdue model. The purpose of this book is to show the type of systems and data sources within each of the levels or layers and subsequently show the reasoning behind the functional area partitioning as well as the network, security, and application requirements for acquiring the data. The control systems (shown as levels 0, 1, 2) or, as ISA generically refers to them, Industrial Automation and Control Systems (IACS), are the business-critical systems that run the manufacturing operations and are normally isolated from the rest of the network.

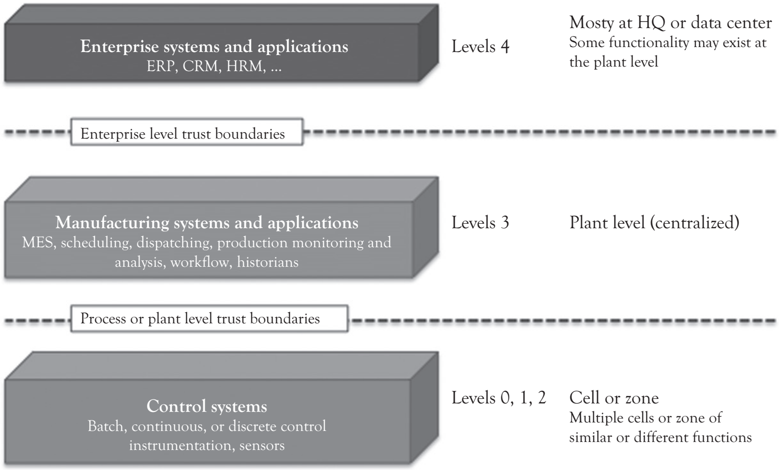

Figure 9.1 Simplified representation of the ISA95 levels

Due to safety and operational availability, access to the IACS systems is granted only to personnel directly associated with or directly responsible for them. As you can imagine, a security compromise within this area not only disrupts productivity but also compromises the safety of the people and assets on the shop floor.

Depending on the type of operation or final output of the *factory*, the *control systems* layer could be a single zone or cell, or it could be multiple zones with each zone having multiple cells. What matters here is that the majority of times, all zones or cells are monitored, managed, or analyzed by a set of *centralized* applications with the plant. Scheduling of operations, recipe servers (e.g., food and beverage manufacturing), dispatches, historical data logging (data historians), and monitoring are few simple examples of what takes place at level 3. Security at level 3 is as important as that for levels 0 to 2, especially, from compromise or malicious attacks that come from the enterprise side (i.e., level 4), from an infected CD, from personal computer of a service technician, or simply from an employee using an infected USB memory stick.

This is why some models are displayed in a demilitarized zone (DMZ) that sits between levels 3 and 4. Some publications refer to it as level 3.5. Level 3.5 is mainly a layer of firewalls, intrusion prevention systems (IPSs), and other security appliances, application, and services that control access and flow of data from and into the manufacturing zones. The DMZ also houses mirrored manufacturing applications and other services seen in level 3 of Figure 9.1. A common example is the data historians. No direct access is granted to the historians in level 3 of Figure 9.1.

Security is not the scope of this book; we just wanted to give you an idea about the challenges of acquiring data from processes and things deep within the manufacturing floor. After all, the IoE picture is not complete without *data*, *processes*, and *things*.

The Value Chain

Before we take a look at the concerns of manufacturers, it is important to understand the manufacturers' value chain and how different items relate to each other. Of course, the value chain differs from one manufacturer to another, and it is hard to find a common one that applies to all industries. Figure 9.2 depicts various components of the value-chain elements broken down to show the process from engineering a product to building it, to selling it, and to supporting it in the market place.

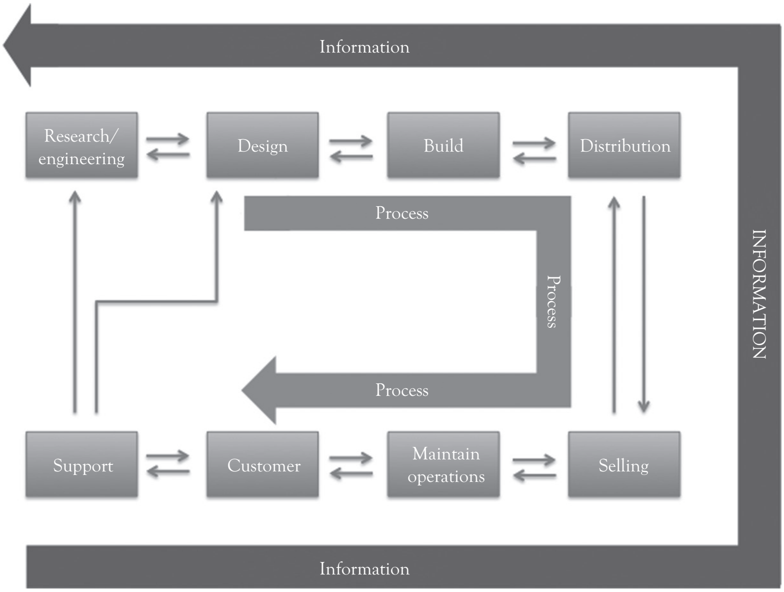

Figure 9.2 Interdependency of product making and services needed to bring it to market

The purpose is to demonstrate the processes, to identify how information generated within each one could be used to analyze a particular process, and to find how information flows backward to help improve a preceding process. Regarding information flow, it is not just within the enterprise and through its IT managed resources and assets but also beyond the boundaries of the enterprise and through the networks of global suppliers, dealers, distributors, and support services organizations.

Manufacturers' "Top of Mind" and IoE Solutions

A number of issues or scenarios keep manufacturers at their toes. Today, manufacturers are interested in integrating their IT operations with their control systems, networks, and applications, increasing the availability (reducing mean time to repair), increasing overall equipment effectiveness (OEE), reducing cost, and improving asset utilization. We will briefly discuss few of them before we discuss how IoE helps or will help to solve them.

Manufacturing Skills Gap and the Adoption of New Technologies (Training)

It is no secret that the manufacturing industry is one of the top industries facing a shortage of experienced workers. The wave of retirement of the skilled manufacturing workforce (mainly from the baby boomer generation) is creating a shortage in skilled workforce. In addition, the economic climate is forcing some of these workers to work beyond the normal retirement age leading to a reduction of available opportunities for employees with lesser years of experience. Although both issues are *top of mind* for the manufacturing industry, the skills gap issue is getting the most attention.

The adoption of new automation and communication technologies like the ones mentioned in the following sections had made it easier for manufacturers to capture knowledge from experienced workers and retain it for the training of new workers. In addition, bringing collaboration technologies made it possible for skilled workers to engage with fellow workers globally on maintenance and repair projects without leaving their home or their office.

Real-Time Visibility (Insights)

One of our clients once said, "Help me connect the executive-floor to the shop floor." Of course, few years ago, we were concerned with just network connectivity and crossing strict security boundaries between the IT-managed and the OT (operational technology) network. Now that the type of connectivity exists (for the most part), we want to connect (or integrate) systems and applications across the enterprise to achieve the highest degree of visibility in operations, orders, supply chain, human capital, and so on. For example, manufacturers have been able to optimize operations, reduce cost, and manage productions and inventories through the integration of manufacturing execution systems (MES), material requirements planning (MRP), and enterprise resource planning (ERP) systems.

Looking back at our modified value-chain block diagram (Figure 7.3), you can immediately recognize the benefit of how having all information (critical or otherwise) from every process in the chain could help you manage operations to meet any condition. The examples are many, but imagine reacting to market conditions, scaling operations, and changes you need to make along the chain. Better yet, imagine having the possibility of having the ability to *simulate* market conditions where manufacturers have real-time data from all processes correlated with historical data or trends; they then use simulation to model the effect of a certain market condition on the rest of the operations.

For example, what would happen if demand for this widget increases by 20 percent, how would the rest of my operations react? How long would it take me to get a modified product to the market after having an engineering change mandated by a compliance issue or by a *recall*? How will my operations meet demand knowing that one plant is experiencing yield, quality issues, shortage of raw material, or even a labor strike? We know that this is being done today by some manufacturers but at the spread-sheet level, geographical level, or plant level, but in the coming years, we expect manufacturers to be able to do this in seconds or minutes with the help of ERP and MES vendors who are opening their products to integration (e.g., using APIs), alongside the network and control system vendors who are also making it easy to capture process level data off the wire.

All of these is limited to a single manufacturer not only having visibility into their own operations but also having visibility into their suppliers and partners. Knowing how my operations will react to external or market conditions is good, but will my suppliers and partners be able to handle the change as well? This means that the flow of data is needed horizontally and vertically to be able to have the best visibility into the future. In summary, insights help us make fast and intelligent decisions based on real data.

Collaborative Operations (Internal Operations + Partners: B2B)

Plant outages, or loss of productivity, are one of the biggest issues facing the manufacturing industry. Loss of productivity means loss of profitability, especially when the outages are unplanned. The ability for a manufacturer to respond to an outage and bring together the proper resources, skills, and even parts to the location of the outage is directly related to the length of the outage and the profitability loss. This means that proper communication and knowledge sharing is of high importance within and outside the manufacturer's operational space.

To completely get the benefit of IoE (bringing together people, data, processes, and things), communication barriers must be reduced or even eliminated. Furthermore, as we bring higher level of transparency we need to also keep in mind the *skills gap* or the *workforce shortages*, we described earlier. Combine that with the hiring of younger and less experienced workers and the need for reliable and instantaneous communication that builds a *community of interest* that includes issue owners (around an issue, or device), experts, and decision makers. We frequently hear from our clients about the need to fly an expert to handle an outage at a remote plant, or the need to wait a couple of days for the system integrator to make it to the site to diagnose and repair an issue. By building the collaborative environment, expertise or *expert opinion* is available at the right time and in the right place without travel or additional expense.

Collaborative operations solutions bring together voice, video, and data communication technologies into a single environment accessible by multiple entities regardless of where they are (headquarters, plant, the field, etc.) and enable them to take informed decisions and to repair an issue without compromising the safety and security of the environment and the workers.

Collaborative operations do not necessarily mean that we overhaul the current infrastructure of communication or video surveillance; it just means that you facilitate the visibility of information available by multiple means into a single pane of glass. It also means using this information beyond its originally intended purpose. For example, there is so much information or knowledge available from video surveillance system beyond just watching people. There is a whole new industry evolving around video analytics, heat-mapping, or virtual fencing. With a virtual fence, for example, you can define a logical area on the screen, and if a person (perceived as intrusion or safety hazard) or a foreign object enters that *virtual* area, an alert is produced and other cameras and means of communication are directed toward collecting data around that event. Similar technologies are used to capture and alert emergency personnel to possible *slip and fall* events. The previous examples do not introduce new technologies or concepts, but they suggest the potential of more intelligent event analysis or prediction when combined with other communication technologies and software applications.

In general, with collaborative solutions, manufacturers can facilitate the engagement of the right resources at the right time, provide training opportunities, facilitate the capture or recording of mission-critical events and their resolution, reduce risk, promote safety, improve compliance, and so on.

Predictive Maintenance

One of the main goals (or challenges) for the manufacturing industry is to have high yields of high-quality products at low cost. Process optimization and optimal asset utilization are also key factors in this equation. Maintaining productivity and quality require developing techniques and processes to avoid unscheduled downtime or outages. Manufacturers have always relied on *scheduled* or *preventive* maintenance to proactively repair or replace worn out parts before they fail.

With the use of advanced predictive analytics, manufacturers are moving beyond preventive maintenance into the use of predictive maintenance to ensure the health of the equipment, processes, and operations at every step of the production cycle. Using regularly scheduled maintenance, manufacturers were able to collect data about the state of the parts they replaced and record the data for future analysis; however, by doing that, they were only able to analyze data (mostly historical data) about a single part or process independently from other parts or processes in the production cycle. In a way, this is closer to *descriptive analytics* than it is to predictive analytics.

The power of predictive analytics is in the ability to capture data from multiple sources with multiple protocols and formats and correlating it together using powerful engines and applications to produce actionable knowledge.

For years, robotics has been a significant component of the industrial automation revolution. The automotive industry was one of the first industries to deploy robots, and benefited greatly from them. Automotive manufacturers employ robots for spray painting, spot welding, assembly, and finishing, in addition to many other manufacturing tasks.

Consider, for example, a manufacturer that uses advanced robots to perform similar tasks in the production of their product. Any outage or unplanned downtime would be very costly. Our several clients have conducted *cost of downtime* studies in an effort to associate a dollar value with each unit of time of equipment downtime. When looking at the numbers, one can quickly realize why manufacturers are sparing no expense investigating, selecting, and deploying availability and performance solutions like predictive maintenance. With predictive maintenance, manufacturers and their contractors, vendors, or machine builders are finding ways to proactively identify performance or maintenance problems and take corrective action before outages occur.

For the purpose of our example, a manufacturer actually worked closely with the robotics vendor to look at ways to rationalize, mine, and utilize the data produced by the various sensors embedded into the robotic arms and motors. Initially, data (e.g., usage, torque, thresholds, etc.) was directly obtained from a robot’s various sensors (by polling or interrogating the controllers) and placed against known thresholds or correlated with intelligence gathered from theoretical and historical data to predict maintenance issues.

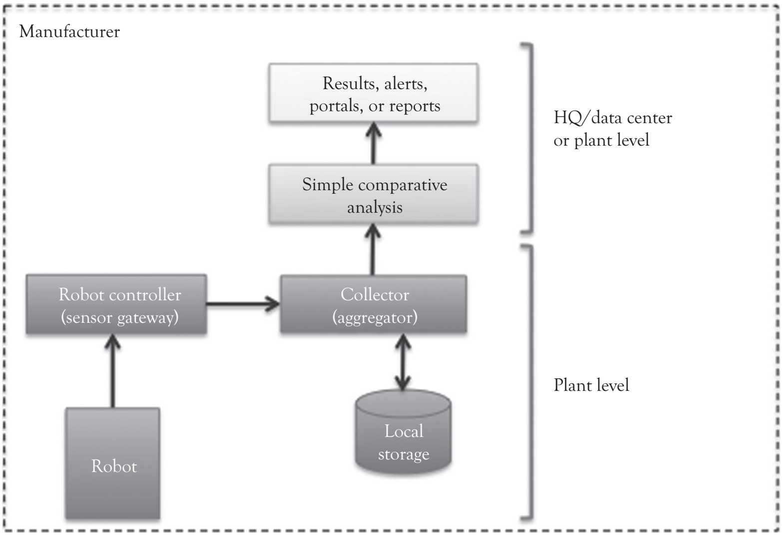

Figure 9.3 Simple predictive maintenance analytics

Figure 9.3 is a simple block diagram of the components used to conduct the analysis. Although this diagram appears simple, for this example, it was a powerful tool that saved them from at least two outages (related to robot joint failure) in a very short time.

However, this solution was an attempt by the manufacturer to interpret robot data based on experience and some proprietary data made available by the robotics vendor. As you can imagine, more than a few errors—*false-positives*—have occurred. In addition, the manufacturer does not have the capabilities to manage the large data sets coming from thousands of robots in various plants across different geographies (domestic and global).

The robotic vendor is better equipped to capture the *right data* from the right source and to better analyze it for more accurate results. The next step was for the robotic vendor to analyze the data remotely (at their data center), where they have very powerful data analytics engines, and where, they have the ability to centralize the data collection and simultaneously crunch data coming from the several thousand robots used by the manufacturer. The manufacturer and the robotic vendor had to work out few important design issues that are beyond the scope of this book, but we will mention few of them to complete the picture:

1. Security, security, and security: Both sides are opening their mission-critical operations for bidirectional data transfer.
2. Whose data is it? Does the raw data belong to the manufacturer so that its data is only used for calculations related to the manufacturer's environment and product specifications? Or can the robotic vendor employ it to further analyze their robots for fatigue?
3. Data sources: It is simpler when the analysis is being done on the robotic data. What happens when additional data needs to be collected to complete the analysis? For example, usage and maintenance logs, robot location, process owners, environmental data (e.g., temperature and humidity levels)
4. Data management: Design backwards. It is highly recommended to have the end-picture before you start, especially when you have the possibility of working with different data formats, structured and unstructured data, and so on.
5. Data acquisition: Polling for the data on demand is simple enough. What happens if the manufacturer or the robotic vendors decide to start streaming data from the sensors or robots? Bandwidth, storage, and security considerations arise.

Now that the data is flowing from the plant and into the robotic builder's analytics engines, data is getting analyzed, results and alerts are being sent back to the manufacturer or hosted by the robotic vendor and accessible by the manufacturer as shown in Figure 9.4. This has proven to be very beneficial for both parties but we can do more. There is the idea of *prescriptive analytics* where instead of simply alerting the manufacturer of potential issues, systems take the next step and convert the *knowledge* into *action* as depicted in Figure 9.5.

For our example, the *appropriate action* we mentioned earlier could be to order new parts and enter a request for a *maintenance window* to replace the parts. Another action would be to adjust operations, but it's not an easy idea to sell to manufacturing and control engineers. Rightfully so, where safety of personnel and assets is at stake, we are not ready to let machines take over control of operations. Another reason is that for the majority of manufacturers proximity and line-of-sight are mandatory before applying changes to a process. Simply put by a control engineer

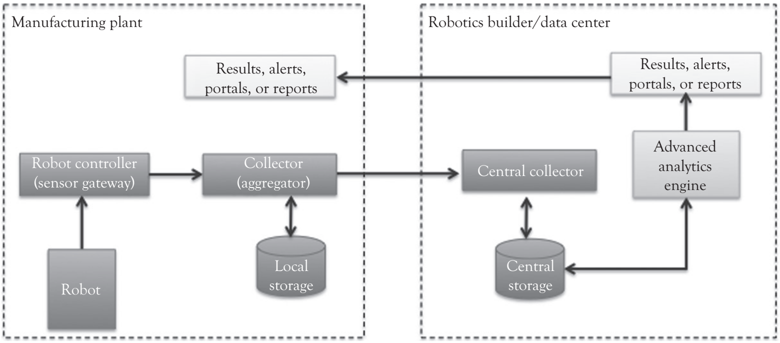

Figure 9.4 Services offered by the robotics vendor

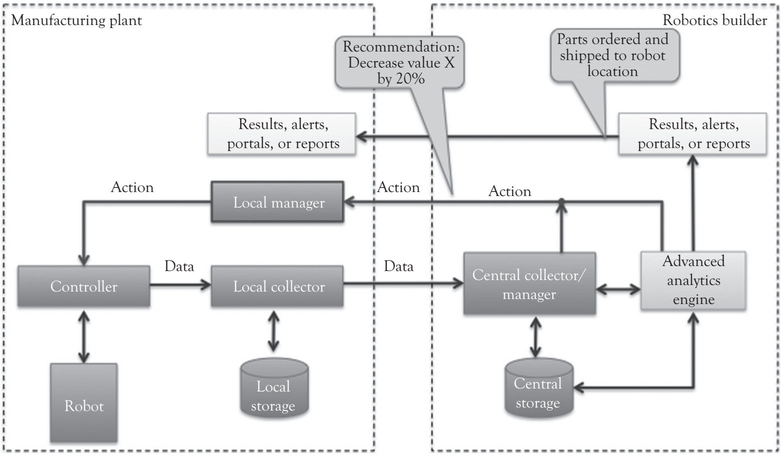

Figure 9.5 From information to knowledge to action

we worked with: "If you are not close to the machinery and you're not looking directly at it, don't mess with it." For that reason, in Figure 9.5, we have used the term *recommendation*. The analytics engine, based on intelligence from historical data, sends a recommendation to a management system where a control engineer considers acting upon it.

With this example, we attempted to give you a high-level overview of this new (and not so new) world of analytics, and how it is used to add more intelligence to operations. But it does not stop here; there is more. There is the idea of *machine learning*. In our preceding example, we left it up to the control engineer to *adjust operations* of a single enterprise based on what she knows about the whole process or procedure. With machine learning, the human intervention is taken out of the picture. The *machine* in this case is the *control system process*, the *application*, or the algorithm that runs the multiple operations of the process, learns from previous operations and their consequences (more like, learns from its previous mistakes), and adjusts itself to drive the best outcome possible for the process. Returning to our example, in the future, it might be possible for the *control system* to not only adjust operation and order parts but also to adjust the whole operation or production cycle (even after the parts have been installed) to ensure that the operations or robot, or anything related to the process, would run longer and healthier during the same maintenance cycle. For example, after considering or analyzing all the data from all the processes, the *algorithm* determines (calculates, correlates, etc.) that the part that needed replacement was affected by the moisture or temperature levels (even if that part was originally rated for such levels), and by adjusting the process or HVAC systems, it ensures better outcome and longer life for the process while keeping all other devices and processes in consideration. In essence, it guarantees that it does not fix one and break another. What we are describing here is very much similar to IBM's Watson computer, and how it won the game show *Jeopardy*. Watson was not just doing lightening-speed lookups for answers, it actually went through a learning process of watching previous *Jeopardy* shows or consuming a large number of Jeopardy questions, questions styles, and answers. We encourage you to watch *The Smartest Machine on Earth* to get a flavor of what we are talking about. The short film produced by NOVA can also be found on YouTube.com*

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* https://www.youtube.com/watch?feature=player_embedded&v=tAzeGkuQmUU

CHAPTER 10

Use Case in Depth—IoE Solutions for the Retail Industry

Connecting people, process, data, and things shines the most in the retail industry. In retail, customers are willing to share a lot of data about themselves to get the deal. For instance, they are happy to share information about their shopping preferences, age, gender, household income range, and more on a customer loyalty application to get points or discounts. They are also willing to let retailers capture that information directly from their behavior and their mobile devices during the shopping experience (within the store or online) using Wi-Fi access and other means. Retailers have used loyalty programs for decades to judge customer retention and the effectiveness of their marketing campaigns, among other things.

Similar to the manufacturing example, there is significant power in converting customer data into knowledge. With adequate knowledge about customers, retailers are able to customize and personalize their relationship with the customer.

The following few sections discuss a variety of uses for IoE technologies or frameworks in the retail space, and how they are making a difference for a good number of retailers, and how some of these technologies are improving employee productivity, improving customer experience, and reducing cost.

Queue Management and IoE (Front-Line Checkout Process)

This is a very interesting field of study for retailers and data analytics providers. Queue management is extremely important for all retailers.

Significant research has been done about customer patience. Patience of customers vary depending on the queue processing or progress movement. For example, if the queue is progressing, then customers are willing to spend longer time in it. But they are willing to spend a lot less time in a queue that is not progressing or not moving. Retailers, banks, and even hospitals (i.e., emergency room) have always kept an eye on queues lengths and processing time while coming up with various ways to manage them.

In a retail setting and around the area of frontline checkout, research have shown that customers are not willing to wait for more than two to three minutes in a queue that is seeing little to no progress. But they will stay in a queue that is progressing for close to six minutes. Of course, this does not apply to the queue where the latest Apple iPhone is sold, where the wait-times were several hours.

Imagine a hypothetical scenario of a famous bakery or bagel shop that has 500 stores where an average customer spends five dollars between the hours of 7:00 a.m. and 10:00 a.m. The bakery was noticing that customers were abandoning the queue in almost all of their stores quite often. There are many ways to conduct the queue management studies. Queue management has been the subject of research for a few decades now. This is how banks and retailers decide on how many teller stations or frontline checkout registers to open at any time of day. The studies are mostly manual and require capturing data over a long period of time to improve accuracy.

With IoE-enabled technologies, we have new ways of performing real-time queue management, detecting abandonment rates, comparing them with predetermined thresholds, and alerting store managers to the need for additional staff to enhance the customer experience.

The bakery decides to use an IoE solution where additional cameras are installed to monitor the queue and to capture how many customers are in the queue at any time and how many customers abandon the queue and after how long of a wait-time. The solution is simple yet very powerful. The queue cameras (or possibly new models of existing surveillance cameras) give every customer a tag (or ID) and a time stamp and monitor their progress within the queue, when they get serviced, or long before they abandoned the queue.

They determined that customers were abandoning the queue at a rate of three per hour when there are around 10 people or more in the queue. Doing simple math:

> 3 per-hour × 3 hours per day (7:00 to 10:00 a.m.) × $5 per customer × 500 Stores = $22,500 per day

Multiply that by 300 days (removing Sundays and few holidays from the calculations) and we get $6.75 million of lost revenue.

Beyond studying the abandonment rate, the system is subsequently programmed to alert the store management in real time to the fact that customers have been in the queue long enough to start seeing abandonment and that additional allocation of staff is needed at the service counter.

Figure 10.1 shows how the camera and the queue-management system could color every customer based on how long they have been in

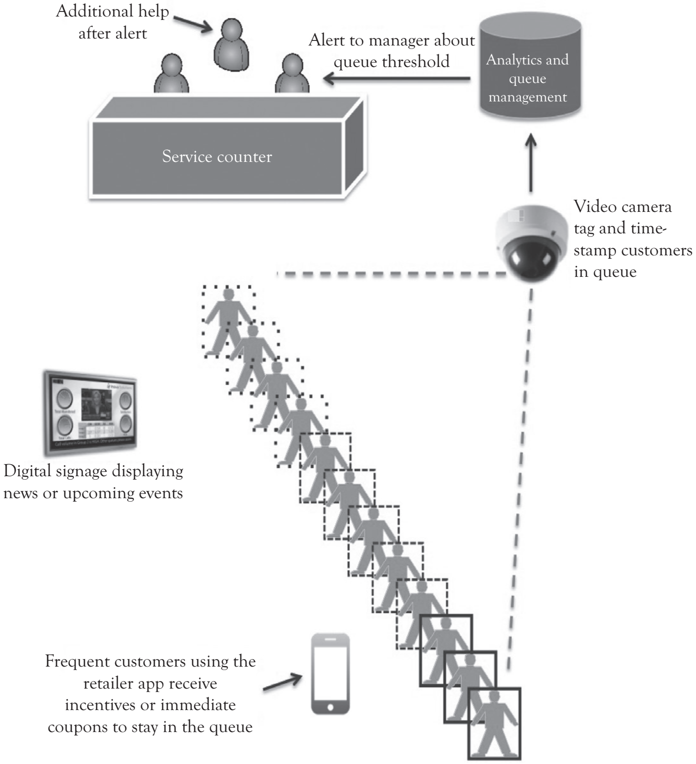

Figure 10.1 Queue abandonment scenario

the queue. For example, dotted line "….." could be for customers who would be serviced in the next two to three minutes, the dashes "------" for customers in the queue close to six minutes, and the solid line "_____" for customers expected to be in the queue for more than seven minutes.

There are endless possibilities for using the *queue* data. This data could be used across all the stores, or across stores in a specific region to decide on staffing needs, coupons, and incentives, as well as lead to additional process and operational evaluations, to speed up the processing of customers.

The hypothetical example used earlier was only to demonstrate the value of data collected about the customers' time in the store and connecting the data with other applications and systems to suggest to the store managers ways for addressing the issues. For example, in a large retailer setting, where there are multiple queues and queue types, the calculations and thresholds may be different, but the idea is the same.

IoE Solution for "On-Shelf Availability"

As we mentioned earlier, the customer experience is important in maintaining loyalty. A big part of loyalty is not just having the product in stock but also on the shelf when the customer is looking for it. Today, the process of keeping the shelves stocked is a manual process that is based on *time of day* or based on visual inspection of shelves. The manual process has gaps and does not always address the issue quick enough to reduce lost sales. The use of point of sale (POS) data is a viable measurement method for many store formats. There are a number of companies that have developed algorithms to estimate out-of-stock from POS data, and some retailers have developed their own in-house systems. The accuracy of estimating out-of-stock using POS data is 85 percent or greater,* which is equivalent or greater to the accuracy of manual audits (where human error is present).

Customer's reaction to out-of-stock varies from buying an alternative product, not buying an alternative product, to buying at a different store. Approximately, 31 percent of customers buy the product at a different

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* Gruen and Corsten (2008).

store (Guren). On the average, retailers lose four percent of their annual sales due to out-of-stock issues.* This often translates into long term customer loyalty issues.

Our definition of out-of-stock here is focused on what the customer experiences. It does not matter if we have the product in the back-room. What matters is that the product is not on the shelf. Various solutions (that complement POS-based solutions) have been tested and implemented in the retail space to combat this issue. Sensor-based solutions that alert the store clerks or employees to the missing product have been proposed and in some cases have been implemented. In this scenario, the sensor could be an RFID sensor on the merchandise box itself or a shelf-based sensor measuring the availability and the count of the product on the shelf. But that system is not fully accurate and cannot completely solve the issue. A misplaced product is not easily detected by the RFID scanner if it is outside the range of detection. The shelf capacity scanner will report *availability* if anything is on the shelf regardless of the correct product or not.

The IoE approach to get the highest accuracy on-shelf-availability measurement is to combine various cost-effective methods and correlate the data together to ensure success. For example, with the advancement of video analytics, we will be able to recognize the product in question by focusing the camera directly on it and analyzing the quantity and placement (ensure that the right product is in the right place). We have seen few solutions where retailers use shelf-based sensors to monitor shelf availability. They quickly found out that it was not a very good solution when their sales associates were putting the wrong products on the wrong shelf. When the sensors were reporting availability, customers were complaining about not finding their favorite cereal box.

A good IoE solution will correlate multiple sources of data to ensure a near-perfect on-shelf availability. A solution that uses shelf-sensors, an advanced video-analytics system that determines type, quantity, and positioning of product, combined with data from the POS system to determine availability of the product on the shelf or in the storage room. If the

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* Vargheese and Dahir (2014).

product is in the storage room, then a real-time alert is generated and sent to the store clerk, manager, or associate to restock the shelf.

Augmented Reality

Augmented reality is gaining a lot of momentum in retail. We believe it is going to be an important part of the customer experience in the very near future. It is already making its way into various major retailers and is making an impact. The concept is not new. More than 12 years ago, hair designers utilized software applications that would superimpose a multitude of hair styles and colors on a picture of a client. Clients loved it. It is not hard to imagine the potential of augmented reality using today's hardware and software technologies. Look at the following excerpt from an IKEA press release:

> **Catalog App** for smartphones and tablets (iOS and Android)—Download from your app store beginning on July 24. The app gives users access to extended catalog content by scanning designated pages of the printed catalog. The extended content includes: an augmented reality **"Place in Your Room"** feature which allows users to virtually place and view nearly 300 IKEA products in their own homes; **shareable videos** featuring quick DIY tips and stories behind IKEA products; **360° views** that allow users to look all the way around a whole room; and **image galleries**. Select content will also be available in the digital catalog.*

Using this app, you can visualize (or virtually position) how various pieces of furniture from the catalog look in your living room or office by simply pointing at the space where the furniture is needed.

Let us take it a little further: You go to the shoe department of your favorite department store and the sales associate is busy or not available. You see a pair of shoes you like and you need to know the price, availability, color choices, country of manufacture or origin, brand, sales, coupons, and so on. You pick your smart device, you point it directly at

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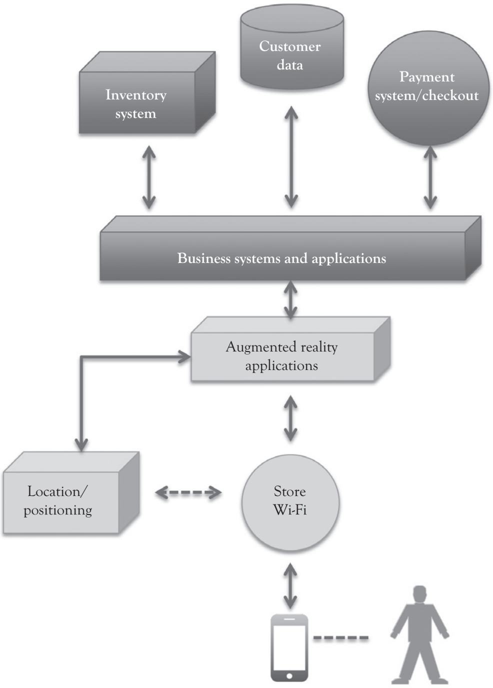
* IKEA.com (2014; emphasis added).

the pair of shoes you like, and you have all your questions answered. You like what you see and you want to buy it but the desired size is not available, no problem, the app will tell you if it is available at another store nearby and will ask you if you want it be put *on-hold* for you. Instead, you prefer to buy it from the app and have it shipped directly to your home.

Similar to all the examples we listed before, this is a true *IoE enabled service*. We will say it one more time, people, process, data, and things are exactly what went into making the services from the given example possible.

Figure 10.2 is a simplified view of data-flow resulting from interaction among multiple technologies, applications, and things. For example, a customer enters the store, his/her smart device associates with the store's Wi-Fi system, the customer then uses the store-specific App on a smart device for various reasons (e.g. coupons, deals, latest fashions), the App relays information to the backend applications about the customer and



Linking customer data with various retail applications will speed up the decision process, simplify the purchasing process, and improve customer loyalty

The ability to locate the customer within the store is essential in providing information as well as measure dwell and linger times around specific merchandise

While using the store-specific App on Smart device, the customer gets real-time product Information while providing information about shopping preference and personal taste

Figure 10.2 Augmented reality in retail

his/her most recent interests and product-searches. At this moment, the retailer knows few things about the customer and is able to "customize" the shopping experience. The customer now walks around the store and sees a pair of shoes that he/she likes and would like to find out the price, available colors, sizes, customer reviews, and few other things. The customer picks up the phone, points it at the shoes and immediately sees all the desired information displayed on the phone's screen. In addition to the information, the retailer displays few options like alerting a store clerk to bring out the appropriate size to be tried out, put the shoes on hold at another store since they don't exist at this store, buy using stored credit-card information and ship to the customer's home, establish an "alert" to email the customer when price-reductions occur, and many more options that retailer could display to give the customer a memorable shopping experience. The above is a result of various technologies and applications exchanging and correlating information to produce the information the customer is looking for. Wireless and "Location Services" technologies to identify and produce a "location" of the customer within the store or in close proximity of the merchandise, databases for historical customer purchases and interests, Inventory systems to gather data about the desired product (color, size, ...etc) and its whereabouts (e.g. local store, nearby store, outside an acceptable driving radius), as well as payment systems to facilitate the purchase.

In summary, augmented reality is helping a good number of retailers reach new or existing customer segments, and offer them new shopping experiences. Augmented reality dressing rooms are showing up at many high-end retailers and are being accepted by customers as a fun experience and as an alternative to *physically* trying on garments. Welcome to the world of IoE.

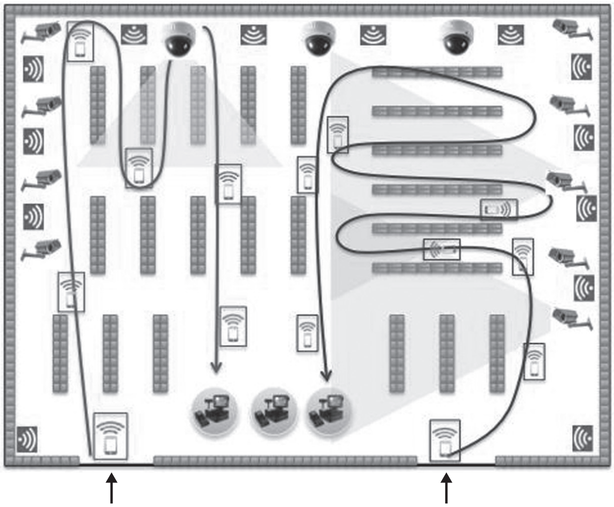
Dwell Profile (Time, Video Analytics, and Path Analysis)

We talked earlier about getting customers to the store. Now they are here, how much time are they spending at the store? And where are they spending it? Dwell time is the time customers are spending at the store. Multiple market research studies have shown that the more time customers spend at the store, the more money they will spend. Therefore, keeping the customer in the store and keeping them interested is important for the bottom line.

We originally thought of writing two independent sections, one about dwell time and one about path analysis. But, we decided to combine the two into what we call "Dwell Profile" (time at the store and the path taken inside the store). From a research point of view, the two may be separated, but from an IoE use-case perspective, we wanted to mention them together and make a case for measuring dwell time, path, heat-maps, and the use of smart-devices and apps to personalize the shopping experience and improve loyalty.

Like the queue management, video analytics play a big role in measuring dwell time and performing path analysis, as well as heat map hot spots, in the store. With the advancement of video and surveillance technologies, retailers are able to get automated detection of customers (even their faces) and track their movement, behavior, and the time they spent at different areas of the store. Same devices and technologies will be able to provide heat maps of the store and allow retailers to identify dead-zones or hotspots within the store. This information is very valuable for measuring the effectiveness of displays and other in-store marketing and advertising strategies. We are currently working with retail clients to help them with the dwell time, path taken, and gender of customers that actually visit their displays of big-ticket items. Knowing this information will allow the retailer to position *shelf-displays* and *digital-displays* for gender-specific items along the path frequently traveled by customers and also measure the return on investment (ROI) for those displays.

Going back to dwell time for a moment, how could the retailer get the customer to spend more time at the store? Retailers keep their customers occupied and roaming the stores using a number of conventional methods that include entertainment, live music, and free stuff (free samples of merchandise and free tastings of food). What additional ways can the world of IoE offer the retailer in this department? There are two key technologies that can help here. The smart-devices, smart-displays (digital signage—the use of interactive displays, in other words, displays with interactive content) provide customers with additional product and promotional information and allows them to find the product and purchase in a self-service fashion.



Cameras and Wi-Fi for tracking customer movement and interests

Example 1: Customer enters through Door “A” and targets a specific product in one section.

Example 2: Customer enters through Door “B” and takes specific path through store while staying within a specific section or side.

Figure 10.3 Dwell-time and path analysis example

In big-box stores (warehouse-like speciality stores or super-centers offering multiple categories of merchandise), dwell-time and path analysis will offer significant advantages. Figure 10.3 depicts a large super store where multiple technologies collaborate to offer the retailer few pieces of information about their store setup and about their customers. The retailer is using Wi-Fi, cameras, and possibly other data-points to profile a particular customer or to measure traffic within specific areas of the store. It also depicts, as an example, two different customers coming through different doors and one having a specific target while the other one roaming the stores through various aisles. Another thing to notice here is the Pan-Tilt, and Zoom (PTZ) cameras at the perimeter used for multiple purposes like keeping track of a customer or zoom on a particular product or shelf to held determine On-Shelf Availability described in an earlier section.

Smart devices will also play a role in increasing dwell time. Research shows that 83 percent of adults aged 18 to 29 and 74 percent of adults aged 30 to 49 have smart phones. In all, 67 percent of cell-phone owners find themselves checking their phone for messages, alerts, or calls even when they don't notice their phone ringing or vibrating.* Loyal customers with store-related-apps can get the latest promotions and discounts in real time. But wait, what about the concept of *me-tailing*? What if a retailer can customize or personalize the shopping experience? Now that I have determined the identity of the customer, having found a few historical facts about him or her, and knowing what isles they have been to and around what sections they lingered, how about pushing them few personalized coupons to help them make a decision in my favor: *spending money*. This customized experience is the result of many data sources working together to help the retailer profile the customer's interests in real time based on historical and current information.

Digital Wallets

We could not talk about retail and not mention digital wallets. There are many digital wallet systems, applications, and devices out there. Whether they are web-based, smartphone app-based, or NFC (near field communication) based, they serve the same purpose of making it easier for customers to conduct financial transactions. For our purposes, we want to point out that digital wallets tell a lot about their owners and their habits while also offering a vehicle for loyalty programs for a number of retailers. Digital wallets are a great source of information for payment-system providers and retailers.

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* Pew Research Center.org (2014).

CHAPTER 11

Conclusions

The accumulation of data and the belief that it can benefit business profitability, customer experience, and society's general quality of life drive the IoE. Now, people are revising existing methods and creating new processes around a rapidly expanding network of digitized things to optimize and improve business, government, and societal outcomes.

IoE is the fourth-evolutionary phase of the Internet. It leverages the digital communication channels established in the networked connectivity phase, the commerce tools created in the networked economy phase, and the multiple means of collaboration—including popular social media platforms—developed and embraced in the networked emerging experiences phase.

In this book, we discussed how the exploding growth of networked, connected devices forced attention from IT, manufacturing, health care, and retail groups among others to define and design for IoT. Those networked things also carry embedded sensors and processing capabilities to orchestrate commands, locally process results, and push data and results to the designated data storage systems. These new data sources can yield many new insights; it is the role of the services industry to help its clients uncover and leverage this new information effectively.

IoE unlocks additional value by uniting people, processes, data and things. Though the influx of data, much of it unstructured, and the secure delivery and retrieval of that data are formidable challenges, the increase in operating efficiency and unearthed value deliver the ROI justification for the IoE investment. Services organizations have clear roles in scope definition, process interrogation, legacy migrations, and IoE systems operation. However, services organizations can make more substantial impact and ramp client relevance by influencing and driving device or thing programmability standards and by developing industry heuristics for process improvement with IoE. The ability to understand the business process or operations and the information needed to evaluate it is of great value to all companies with diverse operations and geographies. IoE as a multilayer ecosystem of hardware and software components will allow various enterprises to capture its value and maintain their leadership or competitive edge. More importantly, it will allow them to uncover new interactions and capabilities that generate new markets and opportunities.

Cloud technologies to store and process data into useful information are vital components in the IoE architecture. At the same time, IoE is transforming the cloud by reconfiguring its composition to bring data processing and analysis closer to the cloud edge in a fog layer to distribute, assess, and act on the torrents of data streaming from devices, sensors, and other newly digitized and connected things.These connections would have never scaled with IP version 4 (IPv4). IP version 6 (IPv6) delivers 128-bit addresses, which yields billions upon billions of possible device addresses for connecting the previously unconnected. IPv6 is an essential building block for the IoE.

For IPv6, circuit miniaturization and electronic component cost reductions enable and ignite IoT and IoE, but the accompanying challenges are substantial. The scalability, reliability, security, and manageability challenges offer many opportunities for technology services industry to innovate solutions and provide meaningful benefits to their clients.

IoE fosters new services in a variety of areas. Some services assess the functionality of current systems and identify components to digitize and connect in a prioritized fashion based on readily accepted measures. Other services map data sources and devices, their attributes, and interconnection points in a taxonomy of digital capabilities, which allows process owners to identify and fill functional gaps. Also prospecting services cross-correlate data sources and uncover nuggets of interrelatedness among device or thing attributes that spur positive process changes.

Finally, the transition to IoE brings sizeable security challenges due to the sheer number of new devices connecting to networks, the range of new system interconnects, and the slate of new protocols needed to connect and interconnect these devices to the network, with each other, and to other systems. Organizations benefiting from IoE must consider, devise, and execute plans for physical security of facilities, processing lines and devices, tamper-evident device construction, and strong data cryptography.

CHAPTER 12

A Service Industry Call to Action

We hope you will use the perspectives offered in this book to create and deliver services to your clients or even within your enterprise that enable new, beneficial insights, efficiencies, capabilities, and outcomes. Here is a final checklist noting key considerations for the success of IoE.

1. Identify and document the internal and external customers who are affected and must benefit from any change spurred by IoE.
2. Rank the economic, human, and societal impact of any proposed new addition or change triggered by moving to IoE.
3. Ascertain the level of un-*connectedness* in the department, the facility or geography where the IoE implementation is targeted.
4. Plan end-to-end connectivity paths for all newly connected devices, and note all other devices and applications that newly connected devices need to communicate with.
5. Analyze the security needs of the technical and business processes. Clearly define and evangelize the systems readiness to reliably orchestrate the intended processes—not just the technical process but also the business processes like billing remediation—while preventing malicious intrusion to maintain data confidentiality and integrity. This ensures that all stakeholders understand the systems' current security posture and agree to the actions required to securely deliver IoE-enabled system enhancements.
6. Determine how device status and telemetry will be secured, extracted, analyzed, and stored. In addition, determine the relevancy and scope of the status and telemetry data to other devices and orchestration layers.

7. Perform a cost or benefit analysis of every proposed technical and business IOE-inspired introduction and change using your client's meaningful metrics. Use this analysis to let your client prioritize and order her IoE transformation.
8. Detect, respect, and support existing organization structures and communication channels. IoE potentially introduces great change into an organization's normal operating procedures—both business and technical. Environmentally aware messaging within the organization is key. Delivering overall project summaries, issuing updates, and congratulations for jobs that are well done should follow and meet a client's expectations regarding message author, audience, content, and timeliness in order for IoE-triggered business and technical changes to have the best chance of acceptance and ongoing support.

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People, Processes, Services, and Things

Using Services Innovation to Enable the Internet of Everything

Hazim Dahir • Bil Dry • Carlos Pignataro

This book guides the reader through the technological advances, business needs, and societal shifts that drive the Internet of Everything (IoE). IoE offers many benefits to industries and organizations that embrace it, but there are real adoption and success barriers to address and overcome. In many cases, services are the solution because they drive IoE application and impact.

The business and technical services need to deliver IoE and realize the promised benefits. Discussions include assisting candidate IoE customers to assess and rank priority gaps in business process insight, strategies to connected *things*, and ways to wrangle and transform data streams of new *things* into actionable information. Knowledge of leading practices, organizational values, and sensitivities are keys to successful IoE transformations.

Hazim Dahir is a Cisco Distinguished Services Engineer. In his current role as the chief architect for the "Internet of Everything" Services Practice, he defines and influences next generation IoT/IoE architectures across multiple technologies and verticals through direct interaction with customers and partners in the manufacturing, oil & gas, retail and healthcare industries.

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Carlos Pignataro, Cisco Distinguished Services Engineer and NC State University Adjunct Professor, is a self-described technology change agent who has spent his career on the "bleeding edge." It all begins with innovation. Innovation, he believes, is not just central to change, it is change. A Services Patent Strategist and co-chair of the Services Patent Committee at Cisco, he has co-invented more than fifty patents (issued and pending), co-authored over thirty-five Internet Requests for Comments (RFCs) and two books, and is a sought-after speaker at networking conferences.

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