Making sense of IoT

How the Internet of Things became humanity's nervous system

By Kevin Ashton

Content

Preface: From Aruba, a Hewlett Packard Enterprise company

The Internet of Things (IoT) is generating increasing amounts of interest and is rapidly making its way into our personal and professional lives. However, there's still some confusion about what it can really achieve.

From a business perspective, here at Aruba, a Hewlett Packard Enterprise company, we wanted to find out which use cases, geographical regions and vertical industries are benefiting the most from a well-executed IoT strategy and which ones are lagging behind.

To help us understand this in more depth we conducted a study of over 3,000 executives worldwide and commissioned this book by technology pioneer Kevin Ashton. Often referred to as 'the father of IoT', it was Ashton who coined the term 'Internet of Things' back in 1999.

We hope that by reading this piece, business and technology leaders across the globe can better understand the benefits of IoT and make informed decisions on where and when to invest.

Chapter one:

What is the Internet of Things?

The Internet of Things is famous, but not everybody knows what it is. I created the term in 1999 at Procter & Gamble, and used it thereafter at the Massachusetts Institute of Technology, but it remained a phrase used only by specialists until 2010, when Google searches for the term rapidly increased. This fast ascent made 'the Internet of Things' a buzzword: something people say to sound impressive even if they don't know exactly what it means. Today, only 1 in 50 executives say they don't know what 'the Internet of Things' means, but many of the other 49 are unsure.

What is the Internet of Things? It is not connecting everyday objects like toasters and refrigerators to the Internet. Products like these exist, but it is hard to see why. Activating a toaster from the Internet has little value: you still have to walk over and put in the bread. The Internet of Things is something else entirely—something that will still be changing the world after every smart toaster has rusted.

What defines the Internet of Things is data capture. In the twentieth century, computers got their information from people, usually via keyboards. This was a big limitation: People can enter data about simple systems that don't change much but they cannot enter data about complex systems that change regularly. As the world is a complex system that changes regularly, human data entry greatly constrained early computers.

The solution was obvious but not simple: let computers sense the world by themselves. Sensing systems—including optical character recognition, barcodes, navigation satellites, and radio frequency identification tags—appeared in the late twentieth century, but were isolated and needed local data storage. For example, the first in-car navigation products used satellites as their only sensor and stored map data on cassette tapes. They were useful, but had no way of knowing about road closures or traffic, and their maps became outdated once new roads opened.

Computer sensing could not realize its full potential until the twenty-first century, when the Internet became ubiquitous. Why? Because sensors work best in networks. Consider the human nervous system: it's a network that connects sensors to the brain, which matches inputs to memories and interprets—or makes sense of—them. Your eyes cannot see a hot apple pie. They only see a pie. Your nose senses the apple. Your fingers sense the heat. It's the correlation of these inputs with memories of hot apple pies past that tells you what's in front of you. The things we think of as our senses—in the case of the nervous system, our eyes, ears, and so on—have limited value unless they are connected. Or, the network is the sensor.
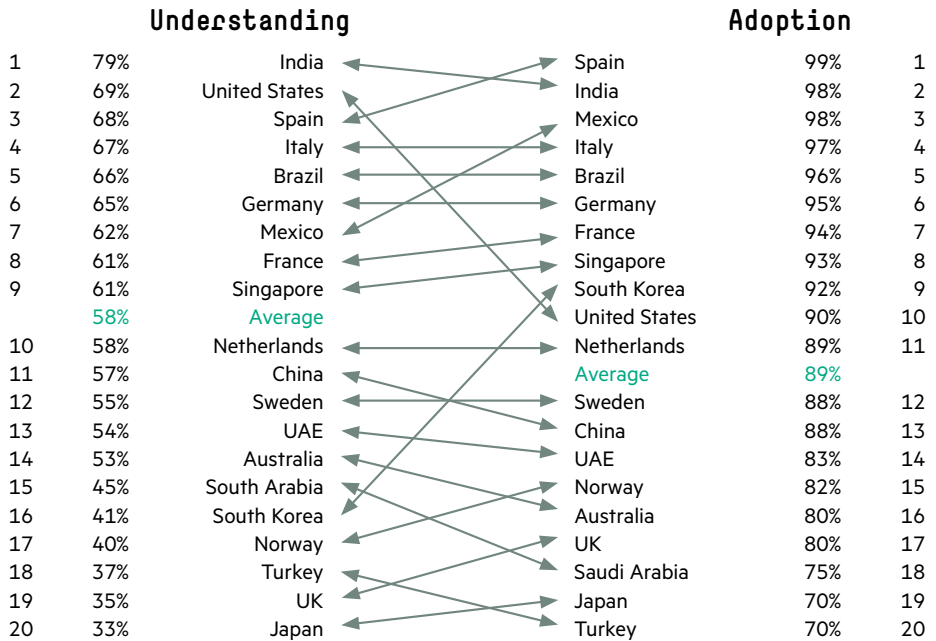
> This is the meaning of the Internet of Things: sensors connected to the Internet, behaving in an Internet-like way by making open, ad hoc connections, sharing data freely, and allowing unexpected applications, so computers can understand the world around them and become humanity's nervous system.

Chapter two:

What are the best Internet of Things use cases?

How many executives are aware of the transformational potential of the Internet of Things? More than half: worldwide, 58 percent of business decision-makers say their colleagues have a good or excellent understanding of the business value of the Internet of Things. This varies greatly by nation: India's executives lead the world in understanding the value of the Internet of Things—79 percent of Indian executives say their colleagues' understanding is good or excellent—while business leaders in Japan and the UK have the world's worst understanding of the value of the Internet of Things—only 33 percent and 35 percent of executives in those countries say their colleagues' comprehension is good or excellent.

In most cases, these levels of understanding correlate with levels of action. Worldwide, 57 percent of companies say they are using the Internet of Things now and another 32 percent say they plan to. India is the world's leading Internet of Things adopter—77 percent of executives say their business has already deployed Internet of Things technology and 21 percent more say their business plans to adopt it. The UK and Japan are among the laggards: just 37 percent of UK executives say their company has adopted the Internet of Things already (only Norway has a lower adoption rate, with 34 percent); 30 percent of Japanese executives either don't know if their companies plan to adopt the Internet of Things or say their companies have no adoption plans. There are a few countries where levels of understanding do not correspond to levels of action, however, and they are telling. South Korean managers rank themselves sixteenth in understanding the Internet of Things, but their companies are ninth in the world when it comes to adoption. In contrast, American executives claim the world's second best understanding of the Internet of Things, but this understanding has not been turned into action: America's Internet of Things adoption level is just above the global average, and below South Korea's.

	Understanding			Adoption		
1	79%	India		Spain	99%	1
2	69%	United States		India	98%	2
3	68%	Spain		Mexico	98%	3
4	67%	Italy		Italy	97%	4
5	66%	Brazil		Brazil	96%	5
6	65%	Germany		Germany	95%	6
7	62%	Mexico		France	94%	7
8	61%	France		Singapore	93%	8
9	61%	Singapore		South Korea	92%	9
	58%	Average		United States	90%	10
10	58%	Netherlands		Netherlands	89%	11
11	57%	China		Average	89%	
12	55%	Sweden		Sweden	88%	12
13	54%	UAE		China	88%	13
14	53%	Australia		UAE	83%	14
15	45%	South Arabia		Norway	82%	15
16	41%	South Korea		Australia	80%	16
17	40%	Norway		UK	80%	17
18	37%	Turkey		Saudi Arabia	75%	18
19	35%	UK		Japan	70%	19
20	33%	Japan		Turkey	70%	20

Understanding—% of managers who say their colleagues' understanding of the Internet of Things is good or excellent. Adoption—% of managers who say their companies either plan to adopt the Internet of Things, or have already done so.

The discrepancy is part of a general trend in the United States: most Americans believe their nation has the world's leading technology economy, but, according to the World Bank, this has not been true since 2004, when the impact of the Internet of Things first started to be felt and China's annual high-tech exports surpassed America's for the first time. Germany took second place a few years later, and today both South Korea and Singapore are challenging the United States for third. Nations that are slow to adopt the Internet of Things become less competitive in today's global high-tech economy.

The world's leading tech exporters changed places during the Internet of Things era
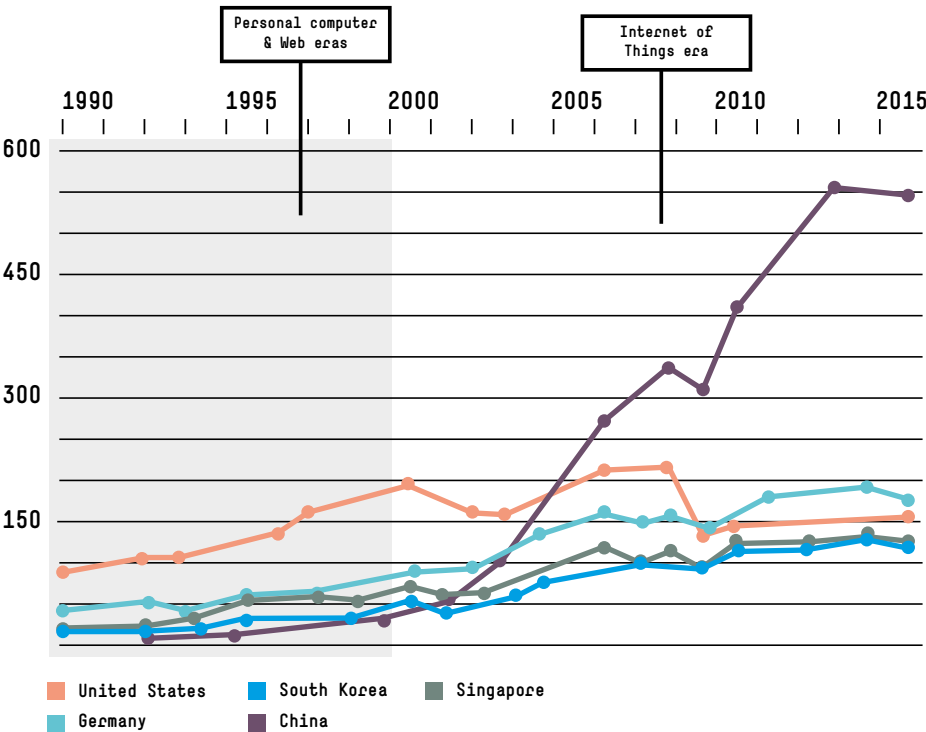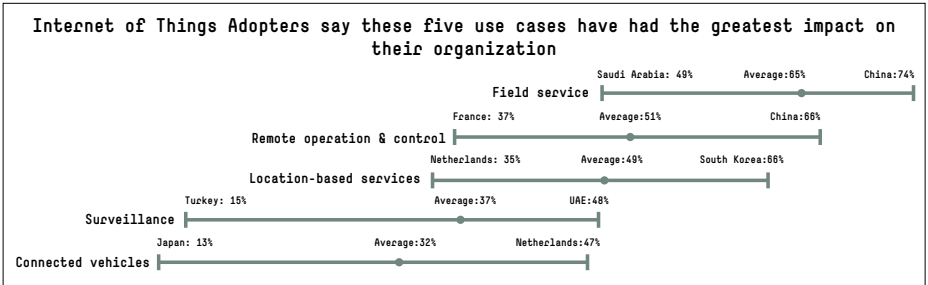

What are the organizations that are using the Internet of Things using it for? The most popular application is monitoring and maintaining critical equipment, also known as field service. Thirty-one percent of businesses that have already adopted the Internet of Things say field service applications have delivered the greatest business impact, and 65 percent of businesses put field service applications in their top three Internet of Things use cases.

Companies that use the Internet of Things for field service typically sell complex products that require regular maintenance—things like photocopiers, industrial heating and cooling systems, or manufacturing equipment—and make a significant portion of their revenue from after-sales service contracts. Each company's Internet of Things story is unique, but many follow a common pattern.

Initially, the company adds Internet of Things technologies to its products in order detect and report problems automatically using sensors and the Internet; this makes diagnosing problems more efficient, shortens customer call times, and means more problems can be solved remotely, reducing service costs and equipment downtime. These benefits increase customer satisfaction and make the service business more profitable, which leads to more sensors being added to the products, and more diagnostic software being developed and deployed. What was once an optional premium feature available in a few markets eventually becomes standard on all products, available in all markets, and integral to the company's strategy.

Next, the company reaches a tipping point: it has so much data, and so much experiencing of handling data, that it begins to see opportunities beyond fixing broken products. These opportunities include analyzing a machine's performance and identifying problems before they occur (an application known as "predictive maintenance"), or using data to help customers operate their equipment more efficiently, or analyzing data to improve existing products—sometimes via overnight software updates—and develop new ones. This is a typical pattern, and not just in field service. Most companies that succeed with the Internet of Things start by thinking of it as an optional feature but soon discover it is an essential strategy.

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Internet of Things Adopters say these five use cases have had the greatest impact on
                              their organization
                                    Saudi Arabia: 49%        Average:65%         China:74%
                     Field service  ├──────────────────────────●──────────────────────────┤
                                France: 37%            Average:51%          China:66%
      Remote operation & control    ├────────────────────────●───────────────────┤
                          Netherlands: 35%       Average:49%      South Korea:66%
         Location-based services    ├───────────────────●──────────────────┤
                    Turkey: 15%             Average:37%         UAE:48%
          Surveillance  ├────────────────────●──────────────┤
               Japan: 13%                Average:32%        Netherlands:47%
  Connected vehicles  ├────────────────●─────────────────┤
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Other widely used high-impact applications of the Internet of Things are remote operations: using Internet connected sensors to control processes from a distance; location-based services that help a business know exactly where its assets and people are; and connected vehicles or drones that can be remotely monitored or controlled. Twenty-two percent of executives say location services is their most valuable use case, 19 percent say remote operations, and 18 percent say connected vehicles.
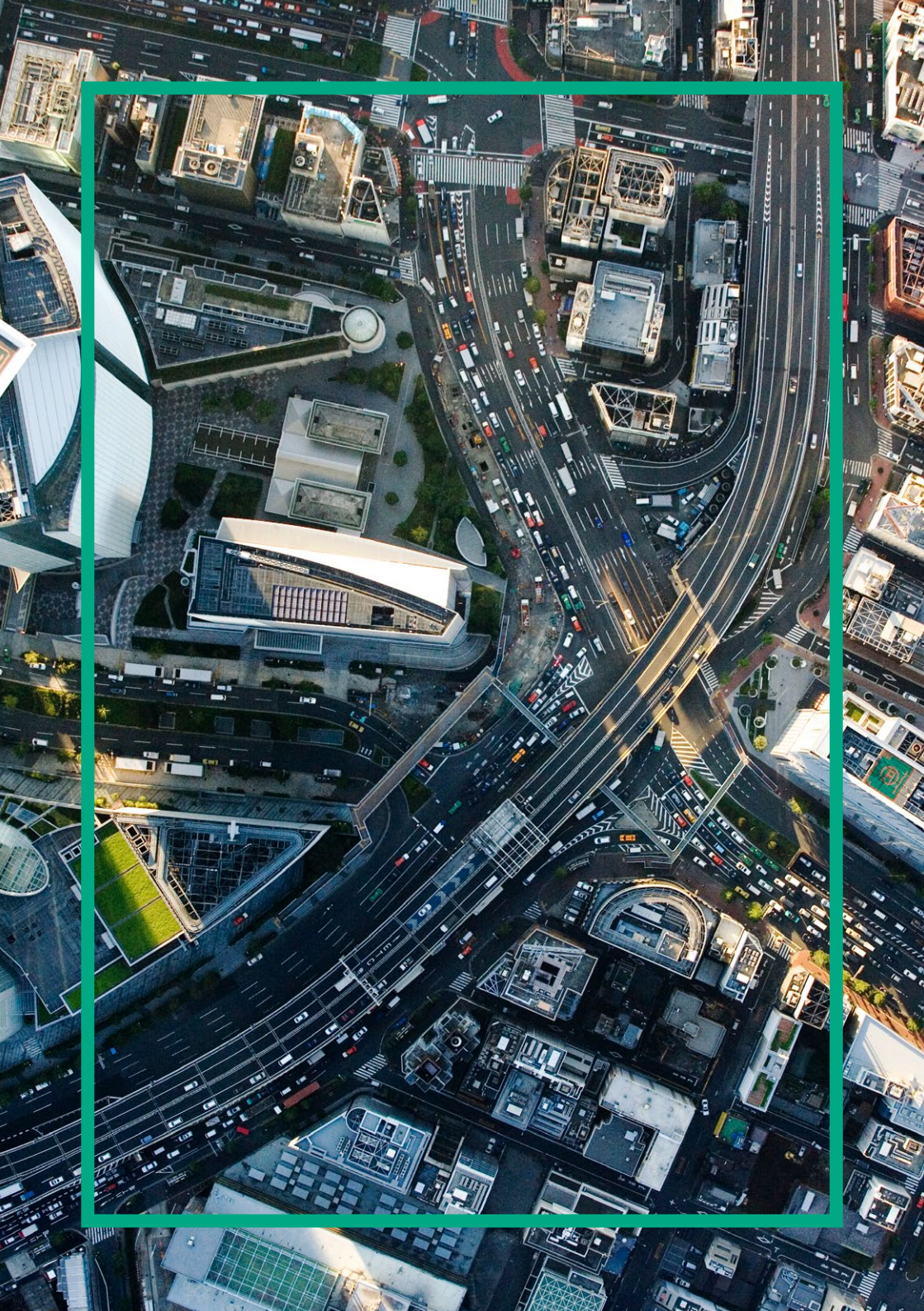
Chapter three:

Internet of Things case study— the smart city of Shanghai

Many Internet of Things deployments combine several use cases in a single vision. One of the best examples comes from local government. Mayors and municipalities all over the world have started using the Internet of Things to manage their urban infrastructure more efficiently, a concept known as 'smart cities'. Smart cities deployments are as rich and complex as cities themselves, applying the Internet of Things to everything from transportation and safety to energy and water. Sanjay Sarma, a Professor of Mechanical Engineering at MIT and co-founder of the Auto-ID Center, where the Internet of Things was first developed, describes Smart Cities like this:

"Cities today are rather dumb: a significant portion of traffic is just drivers 'cruising' while they look for parking, street lights are often on when they are not needed, water systems lose upwards of 50 percent of the total supply to leaks and the electric grid is incapable of truly responding to new technologies such as electric vehicles and solar panels. Smart parking meters, connected street lights, instrumented water supplies, and smart grids will reduce traffic, save energy, save water, and make the grid more friendly to renewables."

The root of the problem is scalability. In the past, 'dumb' cities were manageable because they contained few people, but the future is urban. In 1800 three percent of the world's population lived in cities. By 1900 that number had risen to 14 percent. In 2008 it exceeded 50 percent for the first time. The United Nations predicts that two-thirds of the world's population will be living in cities by 2050.

## An increasing proportion of the world's population lives in cities
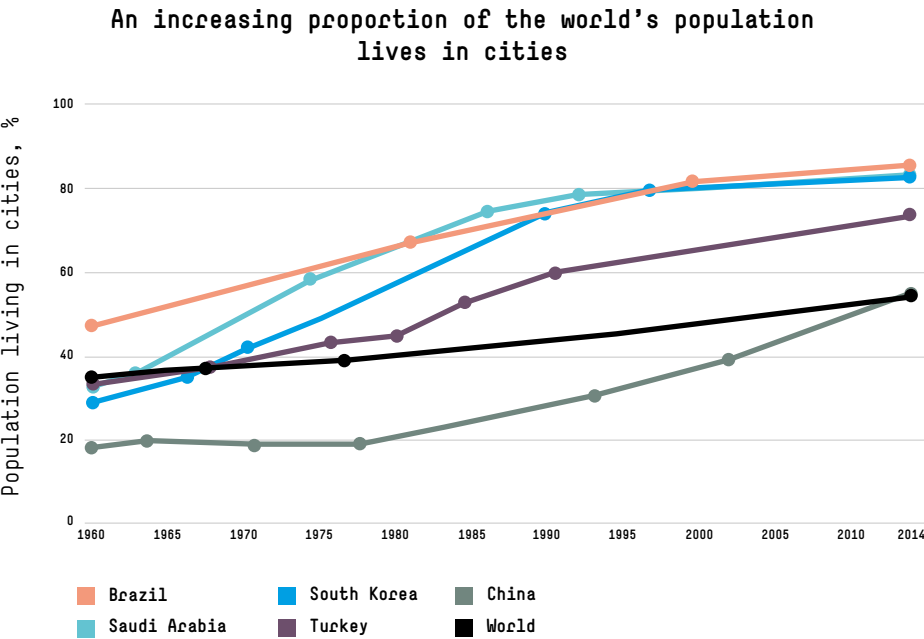
As a result of this trend, as well as increases in total world population and life expectancy, today's cities contain tens or in some cases hundreds of times more people than they did a century ago. The area of land cities occupy has not increased by the same amount, however, resulting in ever larger, ever denser urban populations facing problems including how to manage resources and waste, how to travel efficiently, how to stay safe, and how to maintain vital infrastructure like roads, bridges, and streetlights. The solution to these problems is better information, captured and delivered by the Internet of Things.

Today's largest cities are far bigger than they were in 1990

|	Population		
	1900	2015	Growth
Shanghai	1,000,000	24,256,800	2426%
Karachi	105,000	23,500,000	22381%
Beijing	2,400,000	21,516,000	897%
São Paulo	240,000	12,038,175	5016%
Dhaka	75,000	16,970,105	22627%
Delhi	690,000	16,787,941	2433%
Lagos	41,487	16,060,303	38712%
Istanbul	942,900	14,025,000	1487%
Tokyo	1,497,000	13,513,734	903%
Mumbai	812,912	12,478,447	1535%
Total	7,804,299	171,146,505	2193%

Shanghai, the world's most populous city, is a good example. It has twenty-four times more people than it did in 1900 but occupies only seven times more land. Shanghai started using the Internet of Things to both manage and sustain its growth in 1999, when the municipal government introduced the Shanghai Public Transportation Card, an electronic ticket based on radio-frequency identification technology, or RFID, for its mass transit system. The card can be used to pay for rides on buses, metro trains, ferries, and even in taxis; it can be reloaded with more money as necessary; and, because it is radio-based, it does not need to be swiped, inserted or inspected, which makes it easier for large numbers of people to pass quickly through turnstiles and other mass transit chokepoints. Managing increasing passenger volumes is essential for city transportation services, and smart tickets, which effectively sense whether a passenger is permitted to ride as they enter a station or vehicle, are the best way of doing it. London adopted a similar RFID-based system in 2003, called Oyster Card, which is operated by Hewlett Packard Enterprise. The number of passengers on the London Underground had been increasing rapidly since the 1980s, and Oyster Card enabled London's administrative body, the Greater London Authority, to reduce congestion at transit entrances and exits. Passenger journeys have increased by more than 40 percent since it was introduced.

Internet of Things-enabled smart tickets helped London underground manage 40% more journeys
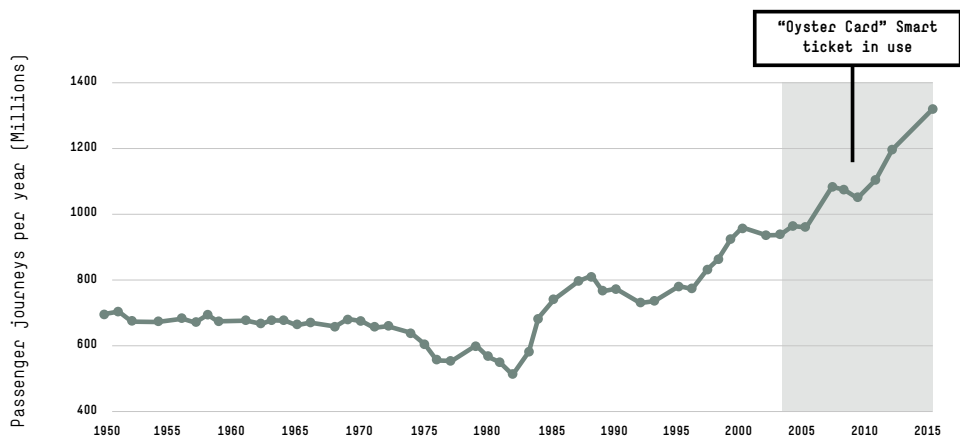
Smart cities like Shanghai are also using the Internet of Things to manage electricity. Generating enough electricity to keep up with an ever growing population is difficult, but that's not the only challenge—adding the power lines, substations, and other equipment needed to transmit electricity reliably from generator to consumer is also hard in a landscape that is already crowded with buildings.

Shanghai's electricity consumption tripled between 1990 and 2005
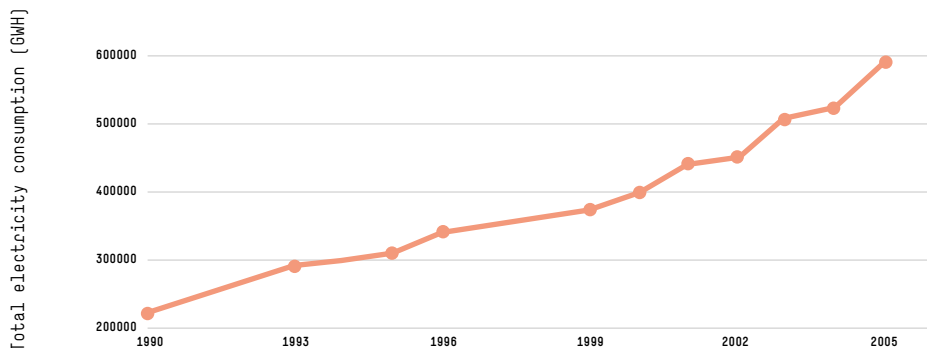
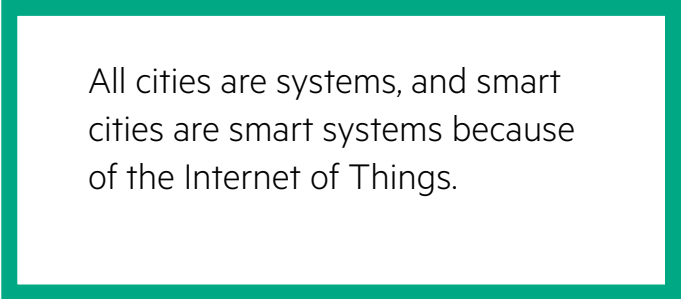After Shanghai's electricity tripled between 1990 and 2005, China's National Development and Reform Commission (NDRC) looked for innovative, Internet of Things-enabled methods to manage electricity in Shanghai and other Chinese cities. Rather than simply generate and transmit ever more energy, NDRC sought to reduce demand, especially at peak times, and especially among commercial and industrial energy users.

In 2015, Shanghai launched China's first pilot of 'demand response'—an energy management method that notifies commercial electricity users when energy demand is peaking, and rewards them if they temporarily reduce their consumption. For now, reduction activities are monitored using a relatively simple networked electric meter and often require manual intervention, such as shutting off heating and cooling systems via a building control panel, but in time, Shanghai and other Chinese cities plan to automate the process completely. The electricity generator will sense that the power grid is reaching peak demand, send a signal over the Internet, and commercial and industrial facilities will adjust their consumption instantly and automatically. Analysts at the University of Oxford, estimate the program could save up to $116 million a year in Shanghai alone by reducing the need to build and fuel power plants, emit carbon dioxide, and invest in new transmission lines.

The Shanghai Public Transportation Card and moves towards Automatic Demand Response are just two examples of Shanghai's smart city initiatives. Other smart city programs in Shanghai include electronic utility billing, smarter healthcare records, and ways to ensure the food supply stays safe. And Shanghai is one of many hundreds of smart cities emerging worldwide. Juniper Research named Singapore, London, Oslo, Barcelona, and San Francisco as five of the smartest cities. China aims to have more than 50 smart cities, in addition to Shanghai, and India is aiming to develop 109 smart cities under a program launched by its Prime Minister Narendra Modi in 2015.

Mark Roberti, the Editor of RFID Journal, has been writing about the Internet of Things since 2000. He summarizes the smart cities opportunity this way:

"There are many different smart cities applications, from monitoring recycling to informing bus riders where their bus is and when it will arrive, to providing information on where an open parking space is. I think the applications that make cities more sustainable are vitally important."

All cities are systems, and smart cities are smart systems because of the Internet of Things.
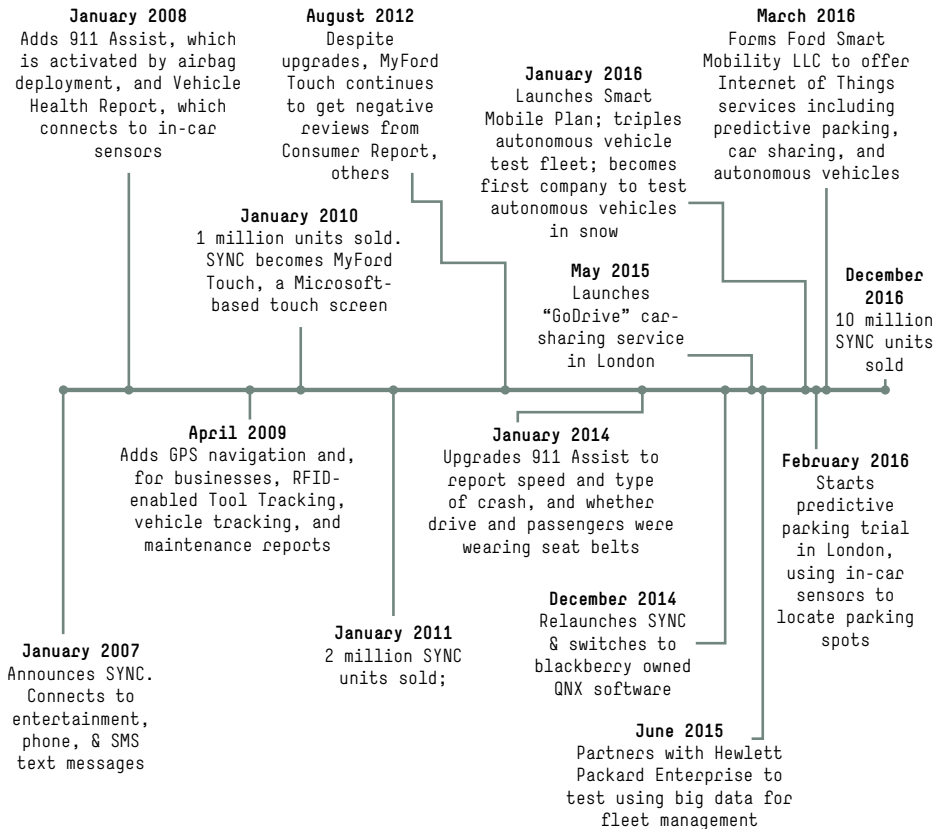
Chapter four:

Internet of Things case study— Ford's connected vehicles

It's not just governments that use the Internet of Things. In January 2007, Ford Motor Company announced SYNC, an in-car, voice-controlled system for operating in-car entertainment and cell phones, available as an optional extra costing $395. This was nothing new: similar technology was already available in Chryslers, Hondas, and other vehicles. The most distinctive thing about Ford's announcement may have been its partnership with Microsoft, which was not known
for in-car technology.
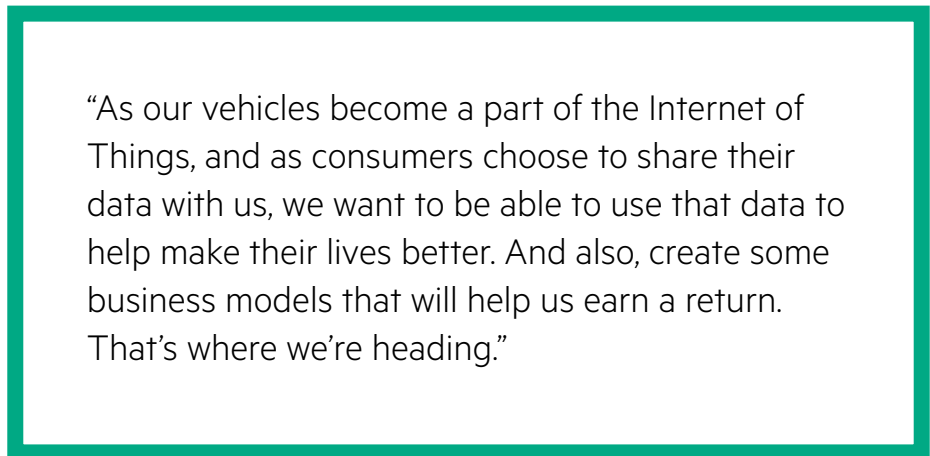
But, over time, Ford added new, sensor-enabled features. Soon, Ford cars could automatically contact emergency services if they deployed their airbags or shut off their fuel pumps because of a collision; they could automatically generate reports about their fluid levels and the condition of their brakes and engines; and they had GPS-based navigation services. Trucks for the construction industry were also equipped with radio frequency identification readers to track tools, and GPS-enabled fleet tracking. SYNC had become an Internet of Things platform. By 2011, it had sold more than a million units.

How Ford Motor Company transformed Internet of Things features into an Internet of Things strategy

January 2008
Adds 911 Assist, which is activated by airbag deployment, and Vehicle Health Report, which connects to in-car sensors

August 2012
Despite upgrades, MyFord Touch continues to get negative reviews from Consumer Report, others

January 2016
Launches Smart Mobile Plan; triples autonomous vehicle test fleet; becomes first company to test autonomous vehicles in snow

March 2016
Forms Ford Smart Mobility LLC to offer Internet of Things services including predictive parking, car sharing, and autonomous vehicles

January 2010
1 million units sold. SYNC becomes MyFord Touch, a Microsoft-based touch screen

May 2015
Launches "GoDrive" car-sharing service in London

December 2016
10 million SYNC units sold

April 2009
Adds GPS navigation and, for businesses, RFID-enabled Tool Tracking, vehicle tracking, and maintenance reports

January 2014
Upgrades 911 Assist to report speed and type of crash, and whether drive and passengers were wearing seat belts

February 2016
Starts predictive parking trial in London, using in-car sensors to locate parking spots

January 2007
Announces SYNC. Connects to entertainment, phone, & SMS text messages

January 2011
2 million SYNC units sold;

December 2014
Relaunches SYNC & switches to blackberry owned QNX software

June 2015
Partners with Hewlett Packard Enterprise to test using big data for fleet management

Then Ford lost its way. Perhaps distracted by the resurgence of Apple, smartphones, and tablets (the iPhone launched six months after SYNC, in June 2007, the iPad launched in April 2010, and in May 2010 Apple's valuation became bigger than Microsoft's), it repositioned SYNC as 'MyFord Touch', a Microsoft-based touchscreen that connected to smartphones and played music from Microsoft's Zune music service. MyFord Touch received scathing reviews. It crashed frequently, the touchscreen was hard to use and could distract drivers, and in many models, there were no buttons or dials. Consumer Reports refused to recommend cars that had the system, saying it "stinks," and Ford dropped from fifth to twenty-third in J.D. Power's quality ranking, almost entirely because of MyFord Touch. Ford tried to solve the problems with upgrades and patches that had to be transferred to a USB drive and installed either by the driver or a dealer, but these were only moderate improvements. To make matters worse, in 2012, about a year after MyFord Touch became available, Microsoft discontinued the Zune music service.

Making sense of the Internet of Things

But Ford responded by doing more than just issuing patches. Through 2013 it looked for a new software platform and planned a return to the Internet of Things features that had made SYNC successful. In 2014 it selected BlackBerry's QNX, a Unix-like system already used in millions of cars, and restored the SYNC brand while upgrading 911 Assist so that it would provide emergency responders with essential information about the speed and nature of a crash, how many impacts there were, and how many people were likely to have been in the vehicle. The following year, the ten millionth SYNC unit was sold, and with its touchscreen troubles behind it Ford started investing heavily in the Internet of Things. It expanded its autonomous vehicle fleet, developed tools to predict where drivers might find parking spaces, tested car-sharing services, and worked with Hewlett Packard Enterprise to use big data to improve corporate fleet management. Then, in March 2016, Ford formed an entirely new company, Ford Mobility Services LLC, to bring all these new products to market. Ford Mobility Services reports directly to Ford CEO Mark Fields, who is very clear about the new company's purpose:

> "As our vehicles become a part of the Internet of Things, and as consumers choose to share their data with us, we want to be able to use that data to help make their lives better. And also, create some business models that will help us earn a return. That's where we're heading."

Less than ten years after it was first announced, SYNC had helped make the Internet of Things the heart of Ford's strategy for the future.

Chapter five:

Internet of Things case study— Boston Children's Hospital and smarter healthcare

Healthcare is one of the richest areas of opportunity for the Internet of Things. Shwetak Patel, a MacArthur Fellow and a Professor of Computer Science and Engineering at the University Washington who specializes in developing Internet of Things technologies says, "the next wave of the Internet of Things is going to have a huge impact in healthcare. For example, health sensing in the home is critical for managing chronic diseases." One of the diseases Patel is targeting with the Internet of Things is chronic obstructive pulmonary disease, or COPD.

COPD, which was once called chronic bronchitis or emphysema, is a progressive lung condition that causes shortness of breath and coughing. Five percent of the world's population suffer from COPD and three million people die of it each year. In the United States, for example, COPD accounts for three-quarters of a million hospitalizations annually and is the third biggest cause of death. The disease is diagnosed and treated using devices called spirometers, which measure air flow in and out of the lungs. Spirometers cost thousands of dollars, are only available in hospitals and occasionally at doctor's offices, and many COPD sufferers do not have easy access to them. To solve this problem, Patel created an Internet of Things-based alternative to spirometers, using the most abundant networked sensors in the world: the microphones in telephones.

The rise of cellphones means there are now nearly nine billion phones in the world
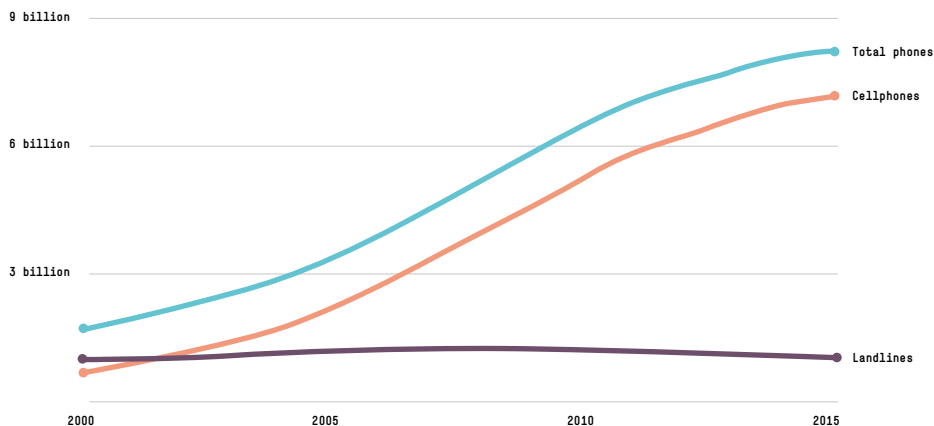
There were less than a billion phones in the world twenty years ago. Today there nearly nine billion phones, most of them cell phones. Patel's team developed an algorithm that measures lung health by analyzing the sound of someone blowing on a phone's microphone. This replicates a spirometer without the expense and hospital visit. All a COPD sufferer has to do is call a toll-free number and blow on their phone. Networked computers take care of the rest by performing complex calculations, then delivering the results a few seconds later via a voice or text message. The early versions of the algorithm only worked on expensive smart phones, but Patel and his team refined it over time until it could work on any phone. The approach now has 95% accuracy across all types of phones, including landlines. Diagnosing and treating COPD provides a glimpse of how the Internet of Things will improve healthcare in the future. But the Internet of Things is also improving healthcare now. For example, one of the biggest, least glamorous, problems in modern hospitals is figuring out how to get to where you are going, or 'wayfinding'.

Wayfinding is a big problem in hospitals. When people get lost in a hospital, it causes them stress and costs the hospital money. Outpatients and people visiting sick family members are both unfamiliar with the hospital and already under duress—a condition that makes it harder to process information. A study at Emory University Hospital, an acute care facility in Atlanta, found that wayfinding problems cost that hospital $400,000 per year—over $800 per bed—the equivalent of at least two full-time staff. Most of this expense comes from interruption and distraction when people ask staff for directions. This problem is especially bad at pediatric hospitals, where visitors are worried parents and the outpatients are children.

Visitors often ask pediatric hospital staff for directions

Destination	Requests for directions per week
Pediatric intensive care unit	223
Medical imaging	115
Outpatient clinics	107
Cardiology	83
School-age / Toddler units	70
Total	598

The costs and harm of wayfinding problems in hospitals have received a lot of attention in the medical community in recent decades, and as a result new hospitals are often designed to be easy to navigate. But few hospitals are new. In fact most are very old. In Boston, Massachusetts, for example, most hospitals have roots in the late eighteenth or early nineteenth century. Some have moved to new sites relatively recently, but others have not—instead they add new buildings to old buildings and grow incrementally with little thought to wayfinding. It is not possible to redesign these hospitals for easy navigation: they need another solution.

In 2017, Boston's major hospitals had an average age of 101 years

	Year built / Founded	Age
Beth Israel Deaconess Medical Center	1973	44
Boston Children's Hospital	1871	146
Boston Medical Center	1855	162
Brigham and Women's Hospital	1980	37
Carney Hospital	1853	164
Dana-Farber Cancer Institute	1947	70
Faulkner Hospital	1900	117
Joslin Diabetes Center	1952	65
Lemuel Shattuck Hospital	1974	43
Massachusetts Eye and Ear	1824	193
Massachusetts General Hospital	1811	206
New England Baptist Hospital	1893	124
Shriners Hospitals for Children	1999	18
Spaulding Rehabilitation Hospital	2013	4
St. Elizabeth's Medical Center	1868	149
Tufts Medical Center	1950	67
Average age		101

Making sense of the Internet of Things

Boston Children's Hospital has already created one, using the Internet of Things. The hospital was founded in 1869 and moved to its present location in 1871. Today it is widely regarded as one of the world's leading pediatric hospitals. It treats around 25,000 inpatients and 500,000 outpatients each year in more than 300,000 square feet of space spread over twelve buildings and five floors, which are accessed via five elevators.

In 2012, to make wayfinding simple in its complicated building, Boston Children's Hospital developed a free smartphone app called MyWay. MyWay uses GPS to sense where a visitor or patient is and guide them to their destination. The app can also show the quickest route to facilities like restrooms, parking, and information desks. It took the hospital only a few months to build the app using a platform called Meridian, made by Aruba. One of the most important features of the app is that hospital staff can update it instantly whenever things change in the hospital. If an elevator is out of order, or a corridor is closed because of construction, for example, MyWay can automatically select another route. In its first six months alone the app was downloaded 4,500 times, and 65% of patients said it improved their experience at the hospital. Five years later, the app has four-star ratings on both the Apple App Store and Google Play, and continues to reduce stress for patients and visitors and help hospital staff avoid interruptions.
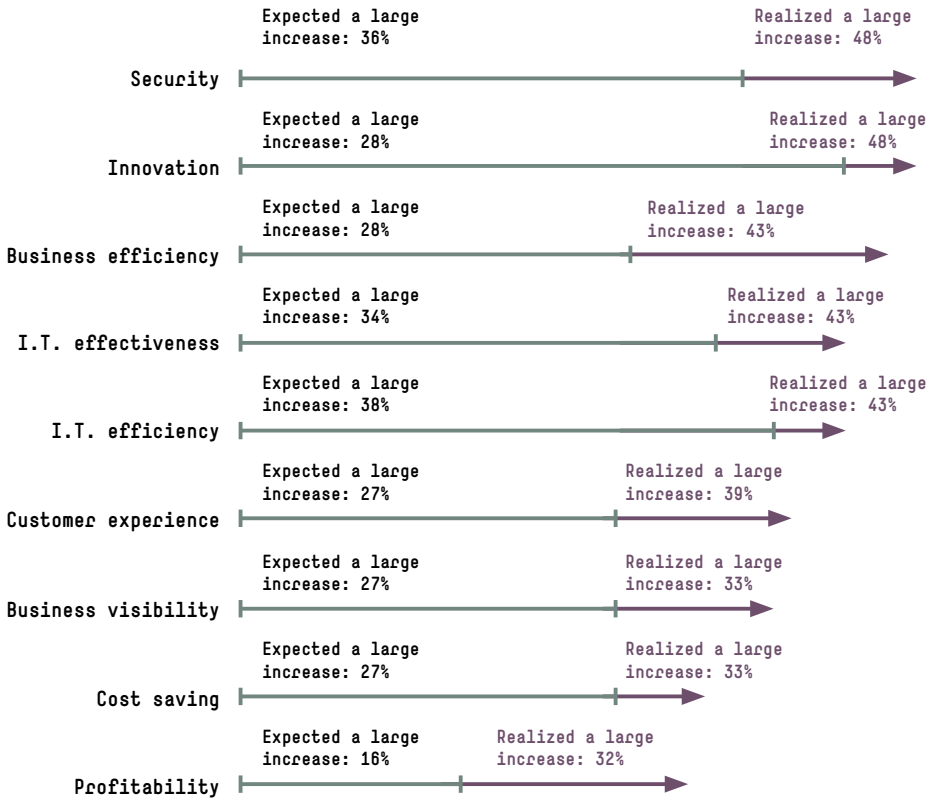
Chapter six:

How to get started with the Internet of Things

One of the most interesting things about Internet of Things deployments—especially when compared to many other high-hope corporate strategies—is that they tend to deliver far more value than expected. Ford Motor Company started its Internet of Things program so that drivers could place phone calls and control in-car entertainment systems more easily: it ended up with a whole new set of offerings, from predicting parking spaces to car sharing services. Boston Children's Hospital wanted to help visitors and outpatients to find their way around, then discovered it could dynamically redirect people away from broken elevators and construction zones.

This effect is not isolated to these two organizations. Around the world, there is a striking difference between the results businesses expect from the Internet of Things, and the results they actually get. For example, 27 percent of executives who are planning to adopt the Internet of Things expect it will lead to a large improvement in customer experience, but 39 percent of executives who have already adopted to the Internet of Things say it did deliver a large improvement in customer experience. Sixteen percent of executives planning to adopt the Internet of Things expect it to deliver a large increase in profitability, but 32 percent of executives who have already adopted the Internet of Things say it did deliver a large increase in profitability. This 'expectations dividend' seems to apply to all Internet of Things benefits, and suggests that most businesses that adopt the Internet of Things get more return on investment than they anticipate.

Internet of Things adopters get more value than they expect

Security
Expected a large increase: 36%
Realized a large increase: 48%

Innovation
Expected a large increase: 28%
Realized a large increase: 48%

Business efficiency
Expected a large increase: 28%
Realized a large increase: 43%

I.T. effectiveness
Expected a large increase: 34%
Realized a large increase: 43%

I.T. efficiency
Expected a large increase: 38%
Realized a large increase: 43%

Customer experience
Expected a large increase: 27%
Realized a large increase: 39%

Business visibility
Expected a large increase: 27%
Realized a large increase: 33%

Cost saving
Expected a large increase: 27%
Realized a large increase: 33%

Profitability
Expected a large increase: 16%
Realized a large increase: 32%

There are several reasons why, and they lead us back to what the Internet of Things is and why that matters. First, the Internet of Things is not only a new way to gather facts but also a way to gather new facts. Most data that is gathered automatically is data that has never been gathered before. When an organization adopts the Internet of Things, it gains knowledge where it was ignorant, moves from assumption to information, and understands new things. Second, Internet of Things technologies, like the Internet itself, tend to be open, flexible, and easy to build upon. When an initial Internet of Things deployment uncovers new opportunities, it is relatively easy to expand the system to take advantage of them. There's no need to say "I wish we had thought of that when we designed this thing." If you want to turn your great Internet of Things navigation system into a tool for helping business customers manage their fleets more efficiently, or for predicting where to find parking spots, or for launching a new car sharing service, you probably can. Internet of Things deployments seldom end: most users keep thinking up new ways to get value out of them.

The return on investment from an Internet of Things deployment depends on many things, but the most important is whether the organization has an Internet of Things strategy or is investing piecemeal. Businesses that adopt the Internet of Things opportunistically and tactically see good returns: their average return on investment is 30 percent. But businesses that adopt the Internet of Things strategically do much better: their average return on investment is 38 percent.

The average return on a strategic Internet of Things investment is 38%

Approximate return on investment	Tactical adopters	Strategic adopters	Difference
Greater than 80%	0%	1%	+1%
60-80%	4%	15%	+11%
40-60%	14%	19%	+5%
30-40%	49%	46%	-3%
Less than 20%	8%	4%	-4%
No return on investment	11%	8%	-3%
Return on investment not quantifiable	11%	4%	-7%
Don't know	3%	2%	-1%
Average	30%	38%	+8%

What does a good Internet of Things strategy include? One of the most important things is a robust plan for keeping your system secure. Eighty-four percent of Internet of Things adopters say they have experienced at least one Internet of Things security breach, with malware, spyware, and human error being the most common problems. Ninety-three percent of executives expect Internet of Things security breaches to occur in the future.

84% of Internet of Things adopters have experienced a security breach

Have had one or more Internet of Things-related security breaches	84%

Malware	49%
Spyware	38%
Human Error	38%
Phishing	30%
Distributed denial of service attack	26%
Physical theft	25%
Skimming	18%
Ransomware	14%
Spear phishing	12%

No Internet of Things-related security breaches	13%

Don't know	2%

93% of executives expect Internet of Things security breaches in the future

There is a high threat of Internet of Things breaches in the future		93%
Malware	56%	
Spyware	50%	
Distributed denial of service attack	38%	
Human Error	38%	
Phishing	36%	
Physical theft	27%	
Ransomware	25%	
Skimming	23%	
Spear phishing	17%	
No Internet of Things-related security breaches		4%
Don't know		3%

Matt Reynolds, an Associate Professor at the University of Washington who has specialized in the Internet of Things since the 1990s, says:

"The world-changing promise of Internet of Things technology cannot be realized without a focus on security as the bedrock. The whole point of the Internet of Things is that a combination of human and automated systems will make decisions about the allocation of time and resources based on inputs from sensors and systems distributed throughout our environment and our lives. If those sensor inputs are not trustworthy, human and automated systems will either disregard Internet of Things sensors and systems, or worse, the human and automated systems will make bad decisions. In extreme cases, such bad decisions could cause financial losses or even injury to people and our environment."

Making sense of the Internet of Things

Perhaps security in the Internet of Things world is not just about data. Malicious attacks on the Internet of Things can cause direct physical harm. For example, while Ford Motor Company was worrying about its Microsoft-powered touchscreens crashing, its competitor, General Motors, which had implemented a similar Internet of Things-based in-car system called OnStar, faced a much more serious problem: its cars crashing. In 2010, a PhD Student named Karl Koscher showed the IEEE Symposium on Security and Privacy in Oakland, California how he had been able to hack GM's OnStar system to make a GM Chevrolet Impala spin. The Impala later appeared on the TV Show 60 Minutes, where it was driven by journalist Lesley Stahl. Koscher's software remotely disabled the brakes while Stahl yelled "No! No! Oh my God! I can't operate the brakes at all." In another case, researchers hacked wirelessly controlled lightbulbs and were able to turn them off, make them burst, and flicker fast enough to cause seizures.

The lesson is simple: when developing an Internet of Things strategy, security of the things is even more important than security of the data. This is a new way of thinking for most information technology departments. The best and simplest way to address this is to select a technology partner with a track record of Internet of Things security, not just data security, and then to hire separate, completely independent Internet of Things hackers and give them incentives to find your system's vulnerabilities.

Beyond security, another essential aspect of developing an Internet of Things strategy is understanding and learning from the experience of others. Insights from companies like Ford, cities like Shanghai, and organizations like Boston Children's Hospital can guide you as you plan your next step in the Internet of Things age. They show that it is important to start small and be able to fail as you find your way, for example. Shanghai's Internet of Things-enabled infrastructure may seem like an overnight success, but it took eighteen years for the city to get from its first deployment of RFID-enabled mass transit tickets to where it is today. Ford's corporate strategy now depends on connected vehicles, but it took ten years for the company to get there, starting with three vehicles that had voice controlled audio systems and could read text messages aloud. Partners are important too. Boston Children's Hospital was able to launch its wayfinding application within months because it chose Aruba Meridian. London's Internet of Things-enabled Oyster Cards are a success partly because Transport for London partnered with Hewlett Packard Enterprise. Last, if you want to succeed in the Internet of Things, you have to be loyal to your vision. Investors, analysts, board members, and colleagues who doubt the value of your Internet of Things strategy will take every opportunity to complain about it, especially during the many inevitable disappointments and delays. Ford Motor Company's management stuck with its program through software crashes and bad reviews rather than quitting—and became stronger because of it. David Sargent, vice president of global vehicle research at J.D. Power, who was one of Ford's biggest critics during its difficulties, said, "Ford took the, let's say, brave decision to be a leader." Sargent meant 'brave' as a euphemism for 'bad'. But Ford was brave. Courageous and persistent innovation is essential to every organization's survival. All paths to discovery are rough. Smooth roads only go to old places.

That last lesson applies to the Internet of Things as a whole. Since its inception in 1999, the Internet of Things has been ridiculed, criticized, and misunderstood. I have heard it called vaporware, a fad, a violation of the laws of physics, and a solution in search of a problem. And yet here we are, less than two decades later, in a world where tens of thousands of organizations are saving and making hundreds of millions of dollars from the Internet of Things, using cars that drive themselves, subway stations that sense passengers, algorithms that diagnose deadly diseases using phones, and many other once apparently impossible technologies. The future promises far more amazing things. The most important decision you can make now is how to be a part of it.
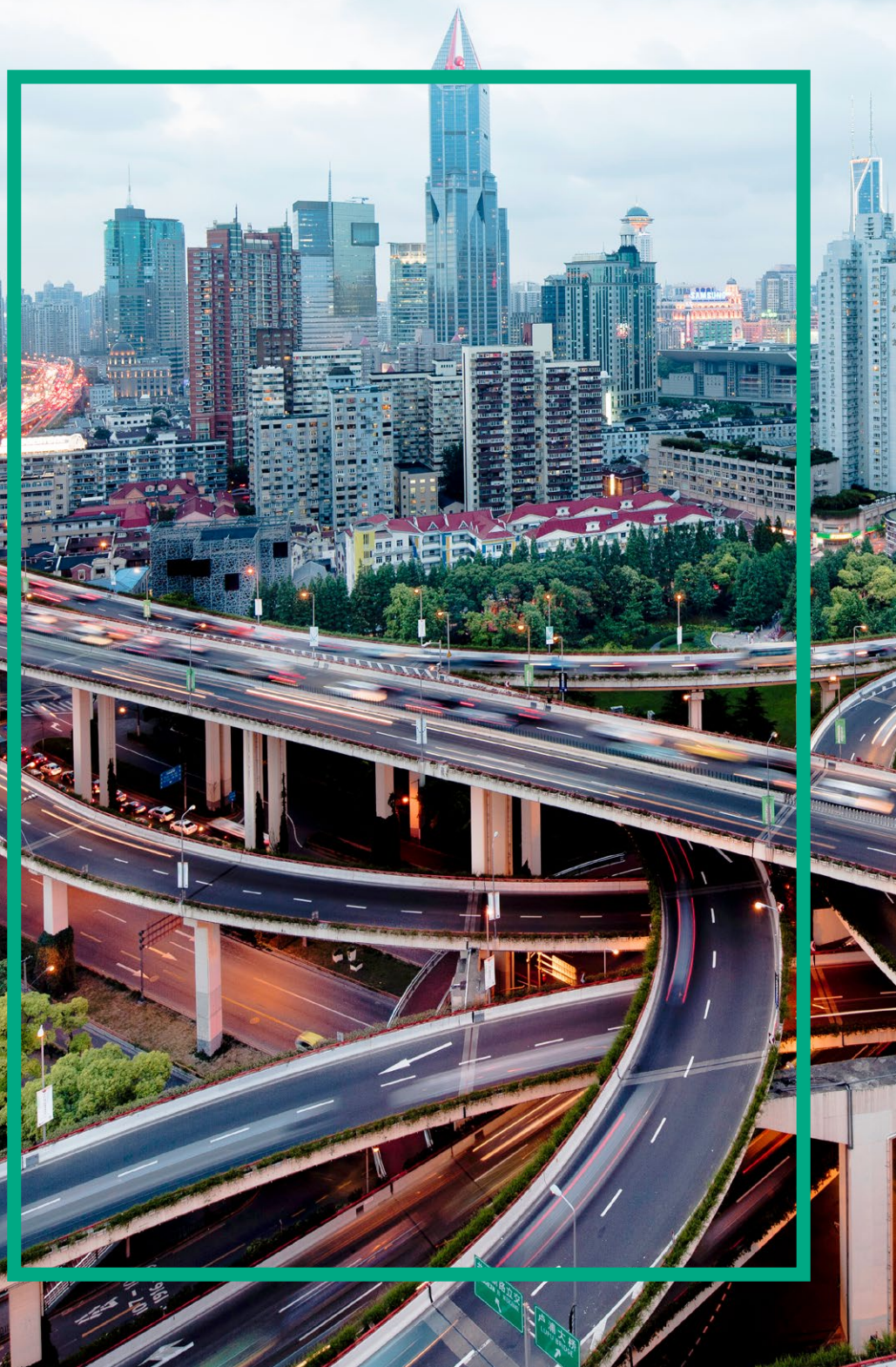
Footnotes

This book features original research commissioned by Aruba, A Hewlett Packard Enterprise company. A total of 3,100 IT and business decision makers were interviewed in November and December 2016. The respondents were from organizations with at least 500 employees, and were from both public and private sectors, but with a focus on the industrial, government, retail, healthcare, education, construction, finance, and IT/technology/telecommunications sectors. Interviews were conducted both online and via telephone using a rigorous multi-level screening process to ensure that only suitable candidates were given the opportunity to participate. Respondents were interviewed in the UK, Italy, Germany, France, the Netherlands, Spain, Sweden, Norway, Turkey, UAE, Saudi Arabia, the US, Singapore, Japan, Australia, India, Brazil, Mexico, China and South Korea.

Kevin Ashton coined the term "the Internet of Things" in 1999 and is the author of "How to Fly a Horse—the Secret History of Creation, Invention, and Discovery," which was named 2015's Business Book of the Year by 800-CEO-READS. He was also the co-founder and former Executive Director of the Massachusetts Institute of Technology Auto-ID Center; the co-founder and CEO of Zensi, which developed Internet of Things technology to reduce energy and water consumption; and the creator of the Wemo home automation platform.

Photo by: The Hayes Brothers