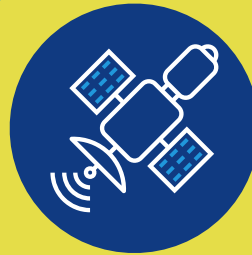
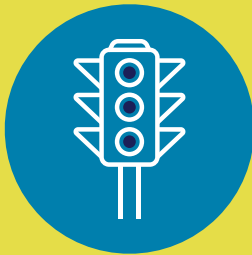
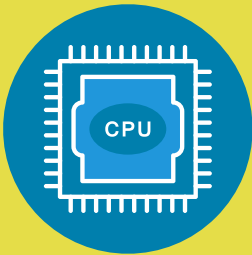
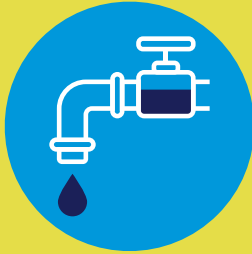


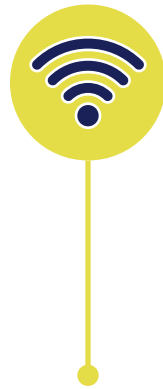
Sensor Sensibility

Getting the Most From
the Internet of Things



Contents

- 3 Emerging Internet of Things Opportunities Are Now Unfolding Almost Every Day
- 4 Continuously Improving IoT Security
- 6 Enormous Gains Can Be Achieved in All Sectors of the Economy, Enabling Massive Societal Opportunity
- 9 Key Technological Advances Are Converging to Enable This Future
- 13 Key Challenges to Achieving IoT's Full Potential
- 17 Endnotes



Despite enormous advances, we've only seen a fraction of what the Internet revolution has yet to deliver. That's because many powerful technological forces are now converging — poised to magnify, multiply, and exponentially increase the opportunities that software and the Internet can deliver by connecting the "things" in the physical world around us. Although the phrase "Internet of Things" (IoT) has been used for years, we are still only scratching the surface of what IoT may become. Just as Alexander Graham Bell could have hardly imagined how the telephone would develop into the smartphones of today, we know that IoT will continue to transform our world in yet unimagined ways.

With computers becoming more powerful, connectivity more ubiquitous, low cost sensors more capable, cloud analytics more transformative, and devices more programmable, the nation is on the verge of another wave of technological advancement fueled by a vast sea of connected devices.

By simply connecting the "things" around us that have never been connected before, intelligence can be embedded into the world around us. These devices — when connected to the Internet and coupled with cloud-enabled data analytics — have the potential to revolutionize our personal lives, our work lives, and how fast we can grow our economies.

We've all seen how powerful the Internet has been — creating as much economic growth in the last 15 years as the industrial age did in 50 years.¹ But as we connect the Internet to the physical world, the opportunities will be even more pervasive, the technologies more transformative, and the effects

more profound. That is why some now compare the effect of the IoT revolution to that of the industrial revolution itself.²

Today it's estimated that only about 1 percent of the things that can be connected, have been connected;³ soon, everything that can be carefully and deliberately connected will be connected. By 2020, as many as 50 billion devices will be connected⁴ — our watches, our TVs, our homes, our cars, and countless other physical things will become connected, and sentient.

Just as we benefit as individuals by being part of a community, our devices can be more effective when they become a securely connected community, too. By connecting devices in the physical world to the Internet, there is a network effect that happens when systems become exponentially more valuable as more things are connected to it — data from one sensor can be combined with data from another and linked with cloud intelligence to exponentially increase how smart

To enable this community of connected devices, innovators are taking everyday things and making them infinitely better by adding computing power and software, and connecting them to the Internet.

the system can become and how valuable it can be.⁵ For example when used in combination, a connected car can let your house know when you depart, enabling your thermostat to learn your patterns, your lights to save energy, and your doors to lock when you leave so your home can greet you when you return.

To enable this community of connected devices, innovators are taking everyday things and making them infinitely better by adding computing power and software, and connecting them to the Internet. They are discovering ways to improve our health with connected sensors, improve our safety with connected cars, cut our energy use with smarter buildings, and simplify our lives by giving us more control over the world around us. Computing intelligence is being infused deeper into the very systems and processes that make the world work — into things no one would recognize as connected computers: power meters,

trucks, containers, cars, pipelines, home appliances, wristbands, thermostats, and almost any electronic device can benefit from two-way communications. Doing so helps enable smarter ways to grow our economy, protect our environment, improve our public safety, and raise our standards of living.

Various studies now show that when these connected devices are comprehensively deployed in myriad ways throughout sectors of the economy, they could help dramatically reduce health costs, decrease crime, unclog traffic jams, minimize energy expenditures, lower carbon emissions, cut traffic fatalities, and improve quality of life. And that's just the beginning. With enormous new opportunities on the horizon, how quickly we reap societal benefits and how broadly their effects can spread will be shaped by key decisions made by business leaders and policymakers alike.

Emerging Internet of Things Opportunities Are Now Unfolding Almost Every Day

It all began in 1990 when someone connected a toaster to the Internet to control it remotely.⁶ The next year, scientists connected a coffee pot so they could check it remotely to see if it was empty.⁷ Since then, innovators have been working — in garages and labs everywhere — to figure out how to connect everyday things to the Internet to transform them into a community of devices.

Today, it is no longer just about connecting devices to the Internet, it's about connecting us to untold new opportunities. Connected devices can mean having unprecedented knowledge and control of our homes in the palms of our hands — from anywhere in the world.⁸ They are helping us improve our fitness, and become better athletes with watches and bands that put a personal trainer on our wrists to help us keep track of the moments when our hearts race, our feet run, and our friends compete. As our society grows older, these devices are also helping a growing population of elderly Americans lead more independent and fulfilling lives by connecting them with doctors, family, and help in an emergency.⁹ While we are on the road, connected devices enable our cars to find a faster route when traffic gets bad, or can call for help after a crash to speed life-saving help to the scene.¹⁰

These connected devices take many forms. Some devices can be life-changers, like those that enable an automatic notification to your doctor if your chronic conditions change.¹¹ They can be simple single-purpose things that can help find your lost keys when they are misplaced,¹² alert you when your pipes are about to freeze, or notify you when water floods into your basement.¹³ Or they can be many things that are integrated to work together, like connected sensors that enable alarms to be set, lights to be turned off, and doors to be locked automatically when it senses you leaving for work. But we are still just at the beginning of what can be achieved.

In 2010, for the first time the number of things connected to the Internet surpassed the number of people. Today, the average North American Internet user already has more than 10 connected devices. By 2022 the typical family home could have as many as 500 connected devices — everything from TVs to alarm clocks, thermostats to lights — and yes, even everyday toasters and coffee pots.



Continuously Improving IoT Security

Robust security is becoming an increasingly important enabler for instilling the trust that makes many of the most important IoT benefits possible. Recently, several high-profile security incidents have underscored the importance of ensuring good security hygiene for all connected devices.

For example, in Fall 2016, numerous low-cost, poorly secured connected devices were infected with malware to create a distributed denial-of-service (DDoS) attack. The attack temporarily prevented people from reaching some of the biggest websites on the Internet.¹⁴ DDoS attacks aren't anything new or terribly sophisticated. What is new is the recognition that DDoS attacks can now be caused by infected connected devices and not just infected computers. In this case, the attack involved numerous web cameras and connected DVRs, many of them containing the same flawed, low-cost circuit boards made by a single Chinese company.

Security Best Practices

Although the manufacturer has since recalled the defective devices, the event has become a teachable moment for highlighting that device security is just as important as computer security. Even more, IoT security is not just about protecting the device or even the owner's network from penetration. The attack demonstrates that unprotected devices can be captured and mobilized as a botnet to injure third parties. Device security is needed to protect against injuries to others, including the possibility of liability being imposed on the device owner.

This event also underscores the importance of following known security best practices that tell manufacturers not to hardcode a default password into a device's firmware, and let device users know they should always change any factory default passwords and usernames when installing a device.¹⁵ This is just one of many known best practices that developers, users, and governments alike can follow to ensure robust IoT security.

IoT Security Is a Shared Responsibility

Because some connected devices will perform critical tasks in our physical world, many people now want to know how we can enable a trusted device ecosystem that is appropriate to each risk profile. To enable a trusted device world, the private sector, technology users, and governments alike all have a shared responsibility for adopting best practices, enabling risk-appropriate security measures, and establishing the same level of trustworthiness for a connected device, as for a computer.

Developers' Role

Companies can make devices secure by design. Every new IOT start up should begin by thinking about security from day one. Developers can employ a secure systems engineering approach when they architect new IoT systems, and apply technologies that are commensurate with the device's potential risk profile. They can also ensure device software is updatable, and prevent the use of hardcoded default passwords. Many developers are also implementing a layered security model that takes advantage of technologies capable of defending IoT assets at the network layer, the application layer, in the cloud, in the device itself, and at the human interface layer.

Users' Role

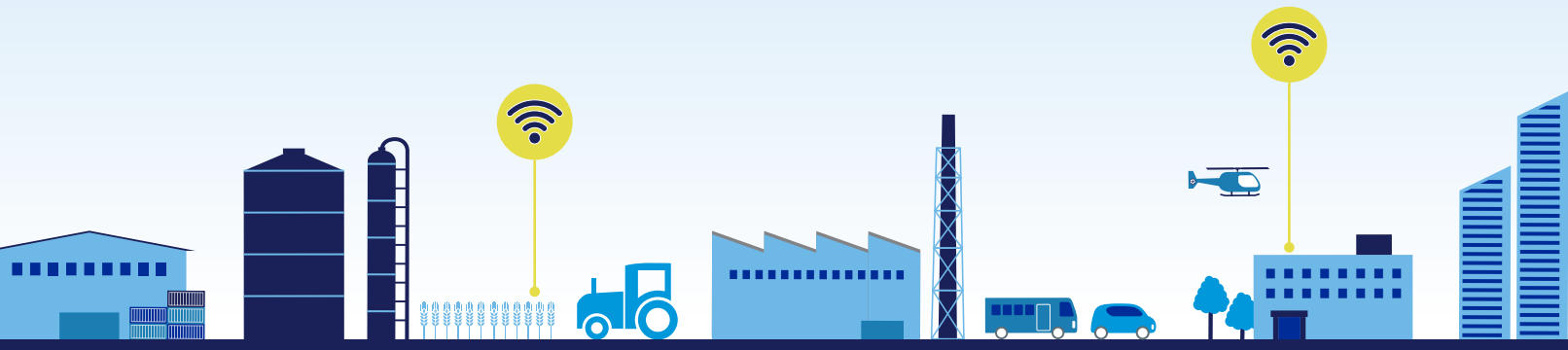
Users can become informed and engaged. In the same way that computer users now understand the importance of basic computer hygiene like keeping software patched, using up-to-date anti-virus software, and refraining from clicking on unknown attachments, device users similarly need to take proactive steps to ensure good device security. These include changing a device's default username and password when it is installed, ensuring that the software embedded in the device (called firmware) is kept up-to-date, and securing authentication keys and the networks they run on. Companies deploying IoT devices in a commercial setting should also develop a rigorous and in-depth security strategy that includes a risk-management framework and takes advantage of National Institute of Standards and Technology's (NIST) cybersecurity framework — as they should for their traditional IT infrastructure.

Government's Role

Policymakers can boost security breakthroughs and the agility to address evolving threats. Policymakers have an important role in continuing to advance good device security by:

- 1) investing in the long-term R&D that can keep us one step ahead of bad actors,¹⁶
- 2) ensuring that companies have the flexibility to develop new security technologies that meet changing threats without constraining or potentially duplicating technology mandates, and
- 3) partnering with industry to combat malicious cyber threats through information-sharing and coordinated action.

Government leaders, like those at NIST, also play an important role in highlighting the global industry developed security best practices that can be used in developing a risk-management framework.



Enormous Gains Can Be Achieved in All Sectors of the Economy, Enabling Massive Societal Opportunity

Although the potential of connected devices to transform our daily lives can already be seen all around us, they also have the potential to drive transformative benefits throughout broad sectors of the economy in ways both big and small. Rather than just connecting for connectivity's sake, many businesses see connected devices as a strategic opportunity. In one survey, 58 percent of businesses see the Internet of Things as strategic to their business, and another 24 percent see it as transformational.¹⁷ For those in industrial settings, connected industrial machines laden with sensors, for example, can cut workplace downtime by providing continuous feedback on machine performance, so upkeep can be scheduled before there's an actual breakdown. Because of the opportunities they see, organizations in every sector are quickly incorporating connected devices into their business models and future strategies. For example:

➔ **Improving health outcomes.** As our populations ages and health care costs rise, innovators are looking to take advantage of connected devices to help Americans live longer, healthier, more fulfilling lives. At a time when the US already spends 18 percent of its GDP on health care each year, connected devices could reduce health care costs by more than \$300 billion by increasing access to diagnostic treatments, preventative care, and chronic disease management.¹⁸ In

fact, McKinsey now estimates that Internet of Things devices could help cut the costs of chronic disease treatment by as much as 50 percent.¹⁹ For example, platforms like IBM's Watson can now curate data from wearable devices to provide specific data-backed insights on ways consumers can improve their health and fitness.

Many consumers already see the direct health benefits of wearing these connected devices. In one study, 80 percent of consumers listed eating healthier, exercising smarter, and accessing more convenient medical care as important benefits of wearable technology.²⁰ Because wearable devices can transmit a wide range of health data, such as temperature, glucose levels, and heart rate, automatically in real time, the data can also be used to enable doctors to better monitor patients and provide better care.

➔ **Reducing energy consumption and improving the environment.** Connected devices don't just help people save more on their energy bills, they can help people who want to save the planet, too. Already, connected thermostats are helping us cut our home heating and cooling costs by as much as 20 percent simply by letting our homes to turn down the thermostats when we are away.²¹ We are likely to see outlets that automatically power down when our phones are fully charged,



lights that shut off when we leave, and appliances that go to sleep when we head out the door. An American Lighting Association study states that lighting alone consumes about 12–15 percent of home energy bills, and 50 percent of lighting is wasted on empty rooms — a problem that connected devices in a home automation system can quickly fix. Add up all these energy savings, and the coming sea of connected devices could help to radically reduce greenhouse gas emissions by as much as 19 percent.²²

➔ **Cultivating farm growth.** At a time when the amount of farmland is shrinking but the number of mouths to feed is growing,²³ connected devices are helping farmers produce more food with fewer resources. Sensors allow farmers to track crop yields, soil nutrition, and rainfall with unheard of precision — increasing overall productivity per acre by 15 percent.²⁴ Farmers have found that they can take advantage of various connected devices and agricultural equipment to make better decisions about what to grow, how to grow it, and how to track food freshness from their farm to our forks.

➔ **Enabling smarter cities.** Connected devices are also providing our communities with smarter options for addressing some of our most pressing needs through smart city initiatives. Cities can now connect devices to improve traffic flow, cut crime, deliver city services better, boost local economies, and improve quality of life for their residents. Whether it's smart parking systems that help drivers find and pay for available parking using their smart phone to reduce traffic congestion, pollution, and parking violations, or even connected garbage cans that alert trucks when they need to be picked up to cut city costs by 40 percent, cities are often on the front lines of the connected revolution.²⁵

➔ **Driving transportation gains that save money and save lives.** At a time when we all want to save time, save fuel, and save lives while on the road, transportation leaders are often turning to connected devices to reduce the hours we spend in congestion every year,²⁶ connect cars in ways that save as many lives as the introduction of seat belts,²⁷ enable truck fleets to perform real time engine diagnostics, and identify unsafe driving habits before they become a problem.²⁸

Economically, these things could be a blockbuster. The Internet of Things' greatest untapped potential lies not only in its ability to connect people with new opportunities in every sector, but in its ability to fundamentally transform our economic opportunities for tomorrow. According to McKinsey, if policymakers and businesses get it right, linking the physical and digital worlds through the Internet of Things could generate up to \$11.1 trillion a year in economic value by 2025.²⁹





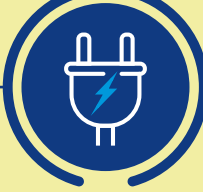


The Internet of Things opens up opportunities to help solve some of our greatest policy challenges.

For policymakers, intelligent devices open up huge opportunities to help solve some of our most pressing policy challenges: smart sensors that can help us cut CO₂ emissions by 20 percent, smart cities that can improve quality of life, connected cars that can dramatically reduce traffic fatalities, and a connected world that can help create thousands more jobs. That's why the Internet of Things is poised to help lift our economy and enable solutions that we just couldn't even consider any other way.

SOCIETAL OPPORTUNITIES BY THE NUMBERS

Capturing value from connecting things

According to various analyses, if widely deployed, connected devices can help advance numerous broad policy goals.

Societal Challenge	IoT Opportunity if Widely Deployed
35,000 lives — the number of Americans who die in traffic accidents each year. ³⁰	 90 percent reduction in traffic fatalities ³¹ — a greater reduction in fatalities than seatbelts ³² — saving almost 300,000 lives over a decade through autonomous and semi-autonomous vehicle technologies.
\$1,700 a year per household — the cost of traffic congestion for the average American household — and it could cost the US economy \$186 billion by 2030. ³³	 5 to 25 percent improvement in traffic flow ³⁴ through smarter connected traffic management — saving Americans countless hours and fuel.
\$440 billion — the cost of crime to society.	 20 to 22 percent reduction in crime rates — through connected city sensors and new types of remote home security monitoring. ³⁵
6,800 million metric tons of CO₂ — the amount of US greenhouse gas emissions released into the atmosphere each year. ³⁶	 19 percent reduction in global greenhouse gas emissions ³⁷ — on a global basis the equivalent to eliminating all of the United States' and India's total greenhouse gas emissions combined.
\$1,300 a year — the average American's annual electricity bill. ³⁸	 10 percent reduction in home energy use , ³⁹ and a 20 to 30 percent reduction in factory energy use. ⁴⁰
133 million Americans (40 percent) suffer — from some form of chronic disease — driving about 75 percent of all health costs. ⁴¹	 50 percent drop in chronic disease treatment costs. ⁴²
Our economy is not running at its full economic potential.	 \$11.1 trillion a year in economic impact by 2025. ⁴³

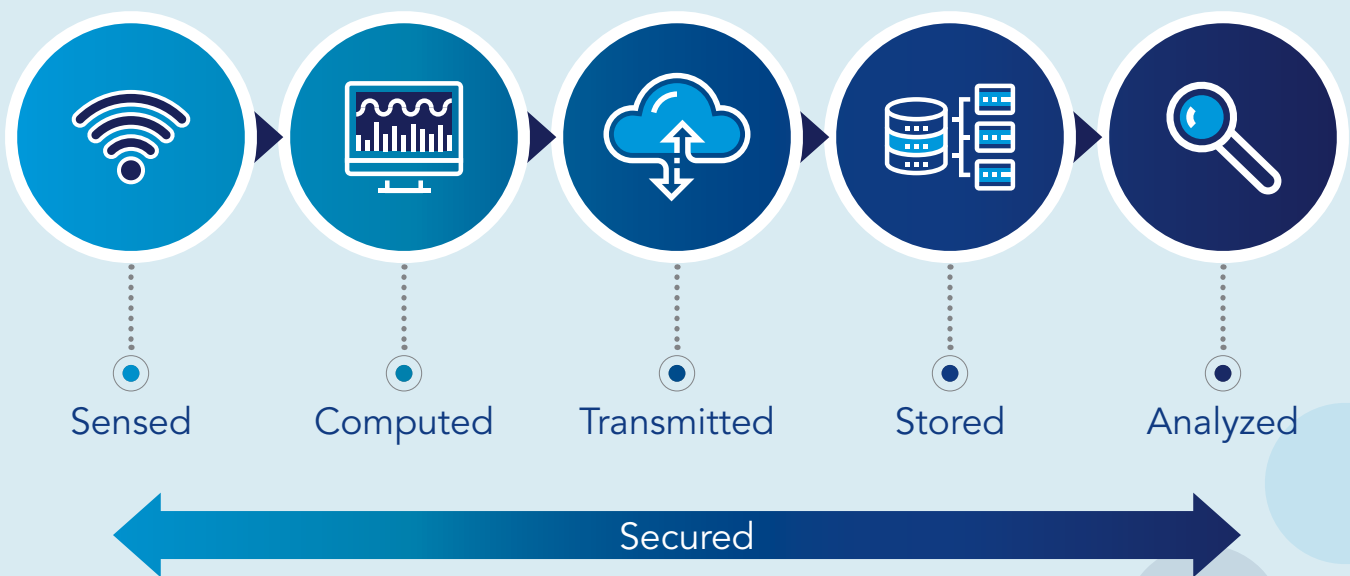
Key Technological Advances Are Converging to Enable This Future

The Internet of Things is an umbrella term for a broad set of technologies that is converging to bring the incredible power of software and the Internet to the physical world, which has for too long missed out on their transformative impact. New advances are extending the power of software into the world around us to help us achieve profound new things both big and small. Devices are being packed with increasingly more powerful sensors with the ability to

access nearly infinite amounts of computing power, which can be managed remotely, and take advantage of big data analytics systems and machine learning technologies to do things that were previously inconceivable. Each of these technologies — **sensors, computing, data, connectivity, encryption, the cloud, and the software that makes intelligence possible** — is converging in a synergistic way to make this revolution possible.

The Data Continuum Enabling Internet of Things Opportunities

DATA IS:



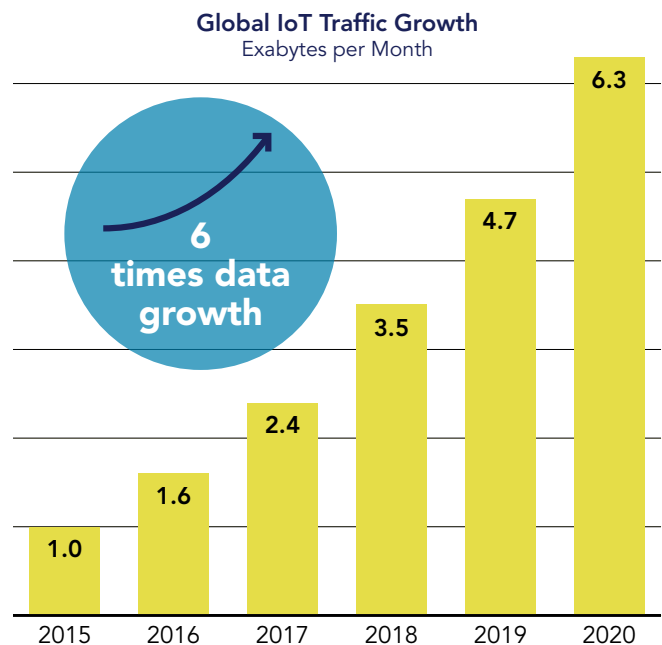


Today's high-end cars can have 100 times more lines of code than the Space Shuttle had when it launched.



➔ **Sensors are getting smaller, cheaper, and more powerful to enable devices to see, hear, and feel beyond human limits.** Connecting things to the Internet starts with enabling devices to control and sense the world around them. A key to the success of the first smartphone was the technology that gave it the senses of touch, sight, sound, and motion. A growing list of different types of sensors, like sensors that can see in 3D, are poised to transform what devices will be able to do. As prices come down and capabilities go up, IBM predicts that the emergence of sensors for context-aware computing will soon grow to more than a trillion sensors by 2020.⁴⁴

➔ **Device created data is growing exponentially, increasing our ability to harness it.** Just as the number of connected devices is poised to explode, so too is the amount of data each one creates. Their growing ubiquity, combined with their growing ability to create new forms of data is converging to make these connected devices one of the fastest growing digital data drivers. As a society, we now generate 2.5 quintillion bytes of data each day — so much that at least 90 percent of the world's data today has been created in just the last two years alone, and the amount of data produced is now doubling every two years⁴⁵ and is projected to grow sixfold by 2020 — even faster than the growth in the number of devices because of advancing sensor capabilities (see chart.) Even still, most data currently generated by device sensors is being underutilized. Take for example an oil rig, which today can have 30,000



Source: Cisco VNI Global IP Traffic Forecast, 2015–2020

sensors but may only use about 1 percent of its data — because the data is only used for anomaly detection, and not optimization and prediction.⁴⁶ As we are able to make full use of our growing amounts of data, we will be able to increase the opportunities that are derived from it.

➔ **Clever software can now be embedded everywhere to make everything more intelligent.** To make these devices smarter, clever software is now able to be infused everywhere, connected to the Internet, and connected to



The cloud and intelligent devices are often inseparable technologies. When devices communicate, their first stop on the communications path is often the cloud — to store data, to process data, and to make sense of data.

the cloud. Today's newest refrigerators can have more lines of code than a desktop computer had 20 years ago.⁴⁷ Similarly, today's high-end cars can have 100 times more lines of code than the Space Shuttle had when it launched.⁴⁸ And by infusing devices with software, capabilities can be expanded over time.

- **Connectivity is becoming more ubiquitous, going faster, and reaching farther.** To gain the fullest benefits, these devices must be connected to get to the cloud, and benefit from network effects. Today, low-cost, high-speed, pervasive network connectivity is making almost everything connectable from anywhere. Not only can devices be connected directly to the Internet with wired connections, increasingly they can be connected wirelessly with WiFi through our phones or through short range wireless connections with names like Bluetooth, Zigbee, ZWave, and ANT+. However, to be able to manage densely connected networks that include such a wide variety of different and unique device types, innovators are developing network technologies that are more flexible, go faster, and are quicker to respond (decreasing network latency).
- **Cloud-enabled analytics are making device data more accessible, actionable, and increasingly more valuable.** The cloud and intelligent devices are often inseparable technologies. When devices communicate, their first stop on the communications path is often the cloud — to store data, to process data, and to make sense of data. It is estimated that by 2020, more than

90 percent of all Internet of Things data will be hosted on cloud platforms to reduce complexity, improve management, and enable the blending of data.⁴⁹ The cloud enables device data to be stored remotely and accessed anywhere; it enables disparate devices and systems to be integrated and managed, enabling them to operate in clever new synergistic ways; and it enables intelligence (even Jeopardy-winning level intelligence) to be combined with devices to make them infinitely smarter. As various device inputs are combined in the cloud, and connected with cloud-based analytics, cognitive recognition, or machine learning technologies, they create a network effect that is bigger than the sum of the devices on their own.

- **Continuously advancing security technologies are enabling devices to be connected, and data protected — even as threats evolve.** As digital devices become more integral to our daily lives, so too is security becoming more integral to the success of digital devices. Companies that provide or use IoT systems are increasingly turning to the latest security technologies to ensure critical protections are in place that are commensurate with the sensitivity of any data being collected and the device's potential risk profile. For example, many connected devices build security into each layer in the process and take advantage of the power of the cloud to host critical functions in the cloud where providers can swiftly and uniformly implement security updates as new threats evolve. Similarly, encryption technologies have become an important connected device



Now anyone with a good idea and an Internet connection can buy and connect one of hundreds of off-the-shelf sensors — with servers and switches and a host of other cloud-based analytical tools to create the next smart thermostat, plant watering robot, smart dog collar, or lights that change color with the weather.

security enabler for helping to protect data on the device,⁵⁰ to securely authenticate devices when they connect to a network,⁵¹ to authenticate the devices when they connect to a service,⁵² to protect data while it's in transit, and to help protect data at rest in the cloud.⁵³ As we extend connected devices deeper into our world — into even more mission critical applications where their capabilities will drive some of the biggest gains — elevating attention to security and ensuring continuous innovation have become essential enablers.

➔ **Lowering the technological bar to bring in new innovators with new ideas.** This revolution isn't just about trickle-down innovation from the big players, either. The Internet of Things is enabling new opportunities that bubble up — from

hobbyists, entrepreneurs, and tinkerers working in their garages to invent the next new thing. Now anyone with a good idea and an Internet connection can buy and connect one of hundreds of off-the-shelf sensors — sensors that measure moisture, light, proximity, or motion — with servers and switches and a host of other cloud-based analytical tools to create the next smart thermostat, plant watering robot, smart dog collar, or lights that change color with the weather. As we put more power in the cloud, and more devices within reach, we are seeing barriers get lowered for creating connected devices — shrinking the gap between idea and prototype, prototype and product.

Key Challenges to Achieving IoT's Full Potential



SECURITY: Building trust around how data and devices will be secured is a key to enabling vast societal rewards.



PRIVACY: Enabling trust in the way privacy is protected.



WORKFORCE: Overcoming a looming skills gap by filling the talent pipeline with more people who can code or pursue other tech-enabled careers.



FREE FLOW OF DATA: Maximizing data benefits through data that can flow freely across borders.



STANDARDS: Leveraging global industry-led interoperable standards to maximize network effect opportunities.



IP: Ensuring intellectual property protection to foster creativity and innovation.



CLOUD ADOPTION: Encouraging government cloud adoption to enable greater opportunity.

Although the potential benefits from the Internet of Things are huge, there are numerous important challenges that must be addressed that will determine how quickly these technologies advance, and how broadly their benefits are spread.

- ➔ **SECURITY: Building trust around how data and devices will be secured is a key to enabling vast societal rewards.** As with all new technologies, trust is a critical factor with the potential to dramatically affect the speed at which future technologies are adopted and corresponding benefits are achieved. As companies develop new Internet of Things systems, they must ensure appropriate security is designed into these systems at the outset using the best available technologies in ways that are commensurate with the device's potential risk profile. To do so, companies must also have the flexibility to continue to develop and implement new security technologies as they evolve, so that they have the agility to update and meet changing threats and circumstances as they evolve. Likewise, policy leaders can help promote cutting-edge cybersecurity practices without requiring the use of specific technologies, or preventing the use of key technologies. For example, encryption is a cornerstone technology for enabling device opportunity because it can be used for securing both data in transit and at rest, and for enabling authentication of connected endpoints so they don't become gateways for broader network access. This is one of the reasons why business leaders and policymakers alike are often turning to strong encryption to safeguard physical systems that are connected to networks.
- ➔ **PRIVACY: Enabling trust in the way privacy is protected.** Because some devices may be capable of collecting personal data, to enable

broad adoption of intelligent devices consumers need confidence in their devices, the ability to trust that their data will be protected, and certainty about who, and under what circumstances, can access their data. Device developers should forethink privacy considerations, use proven privacy engineering approaches, and adopt the best available technologies in ways that are commensurate with the device's potential risk profile. To enable broad adoption, consumers also need to be able to trust how their data is used, and who has access. For this reason, governments can promote the adoption of IoT by adopting smart and clear privacy laws that facilitate innovation.

- ➔ **WORKFORCE: Overcoming a looming skills gap by filling the talent pipeline with more people who can code or pursue other tech-enabled careers.** Some now refer to this new connected device revolution as the emergence of the programmable world,⁵⁴ reflecting the fact that it's really about enabling everything in the world to be improved by the power of software programming. To flourish, we will need a world of programmers and other skilled workers. Right now, though, there are roughly 500,000 computing jobs currently unfilled in the United States, and fewer than 50,000 computer science students graduated from US universities into the workforce last year.⁵⁵ This gap is only expected to grow. As we create more kinds of devices and everything needs an app, we will need even more people who know how to code in order to make sure we can take full advantage of these opportunities and continue to lead in the technologies of tomorrow. And as we connect our cars, factories, and farms, and every connected thing around us suddenly runs on code, are we

Governments can promote the adoption of IoT by adopting smart and clear privacy laws that facilitate innovation.

Enabling the free flow of data across borders is one of the fundamental tenets for enabling the broad benefits that connected devices can deliver.

teaching America's kids the skills they will need to participate in this revolution? It's for this reason that parents and teachers increasingly want computer science taught in K–12 classrooms. Computer science is no longer a skill for nerds, it's a basic skill that is a ticket to the 21st century economy, right along with reading, math, and science.

➔ **FREE FLOW OF DATA: Maximizing data benefits through data that can flow freely across borders.** Data is the fuel and the raw resource for today's modern economy. Yet today, while devices are generating increasing amounts of valuable data, only a fraction of data is being fully used. Enabling consumers and innovators to maximize the use of data in the most efficient ways is essential for achieving its broadest benefits. These benefits are being enabled by the global force that is the Internet, and is being fueled by data that crisscrosses the globe between disparate data centers. At a time when cross-border Internet traffic has been increasing by more than 50 percent since 2005,⁵⁶ enabling data to flow freely across borders has become an essential enabler for device opportunities. Governments that restrict data flow are less likely to benefit from the IoT revolution, and they reduce the effectiveness of the entire system. Data localization can also undermine security by preventing valuable data from being backed up in multiple locations to protect it in the event of a natural disaster or technical failure. To achieve the benefits that data can deliver, every country's laws don't need to be identical, but they do need to be compatible. Enabling the free flow of data across borders is one of the fundamental tenets for enabling the broad benefits that connected devices can deliver.

➔ **STANDARDS: Leveraging global industry-led interoperable standards to maximize network effect opportunities.** Intelligent devices must be connected to each other, and to the cloud — often across geographic boundaries — to gain the network effects that are at the core of the opportunity chain. By avoiding the potential creation of silos where connected devices are unable to talk to each other, governments should encourage interoperability between connected device systems, and encourage the development and use of interoperable consensus-based global standards. Policies that rely upon consensus-based global standards can help ensure that devices can be designed to high-standards once, and then mass produced in the most affordable ways to all sectors and all regions of the global economy.

➔ **IP: Ensuring intellectual property protection to foster creativity and innovation.** Fundamentally, the intellectual power of a workforce and the innovative ideas they produce are the core drivers that will produce the most transformative community of IoT inventions. Without ensuring proper protection for those ideas, the IT sector cannot achieve its full economic potential or maximize the societal benefits they create. Thus, in order to unlock the vast new jobs and opportunities that a faster growing IoT sector can create, governments need to take comprehensive and concrete steps to protect intellectual property. This includes ensuring non-discriminatory treatment of software inventions, allowing licensing on terms that both the supplier and customer agree, and empowering American innovators with the legal tools to defend their valuable trade secrets.

➔ **CLOUD ADOPTION: Encouraging government cloud adoption to enable greater opportunity.**

To achieve many of the most fundamental IoT benefits, governments must first encourage and enable broad cloud adoption. Many forward-thinking governments around the globe have already taken important steps to encourage and take advantage of the efficiencies of the cloud to dramatically reduce their own IT costs, enhance the way they deliver citizen services, improve security, and ensure continuity of services. As we enter the IoT world, governments that encourage and adopt cloud technologies are not only better positioned to take fuller advantage of emerging IoT societal gains, but can also enable services to be delivered in entirely new ways, improve employees' abilities to access their work anytime from anywhere, and better position governments to benefit from cloud connected devices that improve what and how they perform.

Given the breadth of Internet of Things technologies; the multitude of players involved in a single system including hardware, software, connectivity, cloud, and other players; and the near endless potential use cases, a one-size-fits-all approach to regulation would likely be counterproductive. And with nearly unlimited potential and many unknowns in terms of how the technology will develop, policymakers should use a certain amount of regulatory humility before deciding if, whether, and when any new rules need to be adopted that could inadvertently or unnecessarily impede development of intelligent devices. Because the opportunities on the horizon are so profound,

the US Senate unanimously approved a resolution calling for a national strategy to incentivize development of Internet of Things to "maximize the promise of connected technologies hold to empower consumers, foster future economic growth, and improve our collective social well-being."⁵⁷ The resolution puts the United States Senate on record supporting a strategy of advancing our US global competitiveness, recognizing the importance of consensus-based best practices, and underscoring the need for innovators to drive the future development of the Internet of Things.

Looking Ahead

Today's connected device revolution won't just improve our lives and transform the way we work; it can be an economic accelerant for creating the new jobs, industries, and opportunities necessary for a more prosperous future. By making everything around us smarter, the smart revolution is poised to move from our smartphones to smart watches to smart cars and smart cities. But we will need smarter policies to accompany and enable this change. That's why as the devices all around us start talking to each other, innovators and policymakers need to start talking, too — about how to remove barriers to maximize opportunities for consumers, businesses, and society alike. With pragmatic policies that tap human talent and tenacity, harness innovation and investment, and encourage trust through privacy and security, policymakers can help maximize the vast benefits that connected, device-driven benefits can deliver.

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