Issue: The Internet of Things

The Internet of Things

By: Scott Sowers

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Will vulnerabilities undermine its potential?

Executive Summary

The promise of the Internet of Things (IoT) is abundant, according to proponents: This growing array of internet-linked devices, ranging from baby monitors to thermostats to cars, will improve lives, increase productivity and create new business markets. Skeptics point to equally substantial downsides, including vulnerability to cyberattack and concerns about personal privacy. They also question whether consumers really want all these interconnected devices, or whether producers have gotten ahead of the market. Whatever the answer, the IoT is spreading; according to one estimate, more than 28 billion connected devices exist worldwide, and that will grow to 50 billion by the end of the decade.

Here are some key takeaways:

- Cloud-based data storage is a central element of the IoT, and two corporate giants, Amazon and Microsoft, are vying for dominance in this field.

- Another key battleground is self-driving vehicles, with early entrant Google facing competition from several corporate rivals.

- Other areas of IoT application include home energy systems, wearable fitness monitors and robots for use in security, health care and retailing.

Full Report

The Nest thermostat can be controlled from a smartphone and can "learn" its users' patterns to anticipate what they want.
(David Paul Morris/Bloomberg via Getty Images)

At 7 a.m. EDT on Oct. 21, 2016, large swaths of the internet in the United States and Europe went dark. The cause: a cyberattack on one enterprise, Dyn, a domain name system company. A second attack happened just five hours later. [1]

CNN, The Guardian, Twitter, Netflix and Reddit were among the companies affected by the attacks. [2] Subsequent investigations linked the onslaught to hundreds of thousands of Web cameras and other devices acting as one, many of which contained components traced to a Chinese electronics company, Hangzhou Xiongmai Technology. [3]

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Hangzhou Xiongmai recalled the cameras and blamed the attack on users who had not changed their default passwords. Hackers were able to guess the passwords and then use the devices to disrupt service to popular websites, according to security experts. [4]

The experts say the attacks highlight the vulnerability of the Internet of Things (IoT) – the connecting of everyday devices, from baby monitors to thermostats, to the internet and through it to each other – and show that cyber foes can corrupt the software on which U.S. society is so reliant. [5] The attacks also raise concerns over privacy, given the potential for hackers to penetrate the IoT and steal personal information.

Estimates for how many devices are connected and how many eventually will be vary. Statista, a research firm based in Hamburg, Germany, pegs the number for 2017 at 28.4 billion globally and expects an increase to 50.1 billion devices by 2020. [6]

The soaring number of connected devices compounds the security issues as more players join the fray. According to a Cybersecurity Insights Report authored by AT&T, 85 percent of more than 5,000 enterprises surveyed are in the process of or planning to deploy IoT devices, but only 10 percent feel confident that they can secure those devices against hackers. [7]

Proponents of the Internet of Things say the technology holds great potential and is already improving Americans' lives. They note the impact the IoT is having on the tech industry as it develops cloud-based data storage and artificial intelligence; the automotive industry as it develops autonomous vehicles; the housing industry as it makes homes "smart"; and the health and fitness industry as it markets sensors for athletes and exercise buffs.

"In our personal lives, the IoT is supposed to help make us more productive and provide a certain level of convenience," says author and futurist Jacob Morgan.

The IoT's impact on business will be substantial. According to a report by Business Insider, nearly $6 trillion will be spent on IoT research over the next five years, and businesses will be the top adopters of the emerging technologies. The IoT is set to improve bottom lines by lowering operating costs, increasing productivity, creating new markets or developing new product offerings. [8]

Cloud-based data storage and artificial intelligence form the backbone of the Internet of Things, with Microsoft and Amazon battling for domination of cloud technology. In the fall of 2016 Microsoft reported that sales of Azure, its flagship cloud product, rose 116 percent from August 2013, when the company began moving toward mobile and cloud computing. Revenue for its "Intelligent Cloud" business increased 8.3 percent over the same period to $6.38 billion. [9] Amazon Web Services is also doing well, generating more than $10 billion in annual revenue from sales of its cloud products in 2016. [10]

In February 2016, Cisco, another major player in the tech sector, announced plans to acquire Jasper Technologies, a privately held firm based in Santa Clara, Calif., for $1.4 billion in cash. [11] Jasper, originally known as Jasper Wireless and founded in 2005, was an early innovator in machine-to-machine (M2M) technology, which allows devices to communicate with each other. Jasper eventually added over 2,500 enterprises to its client list, which includes General Motors, Coca-Cola, Volvo, General Electric and Amazon. [12]

But some experts say backers of the IoT are getting ahead of themselves. "The average number of connected devices per household is 5.2 devices, and that number is going to increase," says Joseph Jerome, a policy counsel for the Center for Democracy and Technology in Washington, which promotes an open internet. "That's not hype, but it doesn't mean there's a use study to connect every item in the home."

Even as the number of connected devices expands, questions arise about a consumer backlash against commonplace devices that don't need to have an internet connection. The media is now actively poking fun at internet-enabled devices, including trash cans, toasters, thermometers, egg trays and mirrors. [13]

Consumer demand may serve as the final arbiter of the IoT. "The only backlash currently is, 'Ha-ha, I'm not going to buy it,' " says Bruce Schneier, chief technology officer with Resilient, an IBM company. "Like an enabled toaster, who needs it? That's a consumer demand issue and the market corrects for that."

As privacy concerns grow, some firms are trying to take advantage with products designed to thwart data theft. In 2015, Silent Pocket, a small company in Encinitas, Calif., raised more than $42,000 on a Kickstarter campaign to develop and market a "Faraday cage" for cellphones. [14] The device is an enclosure used to block electromagnetic fields, including Wi-Fi signals, and is named after scientist Michael Faraday, who invented the cage in the 19th century. [15]

According to Silent Pocket, the pocket-sized cage will "block out all signals, including cellular, Wi-Fi, GPS, Bluetooth and NFC [near-field communication] in all frequencies." The firm sells a full range of internet-disabling wallets, pouches, sleeves and travel bags, with prices ranging from "privacy stickers" for $9.95 to briefcases that cost $675. [16] At least two other companies have manufactured similar products. [17]

Beyond questions about personal information being hacked, the ability of automated devices to perform physical functions is another concern. "The IoT gives the internet hands and feet," says Schneier. "Unlike a computer, the IoT affects the world in a direct physical manner. That makes the effect of these vulnerabilities very different. It's a world of difference from your spreadsheet crashes and you lose your data and your car crashes and you lose your life."

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Autonomous Cars

Google has been pushing the IoT forward in a number of ways, including its efforts to build a self-driving car. Eight years of research and 2 million miles of road testing have resulted in Waymo, a stand-alone autonomous vehicle company recently launched under the Google umbrella. [18]

Plans for moving Waymo from the testing stage remain murky, but the firm has signed a deal with Fiat Chrysler to try out its technology in a fleet of Pacifica minivans. [19]
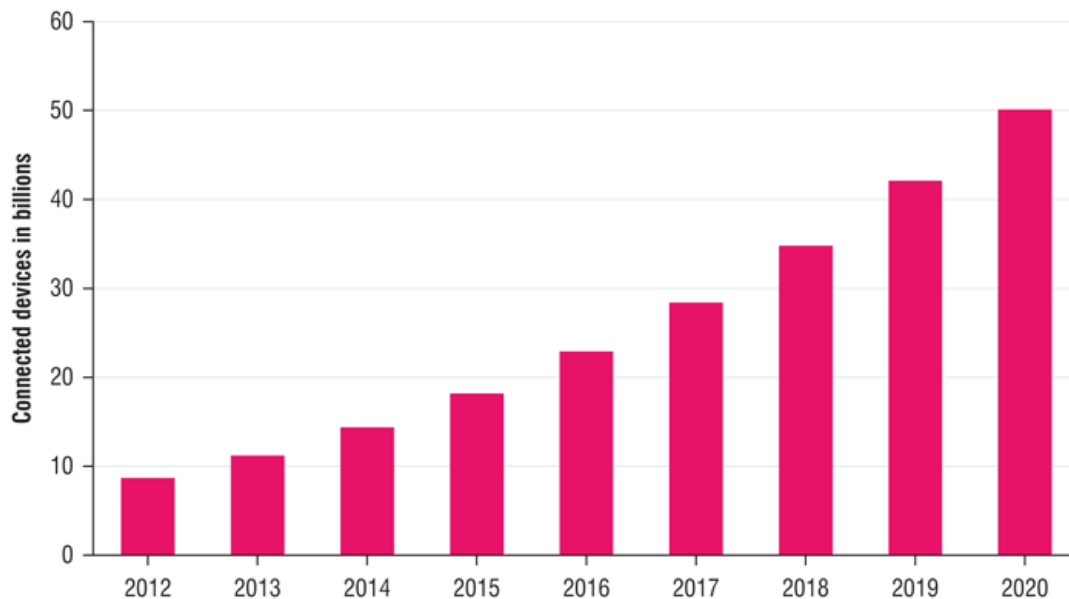
Once considered to be the leader in autonomous vehicle technology, Google is now facing serious competition from Ford, General Motors, Uber, Tesla and Baidu, a Chinese tech company.

In early 2017, the race for dominance in the market spawned a lawsuit in federal court as Waymo accused Uber of stealing key technology for use in "Otto," another self-driving car company that Uber bought in August 2016 for $680 million. [20] An Uber spokeswoman told Bloomberg News: "We have reviewed Waymo's claims and determined them to be a baseless attempt to slow down a competitor, and we look forward to vigorously defending against them in court." [21]

Cars equipped with cruise control and the ability to park themselves have been available for years. Tesla upped the ante with its "Autopilot system," which it began selling to consumers in 2014 as a $4,250 option. The system uses sensors, a camera, radar and digitally controlled brakes to avoid collisions. Going beyond self-parking, the system also enables the car to steer itself and change lanes at highway speeds. [22]

More Than 28 Billion Devices Connect Via Internet of Things

Estimated number has more than tripled since 2012

Note: The data for 2015 through 2020 are estimated figures.

Source: "Internet of Things (IoT): number of connected devices worldwide from 2012 to 2020 (in billions)," Statista, http://tinyurl.com/j3t9t2w

An estimated 23 billion devices worldwide were a part of the Internet of Things – devices connected to each other through the internet – in 2016. The number is projected to increase by more than 5 billion in 2017.

Its effectiveness came under question in January 2016 when 23-year-old Gao Yaning was killed in his father's Tesla Model S while driving 300 miles south of Beijing. It is still uncertain whether the Autopilot system was engaged at the time of the crash. [23]

In May of the same year, a fatal accident occurred in Florida involving a Tesla S with the Autopilot system engaged. Tesla attracted more unwanted attention when it was revealed that the company did not disclose the crash until late June. The National Highway Traffic Safety Administration (NHTSA) is investigating the accident. [24]

Google's automotive efforts also suffered a setback in February 2016 when one of its self-driving cars crashed into a bus in the Silicon Valley community of Mountain View, Calif. No injuries were reported. [25]

Despite the problems, autonomous vehicles appear to be on their way. "They are never going to get worse; they will only get better," Schneier says. "It's probably coming faster than people think. Computer technology improves really fast."

The automotive industry is also working on developing technology that allows cars to communicate with each other over the internet, a system known as "vehicle to vehicle" or "V2V." NHTSA weighed in on the issue by publishing a notice of proposed rulemaking at the close of 2016. If the rule makes it to the finish line, all auto manufacturers would be required to install short-range communication radios in new vehicles, probably starting in 2020. [26]

Such radios can send and receive short messages about vehicle position, heading, speed and braking status to other vehicles 10 times per second over a range of 1,000 to 1,500 feet. Drivers using the system could get warnings about problems up the road beyond the line of sight. [27] In this instance, the IoT could make the world a safer place to drive.

The Early Years

The road to the IoT began with the inception of the internet in 1969 as ARPANET, a computer-based communication system pioneered by the Pentagon's Defense Advanced Research Projects Agency (DARPA). [28] The first automated teller machines appeared during the same period, which paved the path to online banking. [29] By 1974, grocery stores were using universal product codes (UPCs) and scanning equipment to track inventory levels and point-of-sales figures in select stores. [30]

Data collected at the cash register about how much of a given product was being sold was used to calculate when to reorder. In this way, a can of tuna was in effect communicating with store managers, telling them inventory was dropping. Electronic transactions in consumers' bank accounts recorded at ATMs and retail stores were digitized and communicated directly to the banks to transfer funds.

In 1990, the first website was launched and the first Web browser and first search engine were developed. In 1993 the Mosaic Web browser became popular and the idea of using "HTML" as a way to display images on the Web sprang into existence. By 1994, 11 million Americans were equipped for internet access, and Pizza Hut began selling online. Yahoo debuted the same year. [31]

In 1997, Google was registered as a domain and Go Daddy and Netflix were begun. In 2003 Skype, iTunes, LinkedIn, MySpace and WordPress came online. Facebook followed in 2004, YouTube in 2005 and Twitter in 2006. [32]

Although there is some dispute about who coined the phrase Internet of Things, Kevin Ashton, who was working with Procter & Gamble and on radio frequency identification (RFID) technology, generally gets the credit. Ashton used the term during a presentation to the company in 1999. [33]

The IoT took a step forward in 2011 when IBM's Watson computer, the most visible name in artificial intelligence, beat two past "Jeopardy!" champions in a televised tournament. Watson won a $1 million prize by answering questions, parsing convoluted language and responding faster than its human opponents. [34]

Watson's victory has been followed by projects that include a $50 million foray into cancer research bankrolled by Jho Low, a young billionaire who funded the effort after witnessing his grandfather's unsuccessful leukemia treatments in Malaysia. The plan is to use Watson's artificial intelligence to pinpoint personalized cancer treatments by accessing treatment histories, genetic data, scans and symptoms and comparing the data with the universe of medical data available. [35]

"I see technology like this as a way to really break free from our current health care system, which is very much limited by the community providers," said Lynda Chin, a physician-scientist and an associate vice chancellor at the University of Texas System who is supervising the project. "If you want expert care, you have to go to an expert center, but there are never enough of those to go around." [36]

But even as advances continue, some technology experts are predicting a slowdown. The experts often point to "Moore's Law" when talking about the speed of technological advancements. Gordon Moore, a co-founder of Intel, observed in 1965 that the number of transistors that could be placed on a chip was doubling each year, and predicted that this growth would continue. [37]

For decades, the law pointed the way toward how fast technology was growing; but some experts believe it is now hitting a wall. For example, Intel has delayed its next release of transistor technology from 2016 to late 2017 and is suggesting that silicon transistors will continue to shrink only for another five years. [38] "For the last three years we've seen a kind of stagnation," said Horst Simon, deputy director for Lawrence Berkeley National Laboratory. [39]

The Energy Industry

IoT proponents remain optimistic, pointing to the potential for savings in the home energy sector. The deregulation of energy markets in some states, combined with emerging technology in renewable energy sources, has attracted the attention of Silicon Valley firms interested in selling home energy management systems, smarter thermostats and other products to the utility business and consumers.

Programmable thermostats have been on the market for decades, but Tony Fadell, who is credited with inventing the iPod for [Apple](#), connected his "Nest" thermostat with the internet so a phone app could control it in 2011. [40] Google bought his company, Nest Labs, in early 2014 for $3.2 billion. [41]

Besides a sleek design and the phone interface, Nest is also credited with being able to "learn" the patterns of its users through the use of complex algorithms – the math behind artificial intelligence. The computations are designed to anticipate what consumers want and save them energy and money by adjusting the thermostat a few degrees up or down when the owners aren't home.

SolarCity panel systems can be connected to the local utility via the internet to manage electricity generated at the house.
(Michael Nagle/Bloomberg via Getty Images)

Since the release, Nest has tinkered with the software to improve performance. An update in 2014 that tweaked the "Auto-Schedule" feature addressed homeowners' concerns regarding how much control was being ceded to the machine. "Making users fight against temperature schedules they did not select or want caused not only irritation and discomfort but also thermostat usage that resulted in higher energy usage than before," the company said in a study released in 2014. "By nature, people don't like being told what to do." [42]

Another round of software fiddling backfired in January 2016 when a flawed internet-launched update drained the thermostat's batteries and deactivated the operating system. Nest responded with a nine-step fix that included detaching the thermostat from the wall, charging it with a USB cable for 15 minutes, reattaching it to the wall, pressing a series of buttons and then charging it again for an hour. [43]

"Consumers are frustrated by being turned into product 'beta testers,' " says Jerome of the Center for Democracy and Technology. "When a smart device either is insecure or the company ceases to support it after short order, it can be hard to see how connectivity provided much of a benefit."

Elon Musk cofounded PayPal, an internet-based payment system, and also serves as chairman of [SolarCity Corp.](#), an ambitious venture designed to finance, install and service home-based, roof-mounted photovoltaic power systems on a mass scale. The systems offer a battery backup system (Powerwall) and a home energy management system that connects to the local utility company via the internet to manage the electricity being generated at the house. [44] Musk also heads Tesla.

One of the key areas of interest related to home energy management systems is a house's ability to determine when electricity should be used as power and when it should be stored in the battery system, assuming it has one. [45]

Ideally, the system should also be able to communicate with the utility to determine when power should be "sold" back to the grid or "bought" to take advantage of lower utility rates. All of this requires a certain amount of cooperation from utility companies and regulators and a direct internet connection from the home management system to the utilities.

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In late 2016, Tesla acquired SolarCity for about $2 billion. [46] Both companies are disrupting traditional ways of selling cars and generating electricity, and both rely on their products staying connected to the internet for updates.

"We're trying to make an integrated product," Musk said. "So you have an integrated solar roof with a Powerwall and an electric car, and you just go into a Tesla store, just say yes, it just happens. It all works, it's seamless, and you love it." [47]

But the changeover at the White House from Barack Obama, a supporter of renewable energy, to Donald Trump, who favors fossil fuels, has led to financial concerns about the deal.

Tesla has lost roughly $4.8 billion in market capitalization since the initial offer, while SolarCity's value declined by about $86 million. Tesla reported a quarterly profit late in 2016, the first in eight quarters. SolarCity recorded losses in six of the past eight quarters, and the companies have conducted five separate equity offerings since SolarCity went public in December 2012. [48]

The Fitness Market

The IoT has also influenced the fitness market through the popularity of "wearables." Usually appearing as a "smartwatch," the devices record the amount of steps walked, stairs climbed, exercise time, heart rate and sleep patterns. Major players include Apple, Pebble, Fitbit and Android. Although the launch of the Apple watch in 2015 generated a lot of press, the market's prospects appear mixed.

Pebble was considered a market leader in 2102, but Fitbit bought it late last year. Android delayed the release of the next version of its product until later in 2017, and Motorola has halted plans to market a smartwatch. [49]

Fitbit held an IPO in 2015 that generated more than $4 billion and followed up in 2016 with four new devices. They communicate with Fitbit's website, allowing users to share information with each other. In 2014 a personal injury lawyer used Fitbit data as evidence that the lawyer's client couldn't work after an accident. In 2016 Fitbit data was used to prove that a woman lied about being sexually assaulted. [50]

In January 2016, Fitbit was hit with a class-action lawsuit regarding the accuracy of its heart rate tracking. Lawyers presented evidence alleging that rates were off by an average of 20 beats per minute during moderate to high-intensity exercise. A lawyer for the plaintiffs, John Selbin, said, "This is about the way they market it and that they charge a premium for the heart rate monitor, but it's not giving a meaningful measurement." [51]

Fitbit countered by saying it had conducted "multiple internal studies to rigorously test" the accuracy of the wrist-mounted monitors. [52] The company also questioned the accuracy of the study conducted by plaintiffs' lawyers. [53] As of this writing the case is still active.

Robots

Connecting robotic devices to the Internet of Things opens another area of technological possibilities. Early pioneers include MetraLabs, a robotics company based in Ilmenau, Germany. The company is working on internet-enabled robots that can function as security guards, health care assistants and retailers. Its "Tory" model, an autonomous, self-propelled robot, is equipped to use RFID to record inventory levels in retail stores and recently celebrated its first year of "employment." Tory works in a manner similar to the RFID system used in grocery stores, except that the scanning mechanism actually goes to the shelves to track merchandise. [54]

Funding for research for the next generation of robots comes from educational sources including the "STRANDS" program led by the University of Birmingham in the United Kingdom and bankrolled with more than 7 million pounds (about $8.7 million) from the European Union's Seventh Framework Programme. [55]

The future of robots, artificial intelligence and the IoT could be affected by desires to regulate the use of online data for security and privacy concerns, but questions remain about how this can be accomplished. Some suggest that to make securing data easier, all devices should speak the same language and work with the same protocols.

But for technology companies vying for market share, that idea presents issues, as IoT technology is proprietary. "For the large companies out there like Google and Amazon who are all trying to own the IoT space, they are going to focus on getting customers to use their products, which means playing by their rules," says futurist Morgan.

If the corporate world has a vested interest in keeping the IoT unregulated, and as a result it is more at risk to hackers, the security job could fall to the government. "There are things like the Privacy Act and plenty of other laws and regulations around data collection and how data can be used," Morgan says. "Most of these laws have been around for many years, so I definitely suspect we will need an update."

Jerome agrees. "Governments, and the U.S. federal government, need to play a strong leadership role in the IoT," he says. "A national IoT strategy is important, and that requires regulators and policymakers to get on the same page. But it is unlikely any one entity should or could control all of the IoT. Just like one technical standard would not be appropriate, one massive IoT bureaucracy would also be problematic if only because the challenge of the IoT is that it is cross-jurisdictional."

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"We do need some kind of regulation," Resilient's Schneier says, "and governments have a very important role to play. Just like governments regulate all dangerous things."

About the Author

Scott Sowers is a freelance writer and independent producer based in Washington. He writes and creates content about architecture, design, real estate, energy, technology, the utilities and the automotive industry. His work has appeared in The Washington Post, The New York Times, Home & Design and Hemispheres Magazine. His first novel, "Life and Death at the Dog Park," is available through Big Gorilla Press. He previously reported for SAGE Business Researcher on the electric power industry.

Chronology

The Tory robot uses radio frequency identification technology to track inventory levels.

Mid-to-Late 1900s	**New technologies create new possibilities.**
1956	General Motors unveils the Firebird II, a concept car with sensors that would be guided on an "electric highway" (a road with an electric wire embedded in the pavement). The Firebird, designed to be powered by a turbine engine similar to that of an airplane, was showcased as the car of the future, but never went into production.
1967	Bankomat, Barclays and Chubb launch the first automatic teller machines in Europe and the United Kingdom.
1969	The first message is sent over the ARPANET, the predecessor of the internet.
1973	Inventor Mario Cardullo receives a patent for a Radio Frequency Identification (RFID) tag, which would become one of the building blocks of the Internet of Things (IoT).
1974	The Universal Product Code (UPC), which allows retailers to track sales and inventory levels electronically, is first used in a supermarket.
1982	Members of the Computer Science Department at Carnegie Mellon University install micro switches in a Coca-Cola vending machine and connect them to a computer to monitor the number of bottles in the machine and their temperature.
1995	Siemens dedicates a department to data modules that allow machines to communicate over a wireless network. The modules are used in point-of-sale terminals, cars and monitoring, tracking and tracing applications.
1997	Carnegie Mellon, the Massachusetts Institute of Technology and Georgia Tech co-host the first Institute of Electrical and Electronics Engineers (IEEE) Symposium on Wearable Computers.
1999-Present	**A phrase is coined, connections are made.**
1999	Sanjay Sarma, David Brock and Kevin Ashton team up to develop the Auto-ID Center at MIT, which works on connecting RFID with the internet.… Ashton is credited with coining the phrase "Internet of Things."

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2004	The Defense Advanced Research Projects Agency (DARPA) launches the Grand Challenge series, a competition for designing autonomous cars.
2005	Teachers at the Interaction Design Institute Ivrea in Ivrea, Italy, develop Arduino, a cheap and easy-to-use microcontroller.
2009	Fitbit, a "wearable" fitness recording device, debuts.
2011	Nest, a programmable thermostat that learns the patterns of its owners, is introduced. Google later buys the company for $3.2 billion.
2015	The Apple Watch is launched as the leading tech company enters the wearable computer business.
2016	Cyberattackers use IoT devices to infiltrate Dyn, a domain name system company, and temporarily knock out the websites of Twitter, Spotify and PayPal.

Resources for Further Study

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Books

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The Next Step

Device Security

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Government Regulation

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Yoshida, Junko, "EU Privacy Rules Can Cloud Your IoT Future," EETimes, Feb. 23, 2017, http://tinyurl.com/zwwnn8f. In 2018, the European Union will implement the new general data protection regulation, which could cost violators up to 20 million euros (about $21 million) and affect major companies such as Google, Facebook, Microsoft and Amazon.

Organizations

Center for Democracy & Technology
1401 K St., N.W., Suite 200, Washington, DC 20005
202-637-9800
202-637-0968 (fax)
https://cdt.org
Non-profit organization working to preserve the user-controlled nature of the internet and champion freedom of expression.

Defense Advanced Research Projects Agency (DARPA)
675 N. Randolph St., Arlington, VA 22203-2114
703-526-6630
http://www.darpa.mil
U.S. government agency dedicated to spurring technological advances.

Federal Communications Commission
445 12th St., S.W., Washington, DC 20554
888-225-5322
https://www.fcc.gov
Federal agency that regulates interstate and international communications in the United States by radio, television, wire, satellite and cable.

The Internet Engineering Task Force
5177 Brandin Court, Fremont, CA 94538
510-492-4080
510-492-4001 (fax)

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https://www.ietf.org
An open international community of network designers, operators, vendors and researchers concerned with the evolution of the internet's architecture and its smooth operation.

Internet Society
1775 Wiehle Ave., Suite 201, Reston, VA 201950-5108
703-439-2120
703-326-9881 (fax)
http://www.internetsociety.org
Founded by Vint Cerf and Bob Kahn, two of the "Fathers of the Internet," the group's mission is "to promote the open development, evolution, and use of the internet for the benefit of all people throughout the world."

Notes

[1] Andrea Peterson " 'Internet of Things' compounded Friday's hack of major websites," The Washington Post, Oct. 21, 2016, http://tinyurl.com/h3adrmr.

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