

The Internet of Everything Is the New Economy

It is inevitable. It is here. Are we ready?

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The Internet of Everything (IoE) is potentially the biggest business opportunity in the history of mankind. It will change the world with extraordinary and wide-ranging implications, affecting everyone on the planet. Research firm IDC predicts that this massive shift will generate nearly US\$9 trillion in annual sales by 2020.

By comparison, the total annual sales of the San Francisco Bay Area's 150 largest technology companies in 2012 were \$677 billion. The total revenue of the consumer electronics industry in 2013 was about \$1.1 trillion.

A study conducted by General Electric concluded that the Internet of Things (IoT) over the next 20 years could add as much as \$15 trillion to the global gross domestic product (GDP), roughly "the size of today's U.S. economy." Of the \$19 trillion in profits and cost savings projected over the next decade, Cisco® estimates that \$14.4 trillion will be new private-sector profits, and \$4.6 trillion will come from public-sector cost savings and new revenues.

In its study, General Electric positions the IoE trend "much like the industrial revolution of the 18th and 19th centuries, when mechanized manufacturing made mass-produced goods possible, and rural residents flooded into cities." The study adds, "We are at the cusp of another wave of innovation that promises to change the way we do business and interact with the world of industrial machines."

The payoff of this so-called Internet of Everything could be staggering, especially for technology companies. It is estimated that the IoE market had a value of about \$1.3 trillion at the end of 2013. Three major technology areas valued above \$500 billion collectively (next-generation intelligent networking, inclusive technologies, and Big Data predictive analytics) are still wide open market opportunities.

IoE will change our daily lives, including the way we drive our car, use and save energy, manage healthcare, and live, play, and work. IoE will make people's lives easier, healthier, and safer. IoE will generate new and different jobs, higher wages, and more businesses. At the same time, boundaries of device authority, security and privacy, and universal cyber identity will increasingly be at the forefront of people's minds. That's to be expected. As it is said, "Every challenge is an opportunity in disguise." And most often, big opportunities come from addressing big challenges.

Inching Toward Utopia?

People will be the beneficiaries of this new IoE economy, which will create opportunities unknown today and transform every facet of society. People will be able to reduce waste, protect our environment, boost farm production, get early warnings of structural weaknesses in bridges and dams, and enable remotely controlled lights, sprinkler systems, washing machines, sensors, actuators, and gadgets.

Although we may never solve world hunger, in this new economy, some aspects of utopia could likely become reality. Imagine the following scenarios:

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- If resources were allocated based on people's needs, perhaps poverty and hunger could be significantly alleviated.
 - If we could track any device, virtual or physical, lost and stolen property would no longer be commonplace.
 - If we could eliminate parking problems and reduce urban traffic by 20 to 30 percent, auto accidents and road deaths could also decrease.
 - If improvements were made in waste reduction and management of street lighting, emergency notifications, traffic lights, and environmental monitoring, which saved South Korea \$13 billion in 2013, other countries and cities could achieve similar gains.
 - If factories could decide how to better produce goods on the assembly line, they could optimize energy and save about 20 to 30 percent on their energy bill.
 - If healthcare is location-agnostic, perhaps accessibility to equitable healthcare for everyone, regardless of socio-economic status, would improve.
 - If doctors and emergency responders could be alerted the moment that a patient falls or is injured, the comeback rate among elderly people who fall in their homes could improve.
 - If people were made aware of dangerous heart conditions, perhaps the rate of first-time heart attack victims who don't survive could be lowered.
 - If we could monitor the daily routines of our loved ones when they are discharged from the hospital, could we help them avoid feelings of alienation, or maybe even help them with their daily routine and extend their lives?
 - If built-in sensors were available for pill containers, could they reduce the 55 percent of the world's population who do not take medication prescribed by their doctors, and thereby save or extend lives?
 - If remote home healthcare was commonly offered, it might help eliminate the estimated 70 percent of doctor visits that are unnecessary and alleviate the baby boomer healthcare crisis.
 - If every part on an aircraft was monitored and could be quickly replaced at the slightest sign of failure, fewer plane crashes might occur.
 - If vineyard operators could know precisely when their grapes are perfectly ripened, wines would get even better (good news for California!).
 - If thousands of trashcans in college campuses and other busy places could be made "smart," waste-management officials could view online the amount of garbage accumulating in each container.

Meanwhile, the following scenarios are already unfolding:

- In Essex, England, cows are being connected to the Internet so that their movements from place to place can be tracked and illness detected immediately.
- In Croatia, milking sensors collect and send data about cows' milk production. Farmers can track feed consumption of their animals and quickly analyze the data.
- In October 2013, Starbucks unveiled plans to double the number of its Internet-linked coffee brewers, which track customer preferences. Starbucks also might hook up its refrigerators to the web, so the machines can order new supplies when needed.
- Monsanto, the giant agricultural company, is extending predictive data analytics into the world of big agriculture, disrupting established industries in a way that traditional computing never could. Monsanto will acquire knowledge about the condition of each of the 20 million crop lands in the United States: what is

grown on each crop land annually, the crop yields, and the water-holding capacity of the soil. Each of Monsanto's predictive simulations analyzes 5 trillion data points.

Why Now?

The IoE aligns with the Internet's fourth generation. After 20 years of research and standardization work, this latest generation is now possible because of advancements in the industry, market disruptions, and Internet laws.

The Internet of Everything is a short label for the new economy, which goes by other names. Often the Internet of Things, or IoT, which is one of the four pillars of IoE, is associated with connecting sensors and actuators to the Internet. Vincent Cerf calls it "The Internet of Things and Sensors and Actuators." Others prefer "Internet of Things and Services."

We are just scratching the surface of the new economy, but examples of the Internet of Things are already visible in various forms. These examples include remote home-monitoring technologies, wearable computing (such as Google Glass), self-tracking tools (such as Nike+ and Fitbit), and sensor-rich fabric, as well as intelligent energy and power systems, autonomous vehicles, retail tracking, automated inventory management systems, and much more.

Interestingly, Cisco Fellow JP Vasseur says, "The ironic part of IoT is that it is not about 'things,' but about reusing two decades of technologies we defined for the Internet to connect smart objects such as sensors and actuators and to enable new services. The technologies have been around for about 10 years. What really changed the game is standardizing protocols based on IPv6 in order to have building blocks."

So the first enabler, the enormous ability of IPv6 to address individual cyber-physical, virtual, and people entities (things), is finally becoming a reality.

Two more enablers are important here:

1. Drastic decline in cost and the incline of storage availability, both data center and cloud-based.
2. Enormous growth of global bandwidth availability, including the rise of Long Term Evolution (LTE) technologies for wireless communication of high-speed data for mobile phones and data terminals, broadband penetration, and Wi-Fi coverage.

Several market disruptions are driving IoE relevance: the exploding number of mobile-based end devices; the explosion (seven-fold for the last seven years) of cloud-based applications; and the role and impact of the social media phenomenon on people's lives.

Accelerated changes in the new Internet economy are based on Moore's Law and Metcalfe's Law. Some industry analysts also include the role of Big Data analytics with its ability to lower costs and create new revenues. Note that all three of these factors explain the exponential nature of the world in which we live. The new economy is expected to respond, profoundly affecting the following four major facets of daily life:

- **PEOPLE.** Most of the top-ten paying jobs in 2010 did not exist in 2004. It is possible that technical information in the world doubles every two years. For students starting four-year degree programs, this means that half of what they learn the first year will be outdated by their third year. In terms of people's ability to digest information, it is estimated that a week's worth of the New York Times contains more information than a person was likely to encounter in a lifetime in the 18th century.
- **THINGS.** The world of IT represents a fraction of the cyber-physical world. Only 0.6 percent of things are connected today. There were 1000 Internet devices in 1984, 1 million Internet devices in 1992, and 10 billion in 2008. 50 billion devices are expected to be connected by 2020. In 2011, the number of new things

connected to the Internet exceeded the number of new users connected to the Internet. It is hard to say, but probably between 2008 and 2011, that transformational moment occurred when the third-generation “Internet for the people” became the fourth-generation “Internet about things for the benefit of the people.”

- **DATA.** The first commercial message was sent by text in 1992. Today the daily number of text messages exceeds the world’s population. It is estimated that 4000 exabytes of data were stored in the cloud by the end of 2012, and the contributions from Amazon and Facebook amounted to 20 petabytes of data per day. That is more data than what was created by all humans in the previous 5000 years.
- **PROCESS.** To reach an audience of 50 million people, it took television 13 years, the Internet 4 years, iPod 3 years, and Facebook 2 years. In the future, the adoption of these and other media will drastically accelerate. We will solve problems we don’t yet encounter using computing power not yet realized. In 2013, the computer exceeded man’s computational ability. By 2049, a single \$1000 personal computer will likely exceed the 2009 population’s global computational capabilities.

All businesses, including healthcare, agricultural, industrial, and manufacturing, are now digital businesses. That’s why this revolution is based on the transformational role of digital technologies. Once again, the technology innovation will change the world, similar to the industrial revolution of the 18th century. But there is a difference: Today’s laws are IT laws (Moore and Metcalf), and the current market disruptions are Internet-based (cloud, mobility, and applications).

The change is much bigger than technology alone. The new economy will improve global living conditions. The new urban and big city technologies that we are about to enable will help people save energy, and drastically reduce urban traffic, public waste, and railway system accidents. CEOs and government leaders will become the IT managers of the future.

Shaking Up the Internet Industry

The IoE will require a new intelligent network and enormous data storage capacity, plus the computational capabilities yet to be identified. Per web visionary Marc Andreessen, “U.S. will need massive investment in existing and new networks for decades to come. Status quo not sufficient.” His words essentially are true for any country, city, and enterprise in the world. The investments will be in networks as well as intelligent networking, which is the only “thing” that may connect everything to everything and has the most profound impact on the quality of delivered services and products.

These requirements will challenge some of the evolving underlying laws, including those that will become obsolete. Moore’s Law, first described in 1965 by Intel co-founder Gordon Moore, outlines how the number of transistors on a chip regularly increases. However, the law is reaching its limits. Today’s microprocessors are reaching a point where they can no longer shrink. Fourteen nanometer silicon chips, transitioning for use in such devices as mobile phones, may eventually decrease to seven or even five nanometers. This may be the physical limit for chips as we know them. Such a change will require a radical innovation beyond Moore’s Law around new scientific, mathematical, engineering, and conceptual frameworks, according to the U.S. National Science Foundation. There is a need for new material functionality in states, or “molecular-based approaches including biologically inspired systems.” That new technology could be carbon nanotubes (rolled up graphene sheets), digital circuits delivering 10 times the benefit of performance and energy or computing.

We will witness the shift away from the singular “smaller, faster, better” to the multitude of intelligent/smart things, measured by an enabled mobile platform controlling, tracking, and processing many physical and virtual objects over a network simultaneously.

The first leaders of the new economies will be public- and private-sector innovators in the following key spaces:

- Big cities, governments, military, and public sector
- Gas, energy, oil, transportation, and other big industries
- Integrated circuit industry
- Networking industry
- Big Data analytics and data science
- Software development and application developers

The technology changes will drastically affect the Internet industry, our geopolitical state, and future society. It is no wonder that many government leaders are making relevant statements, city mayors are investing, and industry leaders such as Cisco, Intel, IBM, and Oracle have also been investing in the areas mentioned above. IT technologies and operational technologies are expected to merge when the IoT connectivity platform connects the “unconnected” to the Internet. That change will expand the role of the IT industry from the conventional IT world to the cyber-physical world. All this change and growth are expected to accelerate in the next three to five years, and will transform how IT and business enterprises are run.

So, Are We Ready?

During the 2014 Consumer Electronics Show, Cisco CEO John Chambers emphasized that: “This transformation is happening now. It will change the way people live, work, and play.” Unlike other waves of innovation that began in Silicon Valley, he believes: “This one will happen on a global basis at the same time.” Further, Chambers announced that Cisco plans to set up Internet of Everything innovation centers in Germany, Brazil, South Korea, and Canada. “We will build the infrastructure to make this work,” he said.

In this new economy, the key message to people is to *prepare* for:

- Living among millions of intelligent or smart devices across the globe
- Living and dealing with an incomprehensible amount of data, and making inductive (pattern-based) decisions based on data science versus deductive (hypothesis-based) reasoning
- Continual changes and evolution of devices and applications
- Data sharing as a business imperative
- Any application and data to exist on any device or thing
- More and more avatars in the IoE cloud, not only virtual versions of yourself such as on Facebook, but also virtual versions of your car, house, and other assets
- Living in an “economy of sharing,” where you subscribe to products versus buying them. That might change the whole model of how people and business operate and generate value.
- Being a “prosumer,” who consumes products and services, shares products, and offers services
- Living and participating in technocracy, where the nature of privacy will change

The World Internet of Things Forum in Barcelona recently identified security and privacy as top concerns. Devices and sensors will augment human senses and become the eyes and ears for companies, law-abiding citizens, and even for hackers. If things can be operated remotely and activated in the physical sense, we must exercise caution. Whether or not we reach a utopian-like state of technological advancements depends on our social desirability, and technical and economic feasibility.

The aggregation of huge numbers of objects distributed across geographic areas (i.e., 50 billion global devices by 2020) will require lightweight device integrity standards and protocols. These devices must be powered by a low-energy consumption and prevent intruder's access to objects to avoid physical damage or misuse of operations.

Furthermore, some emerging IoT-specific websites reveal a disturbingly high number of default passwords for devices all over the world. This practice makes them easy targets for hacking and raises questions about trust, boundaries, and authority of end devices, sensors, and actuators. Unacceptable scenarios involve devices making poor decisions based on wrong or limited information. People may never allow machines to make unauthorized safety decisions concerning their private property such as cars, embedded sensors, and an endless list of other personal possessions.

In the IoE, identity must extend beyond the conventional. If identity is compromised, the security perimeter is defeated. Simultaneously, creating a unified identity that addresses users in the physical and virtual world will continue to be a challenge.

The network that secures data sensor information, via wired or wireless networks, will become more critical. The IoE/IoT network must handle data from large numbers of sensor devices:

- Without causing data loss due to network congestion
- While ensuring proper security measures for the transmitted data, and
- While preventing external interference or monitoring

Technology may be affecting privacy more dramatically than anything else.

Each day we hear how peoples' privacy is invaded and how Big Data mines our online activities for profit. We are now beginning to understand the extent and power of these intrusions. In a few years, our faces alone, snapped by a camera on a street, in a crowd, or posted by a friend on the Internet, will be the key for a search engine to reveal the stories of our lives.

What is happening with our images and photos online is just one example of the digital reality: People in the IoE will increasingly live in a world of technological Panopticon, or pervasive visibility as a form of real or perceived power. Here, people may worry more about privacy than security. Is privacy protection an absolute value? How should we handle criminal acts that take advantage of the Internet's anonymity such as identify theft and acts of cyber terrorism? Mandatory safety, security, and privacy are accepted and commonly agreed boundaries.

Failure to establish correct identity and privacy boundaries can eventually circumvent security, render it useless, or violate privacy thresholds. This situation requires abandoning the outside-in paradigm of security and replacing it with inside-out security. Technologically advanced sensors and devices might prevent actions and enforce security policies. However, these policies must be developed with the appropriate balance of knowledge and discernment. In the business world, distributed denial of service (DDoS) attacks or large-scale False Flag attacks through the IoE can devastatingly affect operations, supply chains, and business partnerships.

The World Internet of Things Forum is working on finding wide-ranging security and surveillance applications, including surveillance of spaces, tracking of people and assets, infrastructure, and equipment maintenance and alarms.

As technological, social, and economic advancements continue, the new economy will present us with great innovative opportunities and great new challenges. IoE is inevitable. It is happening. It is here. Are we ready? Quoting a speaker at the World Internet of Things Forum in Barcelona, "If we don't wake up now, we'll sleep forever."

Hold on, because it promises to be quite a ride!

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