The Internet of Everything

Dave Evans

How More Relevant and Valuable Connections Will Change the World

While the Internet is not a cure-all, it is the one technology that has the potential to rectify many of the challenges we face.

This is the first in a series of three Cisco papers that will describe the impact of the Internet of Everything on enterprises, individuals, and countries now — and in the future. Upcoming papers will analyze the "Value at Stake" for enterprises, driven by the Internet of Everything; and provide an "IoE Value Index" — based on an exhaustive global study — for evaluating enterprises' readiness to realize the full value of the Internet of Everything.

Even with amazing advances in science, medicine, communications, and other disciplines, maladies like hunger, access to potable water, and diseases are still with us. As evidence, consider that over the past 50 years, the human population has nearly tripled, while industrial pollution, unsustainable agriculture, and poor civic planning have decreased the overall water supply.[1]

In addition, fragilities in the global financial system threaten to stall, if not reverse, years of economic progress. The rising cost of energy is causing instability among countries, increasing expenses for businesses, and adding to the financial burden of consumers. And rapid climate change, regardless of the cause, threatens our way of life by impacting the weather, agriculture, and much more.

While the Internet is not a cure-all, it is the one technology that has the potential to rectify many of the challenges we face. Already, the Internet, which has gone through several stages in its relatively short life span,[2] has benefited many individuals, businesses, and countries by improving education through the democratization of information, allowing for economic growth through electronic commerce, and improving business innovation by enabling greater collaboration.

So, what's next? How will the Internet evolve to continue changing and improving the world? The purpose of this paper is to address this important question in order to provide industries, individuals, and countries with the information they need to begin planning and making strategic decisions for the coming decade.

Internet Business
Solutions Group (IBSG)

As these "things" add capabilities like context awareness, increased processing power, and energy independence, and as more people and new types of information are connected, we will quickly enter the *Internet of Everything* (IoE) — a network of networks where billions of connections create unprecedented opportunities as well as new risks.

Where Are We Today?

As soon as the Internet was developed, there was a desire to connect more "things" to it. From the handful of computers that made up the Advanced Research Projects Agency Network (ARPANET) shown in Figure 1, the Internet now connects anywhere from 10 billion to 15 billion devices.[3] Even so, less than 1 percent of things are connected to the Internet today.[4]

Figure 1. ARPANET — The Internet Is Born.


ARPANET LOGICAL MAP, MARCH 1977
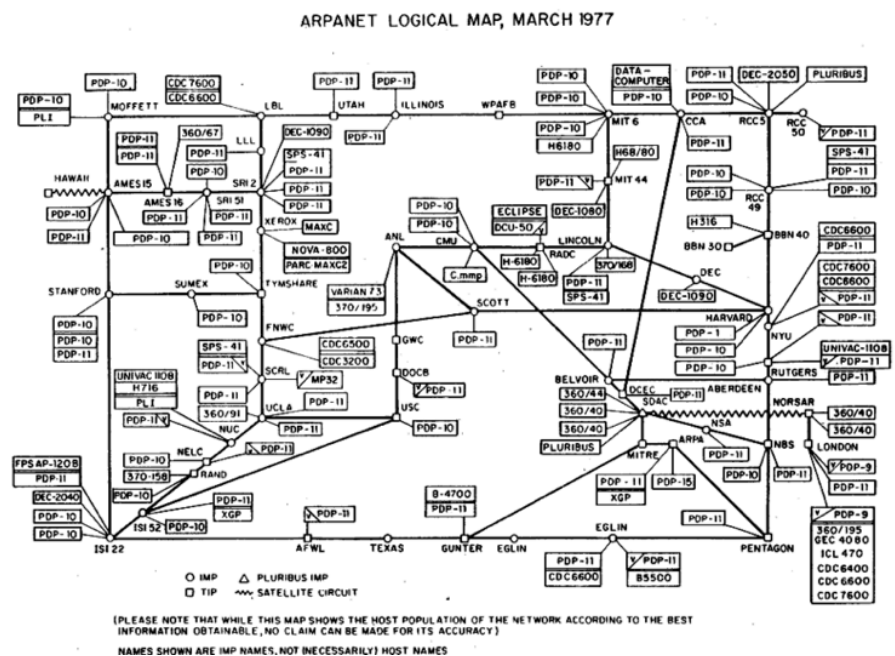
Source: ARPANET Completion Report, January 4, 1978.

In terms of phases or eras, Cisco believes that many organizations are currently experiencing the Internet of Things (IoT), the networked connection of physical objects and one of the many technology transitions creating greater value for organizations that embrace the Internet of Everything (IoE) (see Figure 2). As things add capabilities like context awareness, increased processing power, and energy independence, and as more people and new types of information are connected, IoT becomes an Internet of Everything — a network of networks where billions or even trillions of connections create unprecedented opportunities as well as new risks.[5]

Cisco believes IoE brings together people, process, data, and things to make networked connections more relevant and valuable than ever before – turning information into actions that create new capabilities, richer experiences, and unprecedented economic opportunity for businesses, individuals, and countries.

Figure 2.   Internet Growth Is Occurring in Waves.
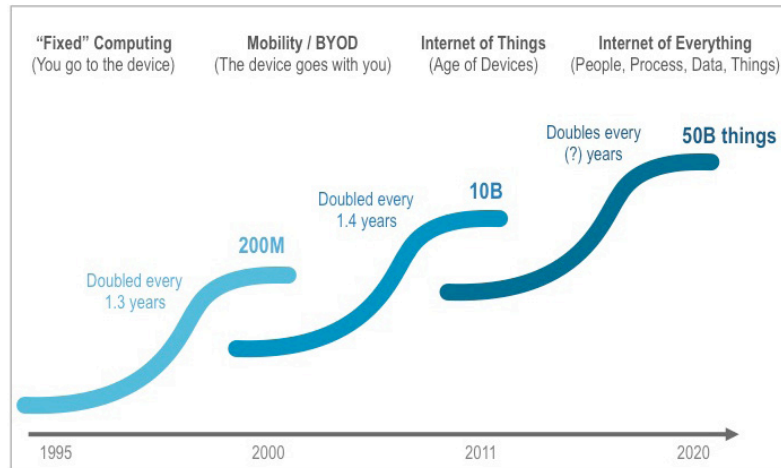
Source: Cisco IBSG, 2012

## The Internet of Everything:
Connecting the Unconnected

Before discussing IoE in more detail, it is important to come to a consensus around a common definition. Cisco believes IoE brings together people, process, data, and things to make networked connections more relevant and valuable than ever before – turning information into actions that create new capabilities, richer experiences, and unprecedented economic opportunity for businesses, individuals, and countries (see Figure 3).

To better understand this definition, we must first break down IoE's individual components.

- **People:** In IoE, people will be able to connect to the Internet in innumerable ways. Today, most people connect to the Internet through their use of devices (such as PCs, tablets, TVs, and smartphones) and social networks (such as Facebook, Twitter, LinkedIn, and Pinterest). As the Internet evolves toward IoE, we will be connected in more relevant and valuable ways. For example, in the future, people will be able to swallow a pill that senses and reports the health of their digestive tract to a doctor over a secure Internet connection. In addition, sensors placed on the skin or sewn into clothing will provide information about a person's vital signs. According to Gartner, people themselves will become nodes on the Internet, with both static information and a constantly emitting activity system.[6]

Rather than just reporting raw data, connected things will soon send higher-level information back to machines, computers, and people for further evaluation and decision making. This transformation from data to information in IoE is important because it will allow us to make faster, more intelligent decisions, as well as control our environment more effectively.

Figure 3. The What, Where, and How of the Internet of Everything.
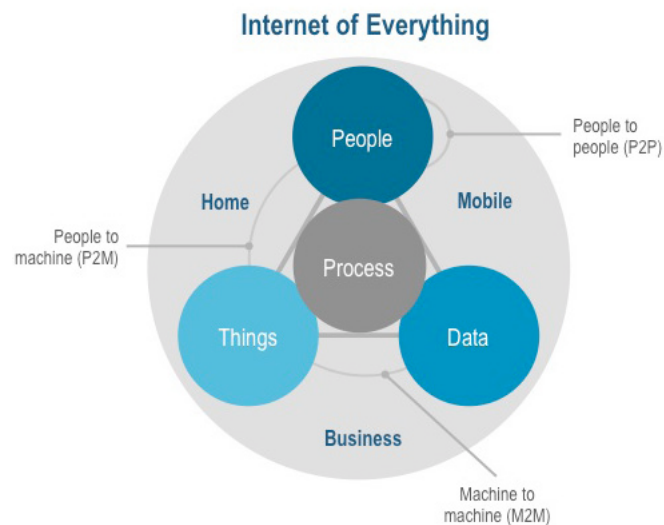
Source: Cisco IBSG, 2012

- **Data:** With IoT, devices typically gather data and stream it over the Internet to a central source, where it is analyzed and processed. As the capabilities of things connected to the Internet continue to advance, they will become more intelligent by combining data into more useful information. Rather than just reporting raw data, connected things will soon send higher-level information back to machines, computers, and people for further evaluation and decision making. This transformation from data to information in IoE is important because it will allow us to make faster, more intelligent decisions, as well as control our environment more effectively.

- **Things:** This group is made up of physical items like sensors, consumer devices, and enterprise assets that are connected to both the Internet and each other. In IoE, these things will sense more data, become context-aware, and provide more experiential information to help people and machines make more relevant and valuable decisions. Examples of "things" in IoE include smart sensors built into structures like bridges, and disposable sensors that will be placed on everyday items such as milk cartons.

- **Process:** Process plays an important role in how each of these entities — people, data, and things — works with the others to deliver value in the connected world of IoE. With the correct process, connections become relevant and add value because the right information is delivered to the right person at the right time in the appropriate way.

"The 21st century will be equivalent to 20,000 years of progress at today's rate – about 1,000 times greater than the 20th century."[7]

Ray Kurzweil,
Futurist, Inventor, Author,
and Entrepreneur

'Network Effects':
The Power of Connections and Exponential Growth

With IoE, networks of networks, built upon billions – and someday trillions – of connections create unprecedented opportunities, as well as new risks. Why? The answer lies in the exponential power of networks – commonly referred to as "network effects." Network effects are often associated with "Metcalfe's law," named after well-known technologist and 3Com founder Robert Metcalfe, which in its basic form states that the value of a network increases proportionately to the square of the number of users. Cisco believes the competitive dynamics of the next decade will fundamentally be shaped by organizations' efforts to harness network effects through the new (and deeper) connections afforded by IoE.

In fact, a core construct of IoE in the context of a "connections economy" is that value will accrue to those who best foster, embody, and exploit network effects. Much of contemporary management thinking, by contrast, focuses on linear responses to change. Simply put, humans tend to think in linear terms. Exponential change, as we see with the advent of the IoE, however, demands that our responses to change must themselves be exponential. Business and government leaders must move from being buffeted by chaotic network effects to generating and directing them to constructive ends.

While competitive dynamics are clearly being transformed, so too are the lives of individuals. As citizens, consumers, and businesspeople, we all encounter network effects in our daily lives: the World Wide Web, communicable diseases, tipping points, the wisdom of crowds, file sharing, social media, user-generated content, and financial contagion are all manifestations of network effects that have entered the popular consciousness in recent years. In a manner of speaking, a simple network effect is generated when participants (or "nodes") within a network are connected in a manner makes "the whole greater than the sum of its parts." *Network effects are at the heart of IoE.*

By combining people, process, data, and things, the exponential power of the Internet will allow us to create exponential responses to the extraordinary challenges faced by individuals, businesses, and countries.

The Internet of Everything in Action

The true measure of success will be the benefits delivered to humanity by converging people, process, data, and things. Because IoE will evolve over the next 10 years, it is important to explore both current and future examples. We also believe that IoE will impact individuals, businesses, and countries in different ways.

- **Individuals:** People experience the world through their senses (hearing, touch, sight, taste, and smell). In this context, IoE becomes an exponential proxy for sensing, understanding, and managing our world. With IoE, things that were silent now have a voice.

> "When the history of IoE is written, its success or failure will be determined by answering one question: How did IoE benefit humanity? In the end, nothing else matters."
>
> Dave Evans,
> Cisco's Chief Futurist;
> Chief Technology Officer,
> Cisco IBSG

- **Businesses:** Succeeding in business is all about delivering a profit. IoE will help businesses achieve this goal by creating new opportunities for greater optimization and efficiencies.
- **Countries:** While there are many forms of government, transparency is critical for countries to deliver services to their citizens. When correctly applied to ensure privacy, safety, and security, IoE will allow all levels of government to increase the level of transparency so that everyone benefits.

IoE Today

Transforming the World's Largest Cities. To revitalize the world's largest cities, City24/7 — a company committed to making public communications more accessible to everyone, everywhere — in collaboration with Cisco IBSG and the City of New York has launched an interactive platform that integrates information from open government programs, local businesses, and citizens to provide meaningful and powerful knowledge anytime, anywhere, on any device. In short, City24/7 delivers the information people need to know, where and when it helps them most.

Located at bus stops, train stations, major entryways, shopping malls, and sports facilities, City24/7 Smart Screens incorporate touch, voice, and audio technology to deliver a wide array of hyper-local (about two square city blocks) information, services, and offerings in real time. The Smart Screens can also be accessed via Wi-Fi on nearby smartphones, tablets, and laptop computers.

The overarching goals of the City24/7 Smart Screens are to:

- **Inform** by instantly connecting people with information that is relevant to their immediate proximity
- **Protect** by giving local police and fire departments a citywide sensing, communications, and response network that can direct needed personal and resources exactly where and when they are needed
- **Revitalize** by increasing levels of commerce, investment, and tourism

Once the Smart Screens have reached critical mass in New York City, City24/7 will start the second phase, which includes expansion to several major cities in the United States and around the world.

IoE Tomorrow

Conquering Climate Change. While it may seem out of reach today (and possibly laughable to some), IoE will eventually allow us to become better stewards of our finite resources by improving how we sense, understand, and even manage our environment. As billions and even trillions of sensors are placed around the globe and in our atmosphere, we will gain the ability to literally hear our world's "heartbeat." Indeed, we will know when our planet is healthy or sick. With this intimate understanding, we can begin to eradicate some of our most pressing challenges, including hunger and ensuring the availability of drinkable water.

To overcome these challenges, government organizations, standards bodies, businesses, and even citizens will need to come together with a spirit of cooperation.

- **Hunger:** By understanding and predicting long-term weather patterns, farmers will be able to plant crops that have the greatest chance for success. And, once the fields are harvested, more efficient (and, therefore, less-expensive) transportation systems will allow for the distribution and delivery of food from places where there is abundance to places where there is scarcity.

- **Drinkable Water:** While IoE may not be able to create water where it is needed most, it will have the ability to fix many of the problems that reduce our clean water supply, such as industrial waste, unsustainable agriculture, and poor urban planning. For example, smart sensors located throughout a city's water system will detect when there is a leak and automatically divert water to avoid unnecessary waste. The same sensor will alert utility personnel so that the problem can be fixed as soon as resources are available.

While these examples may seem "Pollyanna," consider how people, businesses, and countries could contribute to and benefit from all of the various components and processes that need to come together for this scenario to become a reality. The opportunities are nearly limitless.

Overcoming Barriers

Of course, IoE will face many hurdles as it comes to fruition over the next 10 years. Some of these challenges will be familiar, including security, privacy, and reliability, while other problems will require us to have open social and political discussions.

In addition to these challenges, many technical barriers will need to be overcome as IoE pushes the boundaries of what we know is possible today with regard to network protocols, storage, and analytics. For example, IPv6 must become a reality as the number of connections moves from billions to trillions. Other challenges include finding energy sources for powering the huge number of miniature (even microscopic) devices.

To overcome these challenges, government organizations, standards bodies, businesses, and even citizens will need to come together with a spirit of cooperation.

What Now?

In a world where the rapid pace of change has nearly rendered five-year business plans useless, why consider next steps? Simply stated, the more you can prepare for the future, the better off you will be when it arrives. And because of the tremendous amount of transformation and disruption IoE is expected to create, it is not too early to start planning for a world where more people, information, and things will be connected than ever before.

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Here are several thought-provoking questions to get you started:

- How do I set priorities to match the opportunities that will exist in the connected world of IoE?
- Given the impact the Internet already has had on my business, what happens when new categories of things are connected at exponential rates?
- What are the potential benefits and risks of IoE for my business or government organization?
- How should organizations be structured around information and processes?
- How will governance, control, and responsibility change in an IoE world?

As you consider your responses to these and many other questions, remember that IoE operates in an exponential world. The time to prepare is now.

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For more information, please contact:
Dave Evans
Cisco's Chief Futurist and Chief Technology Officer, Cisco IBSG
Email: devans@cisco.com
Twitter: @DaveTheFuturist

Join the conversation:
#InternetofEverything
#IoE

Endnotes

1. Born in the late 1960s, the Internet has evolved through several stages. These include (1) academia (ARPANET), (2) informational (brochureware), (3) transactional (e-commerce), and (4) social (Web 2.0). Currently, Cisco IBSG believes the Internet is entering the Internet of Things stage, and that the Internet of Everything will reach its full potential within the next 10 years.

2. Source: "The Internet of Things: How the Next Evolution of the Internet Is Changing Everything," Dave Evans, Cisco IBSG, 2011. It is interesting to note that today's smartphones are more powerful than ARPANET was in 1977.

3. Source: Cisco, 2012.

4. While we are just entering IoE, Cisco IBSG estimates it will take about 10 years for IoE to achieve its full potential.

5. Source: "Innovation Insight: The 'Internet of Everything' Innovation Will Transform Business," Gartner, 2012.

6. Source: Ray Kurzweil, May 2, 2003.

More Information

Cisco IBSG (Internet Business Solutions Group) drives market value creation for our customers by delivering industry-shaping thought leadership, CXO-level consulting services, and innovative solution design and incubation. By connecting strategy, process, and technology, Cisco IBSG acts as a trusted adviser to help customers make transformative decisions that turn great ideas into value realized.

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