IEEE Spark

IEEE

ENGINEERING INSIDE:

2016 ISSUE 3

THE INTERNET OF THINGS

The Internet of Everything

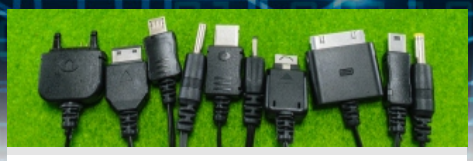
August 2016

Imagine waking up in the morning. Before your alarm even rings, the heat has come on, the hot water is ready, your coffee maker has begun to brew, and your blinds have begun to open. You go downstairs and take a box of cereal from the pantry and a carton of milk from the refrigerator, both of which you use up. You get a notification on your phone letting you know that cereal and milk have been added to your grocery list. When it's time to head to school or work, you climb into your car.

Meet Christine Miyachi!

August 2016

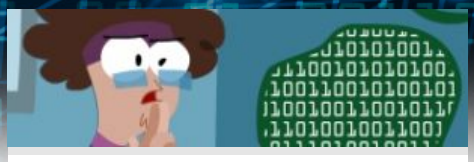
Christine Miyachi has over 25 years of experience working for startups and large corporations. She is the chair of the IEEE Computer Society's Special Technical Community (STC) on Cloud Computing and writes a blog about software architecture. She also is a principal systems engineer and architect at Xerox Corporation and holds several patents.



Design a Phone and Set the Standard

August 2016

One of the challenges in growing the Internet of Things is that connected devices need to be able to work together.In this activity, you will design and build a mobile phone to be compatible with a new kind of charger. After designing your phone, you will develop a technical standard describing what is required for a mobile device to be compatible with this new charger.



Data Driven Decision Making

See what the Spark crew is up to in this issue!

IEEE Spark Challenge

Think you know IEEE Spark? Test your knowledge of engineering, computing and technology with the IEEE Spark Challenge! Answer questions correctly to help your team move to the top of the leaderboard.

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by Robin Hegg

SMART OVEN

Imagine waking up in the morning. Before your alarm even rings, the heat has come on, the hot water is ready, your coffee maker has begun to brew, and your blinds have begun to open. You go downstairs and take a box of cereal from the pantry and a carton of milk from the refrigerator, both of which you use up. You get a notification on your phone letting you know that cereal and milk have been added to your grocery list. When it's time to head to school or work, you climb into your car. On your dashboard's build-in navigation system, the directions to your destination are already displayed and waiting for you. You buckle your seatbelt and turn on the car, which then it begins to drive you where you need to go, adjusting its route according to new traffic reports and communicating with other vehicles to get you there safely and efficiently. While you're away from home, your house adjusts itself to be more energy efficient, letting the water cool and the temperature drop until it begins to prepare for your arrival home at the end of the day. Blinds open according to the available sunlight to allow as much of the sun's heat to warm the house as possible. Should anything break or need attention while you're away, you'll receive an alert on your smart phone to let you know. At the end of the day, your house will be ready for your arrival, begin to dim the lights before you head off to bed, and move into nighttime mode.

This is what the future of the Internet of Things might look like, and it could be a reality sooner than you think. The Internet of Things is a term used to describe the network of devices (such as kitchen appliances, water heaters, refrigerators, thermostats, and even cars and buildings) connected to one another over the Internet and able to collect and exchange data. Experts estimate that between 20 and 30 billion devices will be

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connected to the Internet of Things by 2020, and they will impact all areas of life, leading to greater automation, efficiency, and convenience, while also presenting a whole new set of challenges and questions.

SMART THERMOSTAT

The Internet of Things could soon affect all areas of our lives, from running our homes more efficiently to monitoring our health and safety. In addition to connecting household devices and making it possible to control them remotely, the IoT opens up incredible opportunities for making energy usage more efficient. Devices will be programmable, remotely controllable, and could be programmed to anticipate their usage, turning themselves off when unnecessary. Electronic devices will also be able to communicate with the utility company, giving utility companies the information needed to better balance power being generated and energy being used.

IoT technology in smart cars and other forms of smart transportation would affect not just the vehicle, but the infrastructure, and the driver or user as well. Vehicles would communicate with one another, traffic could be controlled using real-time data to control traffic lights and reflow traffic, and free parking spaces could be detected and broadcast as needed.

In the medical field, a patient's health could be monitored remotely with automatic emergency notification systems in place. Blood pressure and heart rate monitors, hearing aids, and even pacemakers could soon be connected to the Internet.

The Internet of Things could even be used to monitor the health of our environment and infrastructure. Air and water quality, soil conditions, and wildlife movement could all be remotely monitored. Infrastructure such as bridges and railway tracks could also be monitored and controlled remotely using IoT technology. Sensors could alert people to any events or changes that might render the structures unsafe and allow more accurate and efficient scheduling of repairs and maintenance.


KEY FOB ARMING A SECURITY SYSTEM

Alongside the many incredible things the IoT promises to do come many concerns and questions, including some practical challenges. The Internet of Things will generate a tremendous amount of data from an enormous number of locations. This means it will be necessary to transmit, index, store, and process this data quickly and effectively. While the idea of the IoT is based on Radio Identification (RID) technology, which uses radio tags to identify objects, the IoT will use an unique Internet Protocol (IP) address for each object. Internet Protocol version 4 (IPv4), which allows for 4.3 billion unique addresses, doesn't have room for the influx of networked objects the IoT will bring. The Internet of Things will require use of Internet Protocol version 6 (IPv6), which has enough room for the huge number of unique addresses needed. This means, however, that global adoption of IPv6 in the coming years will be a critical component of the successful development of the IoT.

Another problem with the developing IoT is that with so many different manufacturers and engineers working on quickly developing technology, the resulting devices and operating systems may not be compatible with one

another. This means devices made by different manufacturers may not be able to communicate with one another, rendering them potentially useless. To try to solve this problem, technology leaders are joining together to create standards for how devices will communicate with one another. The AllJoyn alliance is composed of 20 world technology leaders working to develop standards and protocols for device communication. Other big companies, however, are still promoting their own protocols.

WI-FI ROUTER – STANDARD 802.11AC

While the IoT offers an amazing opportunity to increase energy efficiency and monitor the environment, the quick development of new semiconductor-rich devices also poses a large environmental challenge. These devices often contain heavy metals and rare-earth metals that are very damaging to mine. They are difficult to recycle properly and these rare-earth metals are infrequently recovered for reuse. Since the IoT also involves adding electronics to otherwise commonplace devices (like light switches and outlets), objects that might have lasted 50 years may now need to be replaced after 5, leading to a massive increase in waste.

One of the major concerns regarding the IoT is cybersecurity. The technology is developing very quickly and concern for the fairly major security challenges is often not a priority of technology companies. Because the IoT involves so many devices involved in our everyday, offline lives, cyber attacks could also become more of a physical than virtual threat. Hackers could use technology to spy on people through computers and televisions and have already shown that they were able to access smart cars' locks, brakes, engines, and hood and trunk releases. Medical equipment like pacemakers and insulin pumps could even become at risk for cyber attacks. In September of 2015, the Internet of Things Security Foundation (IoTSF) was founded to address these concerns. The foundation's mission is to secure the Internet of Things by promoting knowledge and best practices.


CAR WI-FI

The IoT also raises a lot of privacy concerns. There are already devices that can spy on their owners—internet-connected televisions with cameras and microphones, toys that communicate with children and record and transmit audio. The Internet of Things involves collecting massive amounts of personal data about users and their habits. Deciding how this data is collected, stored, and used is one of the big challenges in successfully developing the IoT. A report published in IEEE IT Professional Magazine titled "Privacy of Big Data in the Internet of Things Era" highlighted three main recommendations regarding major privacy concerns. First, that users need to be able to give informed consent to having their data collected. Users, however, have limited time and technical


IOT SECURITY

knowledge, and consent is often necessary in order for the device to work at all. The second recommendation was that both privacy protections and underlying standards should promote freedom of choice. The third recommendation was that user anonymity be prioritized as much as possible. Currently, IoT platforms transmit data without much attention to user anonymity. In the future, platforms could make data anonymous so users can't be profiled too heavily.

The Internet of Things is quickly developing and promises to impact nearly every aspect of our lives. This new technology could lead to greater energy efficiency, convenience, automation, information, and safety. Such a pervasive new technology raises new concerns and questions, particularly surrounding cyber security and privacy. The development of technical standards, cooperation by technology companies, and a deeper focus on security and privacy concerns will be central to making the development of the Internet of Things a successful one.

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Meet Christine Miyachi!

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Christine Miyachi has over 25 years of experience working for startups and large corporations. She is the chair of the IEEE Computer Society's Special Technical Community (STC) on Cloud Computing (**http://www.computer.org/cc**) and writes a blog about software architecture: **http://abstractsoftware.blogspot.com/**. She is a principal systems engineer and architect at Xerox Corporation and holds several patents. Miyachi graduated from the University of Rochester with a BS in electrical engineering. She holds two MIT degrees: an MS in technology and policy/electrical engineering and computer science and an MS in engineering and management.

1. Why did you choose to study the engineering field?
I took an aptitude test in high school. I was thinking of being a journalist. After taking an aptitude test, I scored much higher in the math and science section then on the verbal section. I started to explore the idea of doing something in that area. My guidance counselor suggested engineering and I was attracted to Electrical Engineering given the diversity of areas to work in.

2. What do you love about engineering?
I love the challenge of problem solving. I didn't grow up solving puzzles or breaking apart electronics. Engineering was something I discovered as an adult/ college student and I encourage everyone to try things they are new at!

A XEROX MULTIFUNCTION DEVICE INSIDE A RETAIL STORE. IMAGE CREDIT: CHRISTINE MIYACHI

3. Do you have a simple definition of The Internet of Things?
I use the word "Things" in software architecture and object oriented programming. A thing is another word for an object. So I consider the Internet of Things to be the connection of all objects.

USEFUL LINKS:

IEEE Cloud Computing Community
Xerox Extensible Interface Platform (EIP)
https://christinemiyachi.com

EDUCATIONAL BACKGROUND:

MS in engineering and management, MIT
MS in technology and policy/electrical engineering, MIT
BS in Electrical Engineering, University of Rochester

ADVICE TO STUDENTS:

Make sure you are up on the technologies you need for distributed computing like REST (Representational State Transfer) and other frameworks. Target specific companies and study their products. And be prepared for your interview. We have a number of IoT companies in the Boston area and it is a great place to work and live.

4. How did you first get involved with The Internet of Things? Share a project or inspiration with us please that prompted your involvement…
In 1985, I stumbled upon the "Arpanet", a precursor to the Internet. I connected to my first "thing", a Unix computer in California. I was in awe of being able to be on a machine that was that far away. While I am not directly involved in the Internet of Things in my work, I like to say the Internet of things found me. My work in networking and cloud computing and web services has drawn me in.

5. Can you explain a little about how you think the Internet of Things will impact everyday products or the world in general?
The world will become smaller yet again because of all these connected things. And what you do will become less and less private. One recent IoT example I read about was with automobiles. Most new cars collect a variety of data about the driver. One piece of information was the driver's weight. Some people really don't want their weight collected by other people! In addition, they had no idea that this data was and is being collected.

6. Is there a particular application or industry that you think could benefit the most from IOT developments in the future?
I think health monitoring will be bigger than it is today – and especially elder care, which is close to me right now, as my mom is an elder. Being able to monitor her care would be a huge comfort to me and give me the ability to help her more. I'm also a marathon runner and to monitor my training with data from all the lings I interact with (the road, my heart rate, my oxygen uptake, my foot strike, my sweat, the makeup of my sweat, my recovery heart rate, etc.) would help my fine tune my training in a great way.

7. What are the current challenges to the IOT? What's the biggest obstacle at the moment to IOT progress?
I think the biggest obstacle is the storage and analysis of huge amounts of data. Work needs to be done store and analyze smaller data sets. One way to address this is to break down the data as it is originally collected and get rid of what is not necessary for the analysis that needs to be done. For example, if automobile makers want to collect how fast their cars drive, they can collect that data and throw away other data (like the driver's weight). At another time if they want to collect data on the heat of the engine, they can get rid of the speed of the car.

There will always be a limit to the amount of data we can store and IoT designers and data scientists will have to get innovative on how to store it. New algorithms to compress the data could be a potential innovation.

8. Whom do you admire and why?

I admire Anita Borg and Grace Hopper – both were accomplished engineers and dedicated much of their life to inspire and mentor a younger generation of women in the field. Grace Hopper is recognized as one of the first software engineers. She was a mathematician and she programmed one of the world's first computers in the 1940s. I first saw an interview with her on TV in the 1980s when I was studying engineering and was inspired by her early work. Today there is a yearly conference for women in computing dedicated to her. I saw Anita Borg speak at MIT in the 1980s as well, who was also an accomplished computer scientist. She had a life goal of increasing the representation of women in


ADMIRAL GRACE HOPPER

technical fields and the group Systers and the Anita Borg Institute for Women and Technology.

9. How has the engineering field changed since you've started?
Processes for writing and designing software have improved, and tools give a strong hand in this. I first started in writing code with punch cards in 1980 if you can imagine that. In addition, many companies have diversified their work force which makes for stronger engineering teams and these companies reap the benefits.

10. What's the most important thing you've learned through your work with the IOT?
That my field is constantly evolving and growing and I need to keep learning new things all the time, which thankfully I enjoy. I have several ways I stay current. First, I am a member of several professional groups including the IEEE. The IEEE has many courses/ webinars/ and publications that I read on a regular basis. IEEE Software is a must read for me. In addition, I take college level courses in new areas both from local colleges and now with MOOC (like Edx.org and coursera.org.). The Khan Institute has some great courses as well. I'm always in the process of taking a class.

11. What advice would you give to recent graduates interested in working in the IOT movement?
Make sure you are up on the technologies you need for distributed computing like REST (Representational State Transfer) and other frameworks. Target specific companies and study their products. And be prepared for your interview. We have a number of IoT companies in the Boston area and it is a great place to work and live.

12. If you weren't in the engineering field, what would you be doing?
I'd be a journalist. I still love to write and I'm working on a book now. The book I'm working on has nothing to do with technology and is a novel, although it is a direct experience from my life. I write every day as part of my daily routine.

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Design a Phone and Set the Standard

August 2016

by Robin Hegg

One of the challenges in growing the Internet of Things is that connected devices need to be able to work together. With a wide range of competing manufacturers and operating systems, incompatible devices would slow the development of the Internet of Things and render some otherwise good devices useless. One way engineers work to solve problems like this across disciplines is by developing technical standards.

A technical standard establishes uniform criteria for an area of engineering or technology, setting a norm or requirement for an item, material, component, or system. They influence a wide variety of items, like computers, phones, medical devices, tools, power, energy, transportation, and even toys. They help to ensure that devices, networks, and power systems are safe, used ethically, and can work well together. IEEE Standard 802.11 allows your computer to connect to any wireless router, even if it was made by another company. In the mechanical industry, standards were developed for screw thread compatibility, allowing compatibility of tools and hardware across manufacturers and suppliers.

IEEE is the world's leading standards developer and also works to encourage and enhance standards education through efforts like **IEEE Standards University**.

iPhone chargers use the Lightning connector, a proprietary Apple connector. Most other phones use either a mini-USB or a USB Type-C connector. If there were a universal standard for phone chargers, people would be able to share chargers across phone brands and models. In the Internet of Things, standards will be needed to ensure that IoT devices are compatible and able to work together. This will be a major challenge as the IoT continues to grow and develop.

In this activity, you will design and build a mobile phone to be compatible with a new kind of charger. After designing your phone, you will develop a technical

DID YOU KNOW?

ATM's are considered to be the first Internet of Things objects.

As of 2008, there were more objects connected to the Internet of Things than people.

The Array of Things Project will be collecting real time data from the streets of Chicago starting summer 2016.

FIND OUT MORE:

You can also visit **TryEngineering.org** to explore other engineering activities and resources. Additional activities and lessons can be found **here**.

standard describing what is required for a mobile device to be compatible with this new charger.

Materials

Plastic fork
Paper
Pencil or pen
Building materials such as cardstock, construction paper, clear tape, glue, scissors, markers, plastic wrap, and aluminum foil
Ruler
Protractor

Steps

1. Examine the plastic fork. This is the new phone charger that has recently been developed. What properties does it have? Think about its size, shape, and other properties, taking measurements if needed.

2. Using paper and pencil, design a cell phone that would be compatible with the new charger. The fork's tines need to "plug in" to the cell phone for it to work.

3. Next, using the materials you've gathered, build a model of your cell phone.

4. Test the charger in your phone. Does it fit? Is it compatible? If not, make adjustments to your design until the two products work together.

5. Next, try to develop a technical standard that all devices will use in order to be compatible with the new charger. Thinking back on your initial observations of the charger, the data you collected about it, and your experience designing a compatible phone, what is required of a device in order to be compatible with the charger? Be as detailed and specific as possible.

6. To test out your standard, ask a friend to design a phone that is compatible with the fork charger based only on your standard. Were they able to successfully build a compatible device based on the information in your standard? Are there more details you need to add?

Questions

1. What did you notice about the charger right away? What other details became more important to you as you worked on designing and building your phone?

2. Did the charger fit your phone the first time you tried it, or did you need to make adjustments to your design?

3. What was it like to write a standard based on your experience? How did your initial observations of the fork compare with how you looked at it in writing the standard for it?

4. Was your friend able to design a compatible phone based on the standard you wrote? If not, were you able to pinpoint the missing information that led to the incompatibility?

5. Some standards are voluntary, meaning manufacturers can decide whether or not to follow it. Some are set up as guidelines for major buyers. Others are established as regulatory or legal requirements, making non-conforming products unlawful. How would your standard be used?

6. Some manufacturers choose to ignore voluntary standards. What are some reasons they might choose to do so? Why might a manufacturer decide to ignore your fork charger standard?

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Explore the IoT Home of the Future

August 2016

by Robin Hegg

The Internet of Things promises to revolutionize almost every aspect of our everyday lives, including the way we use the things in our homes and how buildings themselves function. Want to get a closer look at what the future of the Internet of Things will look like in your home? Check out IEEE's **IoT Home of the Future**. This online virtual tour will take you through a house equipped with IoT connected devices that can be programmed, communicate with one another, automatically respond to data received from other devices, and be controlled remotely.

ALL OF THE LIGHTS THROUGHOUT THE HOUSE WILL BE ON TIMERS THAT DIM AND GET BRIGHTER DEPENDING ON THE TIME OF DAY. YOU'LL CONTROL THE MOOD LIGHTING IN THE BEDROOM THROUGH YOUR PHONE OR VOICE, AND THE LIGHTING WILL HELP YOU GENTLY WAKE UP IN THE MORNING. IMAGE CREDIT: HTTP://WWW.DAVEWRIGHTPHOTOGRAPHIC.COM/

The **DOLL Living Lab** in Hersted Industrial Park in Albertslund, Denmark is another example of a real-life space utilizing smart technologies. The DOLL Living Lab's industrial park acts as a real-life laboratory and showroom where outdoor LED lighting technology and Smart City technology can be displayed, tested, and developed.

Want to learn about the Internet of Things in a uniquely visual way? Check out Information is Beautiful's **The Internet of Things: A Primer**. Or, check out these videos:

Verizon Internet of Things

How It Works: Internet of Things, IBM Think Academy

IEEE at CES Day 3: IEEE Member Peter Hoddie on the Internet of Things

To try your hand at the technical side of the IoT, check out camps like the **Microsoft Internet of Things Camps** or **ID Tech camps**. Learning open-source platforms like Arduino and Raspberry Pi can help you to connect devices and make them communicate with one another. If you want to try to connect devices in your home, check out the projects in our **Smart Homes issue** that use Arduino and Raspberry Pi to turn your home into a smart home using IoT technology. Smart Living Maker, a Building Management System (BMS) style dashboard can help you to connect and automate your devices and can be accessed on your computer or phone.

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The Internet of Things Initiative

August 2016

by Robin Hegg

In 2014, driven by the daily influx of new information about the Internet of Things and what it could do, IEEE Future Directions launched the **IEEE Internet of Things Initiative**. The IEEE IoT Initiative helps clarify and distribute the latest information about the Internet of Things and its potential to transform the way we live and the way machines work. The IoT Initiative also serves as a center for the global community of professionals working in IoT related fields across a wide range of industries, the government, and academia. It creates a central place where professionals can learn the latest information, share their knowledge, and collaborate as this exciting field develops. The IEEE IoT Initiative provides access to publications, interviews, videos, webinars, presentations, workshops, and conferences.

The IEEE IoT Technical Community is made up of professionals involved in IoT-related research and IoT implementation, application, and usage. The IEEE IoT Technical Community also works to better define the IoT through its collaborative document, **Towards a Definition of the Internet of Things**. It's hoped that this "living document" can help to create a better understanding of the Internet of Things.

The IEEE IoT Initiative also created the **IoT Scenarios** program, an interactive platform where members can explore how IoT technology is being used and look for implementations that will influence the development of this new and exciting industry.

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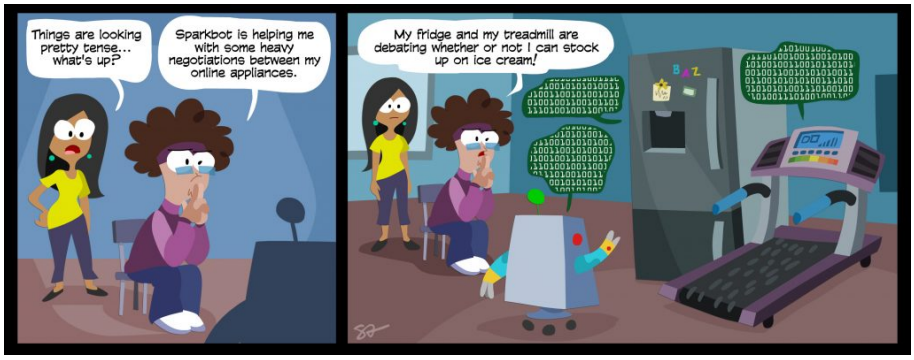

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IEEE Spark Challenge: Internet of Things

Think you know IEEE Spark? Test your knowledge of engineering, computing and technology with the IEEE Spark Challenge!

1) Which is not one of the features of Internet of Things devices?
    a. programmable
    b. remotely controllable
    c. can anticipate their usage
    d. can turn themselves off if necessary
    e. all are features

2) How many devices are estimated to be connected to the Internet of Things by 2020?
    a. 2 million
    b. 100 million
    c. 75 million
    d. 25 million

3) The Internet of Things is based on what technology?
    a. Satellite
    b. Radio Identification Technology
    c. Broadband
    d. Cable

4) Each device connected to the Internet of Things will have a unique IP address.
    a. True
    b. False

5) This alliance is composed of 20 world technology leaders working to develop standards and protocols for device communication.
    a. AllConnected
    b. AllAboard
    c. AllJoyn
    d. AllDevyce

6) Devices connected to the Internet of Things will need to be replaced less frequently than regular devices.
    a. True
    b. False

7) Which is NOT one of the concerns of the Internet of Things?
    a. data storage standards
    b. privacy concerns
    c. efficiency
    d. cybersecurity

8) To ensure operating systems and devices within the Internet of Things are compatible Groups like IEEE are developing
    a. connectors
    b. microchips
    c. standards
    d. rebates

9) Which is NOT one of the applications of the Internet of Things?
    a. Monitoring blood pressure
    b. Announcing parking spaces
    c. Monitoring air quality
    d. Controlling traffic lights
    e. All are applications

10) A new internet protocol will be needed to handle the influx of IP addresses the Internet of Things will bring.
    a. True
    b. False

IEEE Spark Challenge: Internet of Things
Answer Key

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