Internet of Things Becomes Next Big Thing

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ABSTRACT

If you thought grandma saw it all in her 90-plus years—from Kitty Hawk to *Mare Tranquillitatis* and from morning, afternoon, and evening newspapers to the first 24-hour Internet news blog—her grandchildren will have much more at which to marvel by the time their grandchildren are knee-bouncing.

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In the next century, planet Earth will don an electronic skin. It will use the Internet as a scaffold to support and transmit its sensations.

—Neil Gross, 1999

Technological innovation and development has seemingly become the new religion in Silicon Valley (some might consider it the center of the high-tech universe) and more recently within such disparate communities as Boston's "128 Corridor," as well as Austin, Dallas, Seattle, Chicago, and Miami.[1] Tech consumers, of course, are wired in and logged on all over the country and the planet, each minute collectively generating or consuming 640 terabytes of data, photos, and videos on their handheld computing devices, tablets, and, more recently, wearable devices.[2] With mobile phones the most prevalent example of popular technology (the most recent projection of worldwide smartphone devices is 4.77 billion by 2017), there are some amazing developing technologies that aren't quite ready for prime time but when they emerge, will be nothing short of astonishing, perhaps—literally—life altering.[3]

New technologies are often promoted by reference to the "Next Big Thing," which typically refers to a discontinuous, disruptive jump from one level of technology to another. Some Next Big Things have at least partially fulfilled the expectations placed on them. Uber, for example, has been extraordinarily

successful at facilitating and inspiring not just black car taxi rides but also the anonymous pairing of suppliers and customers, as well as being the precursor to automated transportation. At the less successful end of the spectrum, Segway's introductory hype in 2001 suggested the two-wheel transportation devices would soon replace wheeled transportation in urban centers. Not so much.

In the Journal's March and July 2016 Technology columns, I touched on a number of the technologies poised to lead to even bigger Next Big Things in the coming decade. Now, let's dig a little deeper into the Internet of Things (IoT), the connectivity of everything that seemed so remote a decade ago, which promises to utterly change the way we function and interact with our homes, offices, transportation, and health. While IoT is often criticized as being nothing more than refrigerators ordering more milk to prevent a midnight cereal snack crisis, consider this perfectly logical reason connected appliances make sense: Instead of a gas-leak alarm mindlessly beeping in your kitchen, shouldn't it "talk" to the faulty appliance and turn off the gas, while at the same time calling you on your smartphone and advising the local fire department of the degree of emergency, whether you're in the home or not?

Here Today; More Tomorrow

In 2016, more than 5.5 million connected devices are added every day, and IoT is well on its way to involving more than 20.8 billion devices worldwide by 2020.[4] We're not just talking lactose-tolerant appliances here; the IoT is the Next Big Thing. The following are but three current examples of ways in which Internet interconnectivity is already enhancing our lives:

- "Using your smartphone's range of sensors (accelerometer, gyro, video, proximity, compass, GPS, etc.) and connectivity options (cell, Wi-Fi, Bluetooth, [Near-Field Communications], etc.) you have a well-equipped Internet of Things device in your pocket that can automatically monitor your movements, location, and workouts throughout the day."[5]
- "Intended for individuals with cardiac arrhythmias the BodyGuardian is an FDA cleared wearable sensor system that can remotely read a patient's biometrics (ECG, heart rate, respiration rate and activity level), sending the data to the patient's physician and allowing users to go about their daily lives outside of a clinical setting."[6]
- "This smart lighting system from Echelon allows a city to intelligently provide the right level of lighting needed by time of day, season, and weather conditions. Cities have shown a reduction in street lighting energy use by up to 30% using solutions like this."[7]

IoT underlies almost all the emerging technologies touted in today's news. Driverless cars? That's only possible through interconnectivity between the road, online maps detailed down to 10-inch gridlines, and other connected data, including weather predictions and traffic reports. More personally, biotelemetry is the connection between your Apple Watch and your doctor's online computer with software monitoring the norm and alerting him or her of the abnormal.

Then, of course, there's Alexa—the voice-activated virtual assistant from Amazon. Eerily similar to HAL (the computer in *2001—A Space Odyssey*), "she" maintains an always-on connection to Amazon's mothership, making it easy to order products and services without even having to type "www."[8]

Downsides to Today's Innovative Technology

It's pretty cool to be able to instruct Alexa to play your favorite tunes, buy a book and have it delivered within two hours (in some cities), and determine whether you should take an umbrella or sun block before leaving the house for work. To what extent is Alexa listening to everything said in your home or office? We're not actually sure! And what about that IoT thermostat that so intuitively knows your schedule and makes certain the house is perfectly comfortable upon arrival? At what point does the manufacturer stop supporting it? And what is your

recourse midwinter as you huddle around the kitchen sink, burning the 120-page manual to keep warm?

These are not trivial concerns! Those 20-plus billion connected devices we'll have in the next few years are going to be very attractively positioned for convenience, economy, and even safety. Whether you are a "bleeding-edger" or late-to-the-party follower, we need to consider the questions to be asked of the manufacturers or resellers before opening an unprecedented level of access to you and your information. This is not to suggest your thermostat is going to turn into the *Terminator* series's Skynet, but we do need to know what our devices are revealing about us behind our backs!

On a larger scale, there's been much speculation about the degree to which our network of financial accounting and records, power transmission, oil and gas pipelines, and even water resources are vulnerable to cyberattack. The downside of connected technology is not merely that it may retain more personal information than we would like, but that those who would do us harm could do so in unprecedented and disastrous ways thousands of miles away from the attack.

Tomorrow: IoT Becomes the Singularity

No, this is not just the stuff of Star Trek™ and going where no one has gone before. Ray Kurzweil has written for years about the intersection of technologies that, taken together, bring us to an entirely different level of evolution—the "singularity."

Kurzweil is a scientist, best-selling author, and futurist. In his book, *The Singularity is Near: When Humans Transcend Biology,* Kurzweil predicts a technological singularity by the year 2045, "a point where progress is so rapid it outstrips humans' ability to comprehend it."[9]

A review of the book highlights that, "According to Kurzweil's law of accelerating returns, technological progress is moving ahead at an exponential rate, especially in information technologies."[10] Kurzweil suggests that we are at a point where the rapid increase in technological sophistication is in fact aided and further accelerated by the underling predecessor innovation. In other words, it is self-propagating via the IoT.

There are three major components of this evolution leading to singularity:

1. **The ongoing genetics revolution bringing forth the "intersection of information and biology."** Consider what's happened to the science of genetics in just the last 60 years: the mapping of DNA in the mid-1950s; the genome project begun in 1990 that, over 13 years and at a cost of more than $3 billion, assessed the 3.3 billion DNA base pairings of the human genetic spectrum; and the recent introduction of personalized genetic mapping for $1,000 with millions of DNA records accumulating to provide a big data understanding of human evolution and near-future medical miracles.[11] 3-D bioprinting, lab-grown tissues, DNA storage, and the rise of citizen biohackers are just a few examples of the accelerating genetics revolution.[12]
2. **The nanotechnology revolution and the "intersection of information and the physical world."** Kurzweil says nanotechnology "will allow us to redesign and rebuild molecule by molecule, our bodies and brains and the world in which we live."[13] Early nanotech research has provided advanced sunscreens, clothing, paints, and cars and current experimental nanotechnology includes "smart" contact lenses, tiny 3-D printed batteries, cancer-killing nanoparticles, and DNA-based computers.[14]
3. **The robotics revolution, "building strong artificial intelligence."** According to an article by Sveta McShane and Jason Dorrier, Kurzweil says robotics "is embodied artificial intelligence [AI]—but it's the intelligence itself that matters most. While acknowledging the risks, he argues the AI revolution is the most profound transformation human civilization will experience in all of history. Today's examples include speech and image recognition software, pattern recognition software for autono-

mous weapons, programs used to detect fraud in financial transactions, and Google's AI-based statistical learning methods used to rank links."[15]

Ethics of Tomorrow's Technology

Kurzweil observes that while these three revolutions largely came about independently of one another, they now synergize and build upon one another, and their convergence will ultimately lead to unprecedented power for good . . . or possibly harm. McShane and Dorrier point out it's about how well we guide revolutionary technology, and how we keep it transparent.[16] Both genetic technology and nanotechnology have long been the subject for medical ethicists to debate the difference between how far we can go versus how far we should go with the unprecedented technology of creating Human 2.0. And, as referenced in the July 2016 column, as early as the 1950s, scientist and highly regarded science fiction author Isaac Asimov applied his own sense of ethics to the purely fanciful science (at least then) of AI and robotics. Asimov's First Law of Robotics is, "A robot may not injure a human being or, through inaction, allow a human being to come to harm."[17]

That was science fiction; what can we expect from science? ■

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