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The "Internet of Things" (IoT) is often described as a collection of connected sensors, but it is actually a much more complex concept. It involves not only the connection and integration of devices that monitor the physical world—temperature, pressure, altitude, motion, proximity to something else, biometrics, sound, images, and so forth—but also the aggregation, relationship, and analysis of the information those devices create in order to take action on the situation, and the business and technology changes required to use the data and analyses. Some IoT devices—perhaps 20 billion or so—are already in place and connected through the Internet. However, this is only a small percentage (perhaps 1 percent) of the potential total. More importantly, the activities thus far to integrate, standardize, relate, and take action on IoT devices are at a similarly early stage.

Take, for example, the wearable activity tracker and the emerging industry of tracking physical and health activities. These devices are one of the most prominent offerings in the IoT pantheon. Made by such companies as Fitbit, Jawbone, Nike, Withings, LG, Samsung, Misfit, Garmin, and a host of others, these devices—typically mounted on the wrist, ankle, or belt—track the physical activities of the wearer, including steps taken, stairs climbed, sleep hours and quality logged, and distance traveled. Some can also detect and monitor pulse, blood glucose level, and other basic physiological parameters. These devices are popular, despite some growing pains typical to any new device category. Their potential benefits, however, are revolutionary in that they promise to accurately monitor and analyze health and fitness activity on a continuous, real-time basis.

However, activity trackers are only somewhat useful in their current state. Most of them measure only a few activities, vary in their reliability of measurement and physicality, provide little interpretive analytics, can present technical challenges to all but the most technically capable, and are poorly integrated with other health data devices, sites, and sources. Because they are a widely used consumer device, with many millions of global consumers stepping, sleep monitoring, and syncing to the IoT ecosystem, they make a good example for a discussion of the complex nature of the IoT, and we will employ them for that purpose in this article.

WHAT AND HOW LONG WILL IT TAKE?

As with the domain of health and fitness, the IoT has the potential to reshape a variety of consumer and industrial environments. But this potential won't be realized by focusing only on the power and connectivity of low-cost sensors. In order to be successful with the IoT, firms should be placing most of their attention on the integration, analysis, value-add, and action processes around IoT data. They need to focus not only within their own products and services, but outward to a complex ecosystem of partnerships and collaborations, with a variety of business and public policy motivations, which will have to be nurtured to succeed.

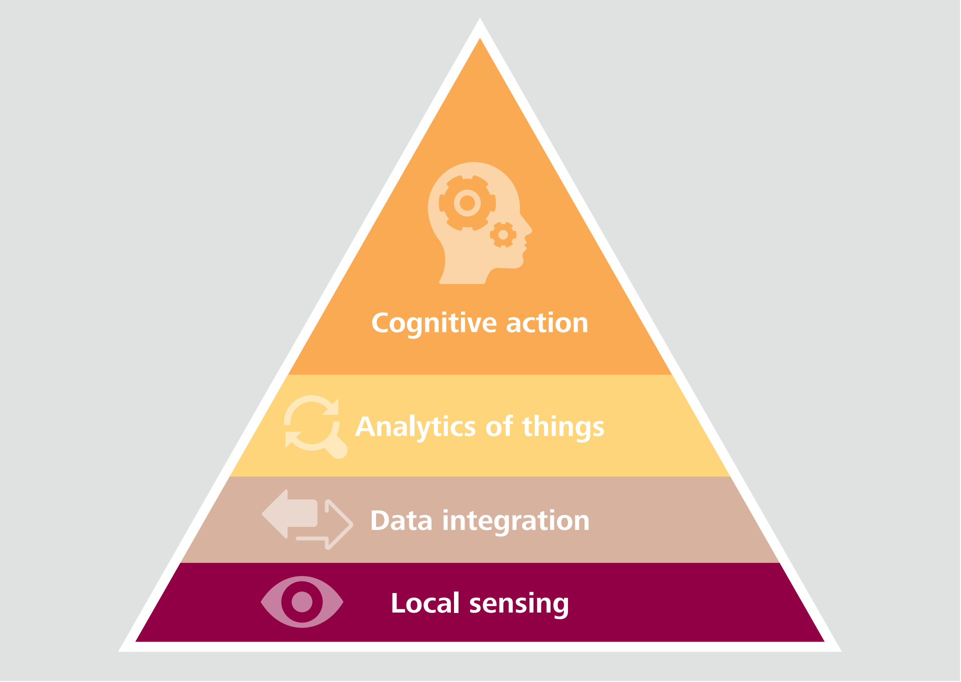
It's not surprising that health activity tracking isn't highly useful for serious health applications yet, because the first devices became available in 2006 (in the Nike+-shoe-based sensor). That may seem like a long time ago, but the necessary organizational and industry changes in the IoT are likely to play out over an even longer period. For example, one of the earliest IoT initiatives began in 1999 at the MIT Auto-ID Center, which was focused on the use of radio-frequency identification (RFID) devices in supply chain processes. A consortium of companies and universities succeeded in developing a suite of standards for RFID devices and data, and the adoption has accelerated as costs have dropped. However, it took 15 years to develop, implement, and scale this one suite of standards, which was called the Electronic Product Code (EPC). Even today the most common use of RFID in retail—apparel and electronics tagging—has less than 10 percent penetration. Despite the active participation of industry leaders such as Procter & Gamble and Sony in the standard-setting effort, it was slow, hard work to get agreement on the details. Such struggles to define and uniformly adopt standards have been experienced in many other industries and applications as well—video tape, digital music, electronic medical records, insurance, banking and securities interchanges, and e-book formats, to name a few.

If it took that long to develop similar standards for health activity tracking and the many other domains in which the IoT holds potential, the progress of the movement would be set back considerably. In this case, the consumer doesn't represent a few thousand manufacturers and retailers, but rather hundreds of millions, and maybe someday billions, of individuals. We need to do something differently this time. New facilities and tools such as cloud computing can perform some of the necessary translation of data without companies having to agree on every data field and format. Or smartphone standards could serve as a massive processing system to prepare and analyze data before flowing to the cloud. But industry dynamics, investment demands, profit motivations, and competing strategies will still come into play with the IoT, and companies should be focusing first on these types of issues. In short, it's not just—or even primarily—about the sensors.

WHAT DOES THE IOT REALLY INVOLVE?

There are several layers of activity mixed up in conversations about the Internet of Things (see figure 1). The most visible layer, at the bottom—the connected sensors that dominate the discussion among technologists—involves some complex and important decisions by the organizations implementing it. However, that complexity pales in comparison to the upper layers. It is these upper layers of IoT activity that, if not done well, can cause most IoT initiatives or products to struggle or ultimately fail. The true value lies in what is done with IoT information and, as with most business challenges, execution is everything.

Figure 1. The Internet of Things "stack"



Graphic: Deloitte University Press | DUPress.com

LOCAL SENSING

The lowest layer of the IoT is the ability to sense some aspect of the physical environment. An individual sensor typically measures a few components of a narrow reality—temperature, pressure, position and speed, a switch that's on or off. In activity tracking, the core sensor is primarily a three-dimensional accelerometer that detects your larger-scale movements. These data are typically then augmented by secondary components providing date, time, and potentially more sophisticated outputs such as GPS coordinates and biometrics.

At this local level of the IoT, the activity tracker is typically connected to one or a few other devices for simple actions and data gathering. An activity tracker, for example, can normally exchange data with your laptop or smartphone. The medium of connectivity at this local level is typically a generic communications standard such as Bluetooth or Wi-Fi, or even a wired connection such as a USB cable.

Many think of sensors and local control as the sum total of the IoT, yet machine-to-machine (M2M) communications are simply the lowest order of business. Local sensing is not by itself capable of orchestrating a complex process.

Furthermore, even within a particular IoT domain such as health activity tracking, there is considerable variation across devices in functions, data quality, and measurement approaches. To put it simply, the presence and size of a step taken are often a different construct from device to device. Sensors such as accelerometers are often developed by semiconductor and microelectromechanical systems (MEMS) firms, each of which may detect and measure something as simple as a step in a different fashion. If you bought several different trackers and compared your step totals on each of them at the end of the day, you would find considerable differences. Some can detect stair climbs and bicycle rides, and some can't. Some require the devices to be worn a certain way to detect certain types of activities. In addition, the other health functions incorporated into an activity tracker vary widely—from monitoring of heart rate to blood oxygen to skin perspiration to skin temperature. Each of these may be measured differently—and with different levels of accuracy—across manufacturers as well.

DATA INTEGRATION

All sensors collect and transmit data, but they do so in a variety of formats and data structures. Integration of the data is necessary for analytics and control to take place. In a car, multiple sensors have to send data to a diagnostic system that decides whether to turn on the "check engine" light or to notify you that you need to change the oil. With activity trackers, integration at the local level is necessary to transmit your tracker data to your smartphone—assuming you have the right phone and app.

But data integration is becoming increasingly complex to enable remote monitoring and action. Health activity trackers increasingly supply data not just to you, but to your social network, your physician, your hospital, and your health insurance company. Since activity trackers collect different types of data on different functions using different formats, the integration layer is a substantial challenge.

Developing the standards to aggregate data and control sensors remotely across different types of sensors and devices can be very difficult and time-consuming. A key challenge is partnering with other organizations on data and communications standards and integration issues.

At the moment, this is the most challenging area of the IoT. At the simplest level, if you're an activity tracker vendor relying on a smartphone vendor, at a minimum you must develop for both Apple and Google mobile operating systems. If you want to make your data available to a website or app that keeps track of an individual's health and fitness data, there are far too many options, including RunKeeper, HumanAPI, My Fitness Pal, WalkMe, MyFitnessSyncer, MapMyRun, Strava, Argus, Walgreens' Balance Rewards for Healthy Choices, Microsoft HealthVault, and many more. Fitbit, for example, lists 37 different apps or sites to which its tracker data can be transmitted. Jawbone's UP lists 30 apps with some overlap to Fitbit as well as some unique relationships and linkages. Application program interfaces (APIs) help with this integration, but there is still custom work involved for each integration partnership as currently no industry-standard API exists to span all devices.

Historically, the only way to speed up agreement on standards is for one dominant vendor in a category to establish a standard—think of Apple in iPhone apps that control a variety of devices (including the new HealthKit, which is oriented to interfacing with devices such as fitness trackers), for example. But there is probably no vendor sufficiently dominant to exercise full control over standards in even specific domains of the IoT such as health activity tracking.

The other option is to wait for a regulator or standards body to mandate a standard. This doesn't seem likely, and no government organizations have announced such standards for health activity tracking thus far. Stakeholders often come together and adopt standards through standards bodies such as IEEE and ISO, but this is often a long and sometimes contentious process. In activity tracking, such consensus doesn't even seem to have begun, and the economic incentives for device makers to do so have not yet developed.

Whether local or remote, integration and control requires some computing devices to convert and aggregate data and issue control instructions. At the local level, this concept is called distributed computing, edge computing, ubiquitous computing, and pervasive computing. In fitness tracking, this function is typically performed by your smartphone or laptop computer. But given the increasing and overlapping fitness tracking capabilities of wearable devices and smartphones, it's a bit difficult to know where the "edge" really lies.

The large-scale remote data integration and control functions in the Internet of Things are increasingly provided by cloud computing. What it provides is data transformation, utility storage, and computing in a centrally accessible way. Cloud computing capabilities can transform data into a common format that cuts across individual vendors and devices—so that companies participating in IoT networks can shortcut the 15 years of standard-setting with RFID. Agreeing on the common format will probably still take years, however. We see an entrepreneurial opportunity for cloud service providers to create the IoT integration layer that is currently missing from the ecosystem.

THE ANALYTICS OF THINGS

The IoT equivalent of the human brain is the cloud-based analysis of the data rising up from sensors to generate insights and decide on actions. Much of the benefit of the Internet of Things lies in our ability to leverage the (useful) data we collect with it. This is the "analytics of things," and this area has, in many ways, received the least attention of all. This is unfortunate, because it is analytics that can add the most business, lifestyle, and health value to the IoT. It has been said that "data without meaning, without soul, will not move people to change their behaviors over the long term."[1] Value-added analytics are what many early adopters of activity trackers believe has been most missing and disappointing.

Sensor data have some unique attributes, so related analytics are unique as well. The data are typically continuous and fast-flowing, so there must be processes for continuous analysis of the data. Technologies such as "complex event processing" and "event stream processing" bring the data to the analysis capability, where they are processed in real time, and then results are sent back where they are needed. Because there is so much data, a major focus of the analytics of things is anomaly detection. Is something broken in our operational network? Does a bike ride appear to be in the middle of a corn field? Are you about to end the day without reaching 10,000 steps? Analytics can identify situations that require some form of human intervention.

Some other typical analytical applications for the IoT include the following:

- Comparative usage—how your consumption of a resource (for example, calories) compares with others in similar situations
- Understanding patterns and reasons for variation—developing statistical models that explain variation
- Predictive asset maintenance—using sensor data to detect potential problems in machinery (or your body) before they actually occur
- Optimization—using sensor data and analysis to optimize a process, as when a lumber mill optimizes the automated cutting of a log, or a poultry processor automates the preparation of a chicken, or when is the healthiest time to go to sleep or when in your sleep cycle to wake up
- Prescription—employing sensor and other types of data to tell the user what to do, as when an activity tracker nudges you to get off the couch or sit up straight
- Situational awareness—piecing together seemingly disconnected events and relating them to a larger repository of data to put together an explanation, as when a series of readings from activity trackers, glucose monitors, connected scales, and other devices tells you that you are in danger of contracting diabetes

The analytics of things is often a precursor to cognitive action—taking action based on the results of analyzed sensor data. Comparative usage statistics, for example, might motivate an energy consumer to cut back on usage, while smart thermostats can monitor and optimize the household environment. Predictive asset maintenance suggests the best time to service machinery, which is usually much more efficient than servicing at predetermined intervals. A municipal government could analyze traffic data sensors in roads and other sources to determine where to add lanes and how to optimize stoplight timing and other drivers of traffic flow.

As we stated earlier, activity trackers aren't as sophisticated thus far with regard to analytics. Most of them provide only a few reports and graphs to describe recent activity. There is little evidence of predictive analytics, or prescriptive analytics that provide guides to action. But we can see a glimmer of what sophisticated analytics can do for our health from leading activity tracker vendors. An online review of one tracker provides an illustration:

> *Yes, it counts your steps. It even plots them on a lovely graph, and gets excited for you when you hit your goal a few times in a row. But the best thing about the Jawbone Up24 is what happens when you miss your goal. If you miss a few days in a row, you'll get a gentle reminder that hey, you might want to get up and get around a little bit extra today. If you're nearing the end of the day and haven't quite hit your goal yet, your Up24 will send a push notification encouraging you to muster up the energy to hit 100 percent.*[2]

This is what makes the Jawbone Up24 most special. Not only does it do everything it ought to, like tracking steps and sleep, it actually turns that data into something useful.

Jawbone created a "data science" team to create analytics from its data, and hired data scientists, data engineers, and data visualization specialists to create these features. We anticipate that other activity tracker vendors will take similar steps in the near future.

COGNITIVE ACTION

Just as the brain needs hands, feet, and speech to carry out its decisions, IoT networks need mechanisms of cognitive action if it's going to accomplish much. This is the business problem that the IoT is solving for your company or its customers. Like all business problems, solving it will involve change in organizational and individual processes, behaviors, nudges, and attitudes—which are often costly and time-consuming to accomplish. This fact alone suggests that cognitive action should be an early focus for IoT initiatives, rather than the afterthought it often is.

At this level, both humans and IoT networks can also be social. Just as a single human brain is much less powerful than an entire community working to address a threat or opportunity, interorganizational networks of connected sensors are much more powerful than those within a particular organization. The most effective cognitive action environments are those that work at the level of a partner relationship, an entire industry, or an entire city or country. These, of course, require even more attention to build and maintain than those involving a single organization.

The steps required to implement a system of cognitive action can be quite extensive, and will vary widely across different IoT settings. Consider, for example, what it would take to develop a widespread program of cognitive action in health and fitness. Some of these adaptations would be necessary:

- Doctors would have to monitor their patients' health-related activities as revealed by fitness trackers and other wearable technologies.
- Health care provider organizations would have to incorporate activity tracking data into their electronic health record systems.
- Patient compliance and usage continuity would need to be measured and perhaps fed into a "stickiness" score.
- Researchers would need to understand the relationship between physical activity and treatment protocols for various conditions and diseases.
- Health insurers would need to factor physical activity and patient engagement into their pricing and risk models.
- Governments and insurers might have to change reimbursement models.
- With money, privacy, and important health decisions at stake, all parties in these transactions would need to improve security and guard against hacking and data breaches.

These changes would take considerable time and energy to implement.

As a society we are very good at developing new sensor technologies. We can perhaps get much better at integrating data across diverse systems and sensors from multiple organizations, though that process could definitely use some work. The speed and accuracy of analytical models have improved dramatically over the last decade, though IoT versions need to catch up. Where we are truly slow as a society is in the human activities that allow IoT-based action: changing cultures, building skills, making political progress, establishing mutually beneficial incentives and reward structures, and committing resources to make all these changes happen well before they become a bottleneck.

This is true in a variety of sectors beyond health and fitness. Consider, for example, the use of sensors in transportation systems. We increasingly have cheap sensors available that can tell us the location and speed of locomotives, ships, trains, truck fleets, and airplanes. Some companies have begun to use them to track and optimize shipping routes, refueling, and safety. In general, the political, organizational, and individual-level changes necessary to fully benefit from these tools are still far away. Most progress thus far has been at the individual company level, which makes an intermodal, interorganizational system a distant objective.

Unions and companies find it difficult to agree on job rules for these new systems.[3] Many managers still have little inkling of what the IoT is capable of and how much business value it can deliver.

All of this suggests, of course, that it is folly to wait until all the technological kinks are worked out at the lower levels of the model to begin addressing the cognitive action issues. Since they take much longer to address, they should be the first focus for planning and preparation. Unfortunately, the sequence of activity starts in most organizations at the bottom of the stack, which means that the sensors are ready long before the humans and business applications are.

WHAT DOES THIS MEAN FOR YOUR IOT APPLICATION?

Given all these components of the IoT, there are some important decisions and perspectives that organizations should adopt in planning their IoT initiatives and applications. It is far too narrow to focus on a single level—for example, the question of what sensor functions to include in your product or devices. To find your place in the IoT, you first need to envision a broad end state for your industry and company. The end-state should address what types of products will be connected, what types of information they will collect and transmit, how the data will be analyzed, and most importantly, what business problems the IoT will solve for you and your customers. The end state vision should also address the implications of the IoT for your company's competitive position and ecosystem relationships.

Within the activity tracker industry, for example, the end-state vision should address how consumers, the health and fitness industry, and the health insurance industry will make use of the devices, functions, and data. How will the accelerometers in activity trackers interact with the activity trackers in smartphones? What other health-oriented functions might be included in wearable devices? How will all the information be integrated? How will organizations provide value-adding analytics? Whose behavior and business processes need to be changed, and in what direction? How might desired or optimal behaviors, actions, and outcomes be better realized through gamification, incentives, rewards, or nudges? And what is the business model that will support all of this?

Executives shouldn't worry too much about the details of how this vision will be executed; it need only be plausible at the early stage. It is also useful to have a timeframe in mind for when this end state will be realized and the incremental steps needed to get there. Of course, organizations will need to revisit their end-state visions for the IoT over time. There will be continued evolution in device costs and capabilities, data standards, integration approaches, and ecosystem structures.

Another important decision is the choice of partners and approaches to collaboration in achieving your IoT vision. No single company can define the IoT; there are simply too many different devices, capabilities, and services involved. As we've discussed, developing data standards is a key collaborative activity, but there are others as well, from sensor design to integrated business processes across an ecosystem.

The next decade or so will be one of progress in IoT technology. But the technology can have much more impact on our businesses and lives if we focus broadly on the entire collection of IoT capabilities. From the perspective of consumers, the IoT provides a diversity of individualized and aggregate data and insights previously unavailable to the masses. Couple that with gamification and social engagement with friends, families, and strangers, and users of the IoT can derive new and unique forms of value. The value comes wrapped in an often intoxicating "coolness" factor that millions of consumers are drawn to, as well as in huge revenue potential now and for the foreseeable future. And as consumers recognize and appreciate the continuum of value that the IoT provides them, they learn to anticipate and appreciate new features evolving from the aggregate insights that emerge. Through the IoT, technological change may make it possible to do without wires, but we can't escape the necessity of creating connections via planned organizational and inter-organizational changes. DR

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Endnotes

1. Janko Roettgers, "Stealth startup alert: Skype co-founder ventures into health and wearables with Project Florida", *GigaOM*, May 13, 2014, <https://gigaom.com/2014/05/13/stealth-startup-alert-skype-co-founder-ventures-into-health-and-wearables-with-project-florida/>.
2. David Pierce, "The best fitness tracker you can buy," *Verge*, August 14, 2014, <http://www.theverge.com/2014/8/14/6001153/the-best-fitness-tracker-you-can-buy>.
3. See, for example, this online commentary from the Teamsters union about the UPS "Orion" project for driver routing, which makes heavy use of sensor-based telematics data: Teamsters for a Democratic Union, "Meet ORION: Telematics on Steroids," January 3, 2014 <http://www.tdu.org/news/meet-orion-telematics-steroids>.