Through the looking glass: thinking through the internet of things

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Internet of things

The Internet serves as the foundation for a staggering array of connections between humans and computers all over the world. As a conceptual model, the "Internet of Things" (IOT) begs the question, what if the Internet expanded beyond humans and computers to include the other everyday objects that surround us? How would our relationship to those objects be transformed if they were integrated into larger networked systems through the Internet?

Companies of all kinds, including Intel, Microsoft, AT&T and DHL are all investing in the IOT, citing a variety of reports that estimate tremendous future growth. For example, a recent report by *Business Insider* predicts that by 2019, the IOT will be the largest device market in the world (overshadowing desktop computers and mobile devices combined) and create $1.7 trillion in new value, affecting business, homes, transportation, health care and government operations (Greenough, 2015). This column will explore how this technology might impact everyday life, and examine this technology's implications for libraries.

Many reasons exist to be skeptical of the exuberant forecasts about the influence of the IOT, not the least of which is that widespread adoption for many applications is predicated not entirely on technological advancements (e.g. LG launched the first Internet-connected refrigerator in 2000), but at least partially on presumed changes in cultural acceptance of these devices (Fletcher, 2015). Yet, almost regardless of the success or failure of any given product, the concept of the IOT is a model that is affecting investors and businesses of all types, and in turn, affecting technologies that are being developed today. By better understanding the IOT, librarians can therefore be better positioned to respond to developments as they emerge.

What is it?

In many ways, the concept of the IOT has not yet been set in stone. Experts are still struggling to define its parameters, even as they invest in its possibilities. For this column, the Wikipedia definition provides a starting point by defining the IOT as:

> [. . .] the network of physical objects or "things" embedded with electronics, software, sensors and connectivity to enable [an object] to achieve greater value and service by exchanging data with the manufacturer, operator and/or other connected devices ("Internet of Things," 2015).

This definition highlights the importance of physical objects transferring information using both software and the Internet. It also stresses the idea that the promise of the IOT can be seen most vividly when a large number of objects are able to connect to create a network of information to draw on rather than any single application connection.

To fully appreciate this point, it may be helpful to step back and consider how profoundly the Internet, which powers the IOT, has transformed our assumptions about technology. Everything from e-mail to large-scale research computing is powered by the robust and evolving infrastructure of the Internet (which was discussed in more depth in this column in Vol. 32 No. 3). Other technologies such as wearables (featured in Vol. 31 No. 9) and smart grids can also fit as a subset of the IOT, depending on what parameters are used.

The Internet allows digital technologies of any kind to share information and communicate. The IOT seeks to apply this same process to more mundane physical objects such as garage doors or milk cartons. Rather than using complicated interfaces, many of these IOT applications require only a simple sensor that provides passive, ongoing information about the object. Proponents of the IOT contend that if that data are used correctly, and therefore can provide meaningful information when added to our modern social environment when attached to objects throughout a library or home, it could have a potentially revolutionary cumulative effect. Google's executive chairman Eric Schmidt has even predicted that the IOT will mean that the Internet as a separate thing will disappear because it will be incorporated into everything around us (Mlot, 2015).

The library of things

Libraries already contain a number of individual objects, such as books, that are tracked by larger systems, making libraries an ideal fit for illustrating the concepts inherent in the IOT. Libraries may also track how many people enter and leave the building on a given day. Rooms may be equipped to turn off the light in the absence of motion to preserve power. At the circulation desk, libraries scan books and perhaps use systems to automate statistics-keeping about desk interactions. Some libraries even use Radio-frequency identification chips to track the exact location of books.

To take a simple use case, if all copies of a book at one branch were checked out, additional copies could automatically be ordered. On a larger scale, perhaps by using large data sets, we might discover that checkout trends in London have predictive power for what kinds of materials should be ordered in a library 600 miles away. By automatically monitoring and reporting use patterns of similar institutions,

individual libraries could use that information to adjust their hours.

Much of this information is already tracked, but libraries struggle to make use of it. For libraries to truly incorporate the IOT, as envisioned by its proponents, each of this data would not only need to be tracked but would also need to be more accessible through a more interconnected Internet infrastructure, rather than kept separately within individual library systems. For the IOT to be meaningful, it cannot simply automatically track data, but must also help libraries to make better decisions or interact with objects in new ways. The most obvious benefit of the IOT is not the sensor on the object but instead is the ability to automate the tracking and sharing of that information.

Before the World Wide Web revolutionized the Internet, many computers operated using local networks. Before social media, people hosted their own blogs, and before blogs, people printed their own self-published magazines (zines). But with each step, the communication process became easier and more automatic and facilitated new kinds of interactions, even as the fundamental technology remained similar.

Much like the IOT, the Library of Things would enable libraries to compile information about their collections and spaces and use software to make those connections meaningful. Moreover, not only would the library be able to communicate internally, this information could be compiled and used at other locations. This could apply within a library system or around the world.

How could it start?

To provide a more vivid example of the IOT in practice, the online retailor Amazon recently announced the Amazon Dash. The Dash uses small buttons that are designed to be connected to an Amazon account. Users are supposed to place these buttons in their home near products that need to be restocked from time to time. The premise is that when you are nearly out of something, for instance, laundry detergent, you can scan an item's associated button with your Dash, and Amazon will automatically ship more to your home. This service is designed to transform your existing home into a shopping catalog for repeat purchases, as well as situate Amazon as the default provider of those purchases.

If successful, Amazon Dash will represent a small step forward in meaningfully integrating everyday household objects with its existing storefront interface. This allows Amazon to tap into an existing retail-based ecosystem rather than create one from scratch. Unlike many proposed applications of the IOT, the major barrier for Amazon Dash is not technological, but rather cultural. Users must decide that the added convenience is worth the potential privacy risks, as well as the effort it takes to set up.

Home

For the IOT to be successful then, it must find niches where it can create a working ecosystem. The next logical step after Amazon Dash is to apply the same logic to consumables that automatically report when they are getting low – for instance, a carton of milk with a sensor in it that beams a signal to an Internet-connected refrigerator when the milk is getting low. The same sensor could also send a signal to the homeowner's smartphone the next time he or she is near a grocery. In turn, the homeowner might pass their need for milk on to the store (either automatically or on an as-needed basis) to ensure they have milk waiting for them when they arrive. Taken cumulatively, such a system could even inform the grocery of how many homes in the area are running low on milk, allowing it to more effectively stock inventory.

Within the home, many such appliances have similar applications. Some could be brought into the IOT due to reasons of cost savings. Home thermostats (as well as hot water heaters) could be easily monitored and controlled remotely. Simple sensors could be added to security systems, garage doors or even stovetops, for increased ease of mind and to alleviate security concerns. This same logic could be integrated into third-party systems that could add an additional layer of convenience to help make decisions without any direct input from the homeowner, creating an entire home that is interactive and able to make recommendations about its own upkeep.

Health care

Health care is another area that can shed light on how the IOT may develop beyond individuals. First, health care involves something that people already truly value, their health. Second, large parts of the health-care industry already operate in a highly controlled environment that is tasked with spending large sums of money if that spending will create better outcomes.

A recent report by Atlantic Council and Intel Security estimates that "cyber-physical systems" (which include wearables and other related technologies) could save the industry $63 billion over the next 15 years (Healey *et al.*, 2015). More importantly, the report also predicts that these devices may significantly improve health care by giving doctors and patients more reliable information about how products are used.

The World Health Organization has reported that approximately half of all patients fail to take their medication as instructed. Pills with small sensors inside them would inform providers when the pill was taken and therefore help ensure compliance, both by monitoring as well as helping to inform more effective protocols (Dance, 2011). While this might not matter with some medications, for a variety of cases, from tuberculosis to high blood pressure, not taking the medication as prescribed can have very serious consequences.

This same principle can be applied to a variety of preventive health-care situations. Potential applications include everything from checking insulin in diabetics, to providing real-time information about an infant's nighttime behavior. The ability to passively and easily track more aspects of people's lives could be a major boon to early detection of ailments. Rather than relying on visits to a physician's office for every issue, this kind of monitoring would enable new fields of detection that rely on small variations in heart rate or other vital statistics over a longer period of time. Over 85 per cent of health-care spending in the USA

involves a patient receiving treatment for a chronic disease and many chronic diseases are particularly well suited for treatments that focus on regular, passive monitoring rather than frequent patient visits to a physician (Ward *et al.*, 2014).

Automobiles

Contemplating the automotive industry can yield further insight into how the IOT might transform society in the future. In this case, the vehicle itself is already a large, complicated piece of technology. Its transition to an Internet-based thing is, on the one hand, a matter of adding an Internet connection to the array of entertainment options, such as TVs, radios, etc., that already exist onboard. Most obviously, entertainment options could be enhanced and supplemented with location data about the driver, similar to the ways many applications on mobile phones already work. For example, information about the grocery visit you need to make (based on the empty carton of milk) could be communicated to the vehicle's GPS.

However, the possibilities expand if we consider the car itself to be an object that needs to communicate with its environment. The sensor that already exists in the car's gas tank could be made accessible and inform the user's experience at a gas stations. Similar to health care, the process of car repair could be revolutionized if, instead of waiting for a problem, passive sensors searched for opportunities to conduct preventive maintenance at all times (which is already happening in many vehicles).

Efforts to create driverless cars can also fall under an expanded definition of the IOT. Here, the power of the IOT becomes truly evident. Not only could a driverless car enable information about other objects to be translatable into actions (such as where the car goes), the car itself could provide beneficial information about the location of other objects. For instance, other driverless cars could provide data about road conditions and their own location. The existence of sensors built into roads and other nearby objects could both guide the car and inform the car (and its driver, if needed) of the best route.

The role of libraries

The Internet is the connecting thread that takes the information about a person's health, about the garage door or about the library book, and transmits it to software and people that can make sense of it. The potential benefits of this integration are enormous, as is the potential for abuse. Both the software and the security of the connection itself are of importance to libraries that are interested in privacy and public good. Already, some of these devices have experienced hacking, and the implications are immense, as the objects that are integrated into daily life become susceptible to privacy invasions. Already there are high-level discussions about what kinds of regulations and infrastructure will be necessary to ensure a safe and secure IOT. As the technology develops, libraries and other advocates will have continued opportunities to engage with their patrons about these issues.

In addition to providing general information, libraries are part of one of the biggest theoretical debates right now: framing how open the infrastructure that underpins the IOT will be. In particular, it matters if the IOT is created as an open system or a closed one. Each object will be connected to the Internet, but that connection can be designed in any number of ways. Clear advantages and disadvantages exist for each, and how open the system should be will vary by the application and the industry.

As highlighted previously, the underlying network of the Internet was around long before the World Wide Web helped it to revolutionize the world. The World Wide Web created an open system of protocols that facilitated connections, and the transference of information was on a scale that was unprecedented. In this context, it is worth recalling that, in the words of Boyle (2008), "Openness is not always right. Far from it. But our prior experience seems to be that we are systematically better at seeing its dangers than its benefits". As he highlights, one can easily imagine the benefits of a closed Internet: it would be easier to stop viruses, spam and misinformation. Yet, it is only through an open system that one can imagine something like Wikipedia emerging.

Conclusion

The very thing that makes the IOT appealing – its ability to constantly transmit simple information about relatively mundane objects to make our lives more convenient – is also what makes it an area for serious privacy concerns. As the IOT becomes operational and manifests itself in the real world, libraries have a role to play to implement the IOT in their own environments in ways that align with their values. Libraries can begin to envision what these changes will mean for them, as they make long-term plans and determine what kinds of security will be necessary for them to incorporate the IOT into their own operations. If the history of related technologies, such as wearables, is any indication, we cannot count on technology companies to invest in security on the front end unless there is an active demand for it.

This developing network is also an opportunity for libraries in the next decade to be active participants as it develops and experiences setbacks. The end result might not look much like what is envisioned today, but given the active participation from so many sectors of the economy, the IOT is setting the framework for the technologies that are being developed. Moreover, as it develops, the IOT will create and share new types of information about the world. Libraries are repositories of information and, therefore, have a role to play in the conversation about how that information is stored and transmitted.

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