The Internet of Things: A primer for information professionals

Matt Moore and Kelly Tall*

This article explores the impact of the "Internet of Things" (IoT) on the information profession and on society more broadly. It begins by outlining the technological developments that have driven the development of IoT. It continues by exploring some of the emerging applications that we can see now and in the near future – with a particular focus on homes and our bodies. It then discusses privacy and security concerns. It ends with observations on the impacts of these technologies on information professionals.

INTRODUCTION: BUSY PLANET

What were you doing in 2008? Whatever you were doing, it is unlikely that you were celebrating the eclipse of the human race (although the global financial crisis may have given you some cause to do so). According to Cisco,[1] in 2008, the number of things connected to the internet exceeded the number of people on earth. These "things" are not just media devices directly controlled by human beings (computers, laptops, phones, tablets) but include sensors attached to plants, animals, cars, buildings and factories.

The IoT is now "a thing". It is a topic of discussion, speculation and investment. Like many of the topics we discuss in these articles, it is almost certainly a source, and cause, of hype. However, the broad range of technologies under the IoT heading are real and will have a long term impact on our personal and professional lives.

This article begins by outlining the technological developments that have driven the development of IoT. It continues by examining some of the emerging applications that we can see now and in the near future, and considers privacy and security concerns. The article concludes with observations on the impacts of these technologies on information professionals.

TOUCHES AND WHISPERS: CONNECTING THE IOT

The IoT is enabled by a number of different technologies. The first set of components is the data-generating sensors that are attached to things (ie material objects). The second set of components is the internet – the network of networks that allows the transmission of data between individual sensors and also the broader systems of which they are a part. The final set of components are the analytical processing systems that can take the sensor-generated data, draw inferences from it and then take action based on those inferences. Human beings may or may not be part of this process – therefore sometimes this is referred to as Machine to Machine (M2M).

Data-generating devices have been around for decades. Over this timeframe, these devices have become smaller and more sophisticated. In 1965, Gordon Moore[2] stated that: "The complexity for minimum component costs has increased at a rate of roughly a factor of two per year".

In his seminal paper, Moore also noted:

* Matt Moore has spent 15 years working in knowledge and information management, learning and development and internal communications with organisations such as IBM, Oracle and the Australian Securities and Investment Commission. He lectures at the University of Technology Sydney and is a former chair of the New South Wales Knowledge Management Forum.

Kelly Tall is an experienced market researcher with a passion for data visualisation. She has worked with many well-known global and Australian brands.

[1] Cisco Systems, *Cisco Vizualisations - The Internet of Things* (2011) http://share.cisco.com/internet-of-things.html.

[2] Moore G, "Cramming More Components onto Integrated Circuits" *Electronics* (19 April 1965) pp 114–117 http://www.cs.utexas.edu/~fussell/courses/cs352h/papers/moore.pdf.

> Integrated circuits will lead to such wonders as home computers–or at least terminals connected to a central computer–automatic controls for automobiles, and personal portable communications equipment. The electronic wristwatch needs only a display to be feasible today.

Over time, Moore's law was adjusted to read that "that computer performance was going to double every eighteen months".[3] As Moore foresaw back in 1965, these computers have disguised themselves as things like mobile phones. They have also become embedded in other everyday devices like refrigerators, heating systems and cars. Since the mid-1990s, cars have become increasingly filled with sensors (around 100 per car at present) connected together by a Controller Area Network (CAN) – your car is its own IoT. Incidentally, this drive for onboard computing was initially propelled not by a need for speed from petrol heads but a need to monitor air pollution for government regulators.[4] Triggers for innovation can come from unexpected places.

Many of these sensors are not particularly "smart". Radio Frequency Identification (RFID) tags do not store or process massive amounts of data themselves – much as barcodes do not hold all the data about an item but allow a computer to match the barcoded item to a more extensive record elsewhere. RFID tags consist of a tiny circuit and an antenna. The circuit stores data and can modulate/demodulate radio signals and the antenna receives and transmits radio signals. RFID tags can be active or passive. Active tags have a battery and periodically broadcast their signal. Passive tags are activated by radio transmissions from a tag reader (though there are also battery assisted passive tags). While passive tags are smaller and cheaper, the reader needs to transmit up to a thousand times as much radiation to read them which can cause issues such as interference. In 2014, 6.9 billion RFID tags were sold – the majority of these were passive tags. These tags are used in contactless cards, tracking clothing in supply chains and stores, car clickers, medicine, manufacturing and smart meters.[5]

Why is the IoT gaining more attention now? In part, this is a function of the decreasing cost of technology that Moore identified 50 years ago. RFID tags are not the only hardware involved in IoT systems – other technologies include microelectromechanical systems (MEMS) and wi-fi routers. All of these components have fallen in price by 80 to 90% over the last five years.[6] Meanwhile the applications capable of managing and analysing the data produced by these sensors have grown in sophistication.[7]

THE IMPACT OF THE IOT

Technologies such as RFID and MEMS are of great interest to engineers but are not intrinsically interesting to anyone else. The IoT will be different to the internet of people in that much of it will be invisible to general users. In the 1990s, the internet was visualised as a place that you visited ("cyberspace"). You won't necessarily visit the IoT but you will see, hear and feel its effects. In the next section of this article, we will examine two key areas where these effects may occur.

Homes

The automated, "smart" home has been a concept that has been around for over a century and yet the technology never really lived up to the promised reality and demand remained subdued. Over the last five years this has begun to change. Smart locks, smoke detectors, lights, thermostats, blinds and kitchen appliances are now available. As of mid-2014, a survey found 10% of all US households have

[3] Intel Corporation, "Excerpts from *A Conversation with Gordon Moore: Moore's Law*" (2005) http://large.stanford.edu/courses/2012/ph250/lee1/docs/Excepts_A_Conversation_with_Gordon_Moore.pdf.

[4] Nice K, "How car computers work" *HowStuffWorks.com* (2001) http://auto.howstuffworks.com/under-the-hood/trends-innovations/car-computer.htm. Wojdyla B, "How it Works: The Computer Inside Your Car" *Popular Mechanics* (2012) http://www.popularmechanics.com/cars/how-to/repair/how-it-works-the-computer-inside-your-car.

[5] IDTechEx, *RFID Forecasts, Players and Opportunities 2014-2024* (2014) http://www.idtechex.com/research/reports/rfid-forecasts-players-and-opportunities-2014-2024-000368.asp?viewopt=desc.

[6] Witchalls C, "The Internet of Things business index: A quiet revolution gathers pace" *The Economist* (2013) p 10 http://www.economistinsights.com/analysis/internet-things-business-index.

[7] Moore M and Tall K, "Big Data for information managers" (2013) 27 OLC 3.

at least one smart device – although this survey also found low levels of awareness about these products among the majority of heads of households.[8]

A significant event in the smart home space occurred in early 2014. Google acquired Nest for $US3.2 billion. Nest does not make products directly connected to Google's core search business. Instead they make thermostats and smoke alarms. However, these are network-enabled devices. The thermostat can learn your routine and automatically set itself – with a claimed 20% reduction in heating and cooling bills.

On their own, Nest gadgets are useful. They become more compelling when they start integrating with other systems:[9]

- Jawbone produces a wearable activity tracker called "Up". Up is designed to work while sleeping – indeed one purpose for activity trackers is to help users manage their sleep patterns better. By connecting to Nest, it allows the thermostat to respond to your waking and going to bed.
- Mercedes-Benz integrates with Nest so that your house is the temperature that you want on arrival based on journey data from your car.
- Dropcam offers home video monitoring and security cameras. Dropcam can start recording and transmitting once a Nest smoke alarm goes off so you can see what is happening in your house. Nest liked Dropcam so much that they bought the company.
- LIFX is an Australian-based manufacturer of wi-fi-enabled, app-controlled light bulbs. LIFX bulbs flash when a Nest smoke detector goes off.
- Whirlpool makes white goods such as washing machines and dryers. Whirlpool washer-dryers can communicate with Nest thermostats to identify when you are at home to save power.

It should be noted that all this is still new – the program has only been running since June 2014. These examples of device integration are experiments. Some will prove to be more useful than others and new integration offerings will be developed. What these early integrations highlight is the importance of linking devices together (the "internet" bit of IoT). However, it is unclear how linked our worlds will be. Last year, Apple released its smart home device framework called "HomeKit" and Samsung acquired a smart home product manufacturer called SmartThings. Apple and Google will almost certainly develop different standards for their platforms so interoperability will be an issue. If your toaster cannot talk to your smoke alarm that may be a problem if the toast starts to burn.

Our bodies

The phone is dead. To put it less melodramatically, the innovations in mobile computing that were realised in the Blackberry and the iPhone have moved to other forms of computing.[10]

- Wristbands such as the Jawbone "Up" and "Fitbit" track activity, heart rate and sleep patterns.
- Lechal shoes are marketed as "haptic footwear" that guide your feet with vibrations.
- Watches will undoubtedly be big in 2015 – with the "iWatch" becoming available and numerous other smart wristwear options being released. Exactly whether the watch will offer a rich-enough user experience remains to be seen.
- Google "Glass" offered another potential place to put a computer – right in front of your eyes. Glass offers augmented reality – with data presentation and the ability to video record what you see. While the hype around Glass has been considerable and Google has not released any official sales figures, it seems that consumer take-up has been slow. Glass are expensive and consumers do not see a compelling need for them at present. Many locations (cinemas, casinos, hospitals, banks) have banned them due to their recording capabilities. The low consumer take-up has blunted the interest of application developers. Augmented reality visual displays may yet become ubiquitous but the jury is out on Glass.
- A related technology are virtual reality headsets. Facebook acquired Oculus VR (with their "Rift" headset) for $US2.3 billion. In response, Google released Google "Cardboard" – a headset

[8] Parks Associates, *Smart Home Ecosystem: IoT and Consumers* (2014) http://www.parksassociates.com/whitepapers/iot-smart-devices. (registration required for download).

[9] Nest Labs, *Works with Nest* (2015) https://nest.com/works-with-nest.

[10] Moore M and Tall K, "Mobile everything" (2013) 27 OLC 246.

consisting of an android phone and a cardboard mount. The initial application for VR headsets is as gaming interfaces although any kind of immersive information presentation may be possible.

The IoT goes beyond accessories into broader healthcare. Sensor-enabled pill bottles and even pills can track whether patients take their medication. Infant monitors can track a baby's vital signs. Smart nappies and pads can check hydration levels and the possibility of infection.

This proliferation of sensing technologies goes beyond our bodies and homes. Cities and communities are increasingly being wired up. Amsterdam has implemented LED-based smart lighting to reduce electricity costs by 60% while the streetlamps of Barcelona monitor traffic flows and pollution levels as well as more efficient management of parking and irrigation.[11] In terms of manufacturing, information flows become inseparable from product flows and IT and manufacturing become essentially the same thing.[12]

TOO MUCH INFORMATION: THE DARK SIDE OF THE IOT

In 2014, Pew Research Center, a respected US polling and analysis organisation, published a research project that aggregated the views of experts and members of the public on the IoT.[13] One thing this report highlighted was the divergent nature of the opinions expressed. This is still a highly speculative domain. Another element was a streak of pessimism as highlighted in the following collection of "downbeat" theses:

- The realities of this data-drenched world raise substantial concerns about privacy and people's abilities to control their own lives. The level of profiling and targeting will grow and amplify social, economic, and political struggles.
- Dangerous divides between haves and have-nots may expand, resulting in resentment and possible violence.
- Abuses and abusers will "evolve and scale". Human nature isn't changing; there's laziness, bullying, stalking, stupidity, pornography, dirty tricks, crime, and those who practice them have new capacity to make life miserable for others.
- Pressured by these changes, governments and corporations will try to assert power as they invoke security and cultural norms.
- Humans and their organisations may not respond quickly enough to challenges presented by complex networks.
- There will be complicated, unintended consequences: "We will live in a world where many things won't work and nobody will know how to fix them."[14]

For the IoT, the two issues getting the most attention at present are the overlapping concerns of privacy and security.

Privacy is "about protecting information that says who we are, what we do, what we think, what we believe".[15] Historically, privacy has been preserved because tracking people's every move was simply not possible. However this is increasingly less and less the case. The ubiquitous nature of IoT means that ever more data about the speech, movements, and bodies of individuals can be collected by corporations and governments. Often this data is collected in exchange for free or lower-priced access to a service – leading to the truism: "When something online is free, you're not the customer, you're the product". Many privacy activists are concerned that consumers and citizens are using products and

[11] Laursen L, "Barcelona's Smart City Ecosystem" *MIT Technology Review* (18 November 2014) http://www.technologyreview.com/news/532511/barcelonas-smart-city-ecosystem. ABC Radio National, "Smart Cities, Digital Skins" *Future Tense* (16 November 2014) http://www.abc.net.au/radionational/programs/futuretense/smart-cities-digital-skins--ep/5881858.

[12] Löffler M and Tschiesner A, "The Internet of Things and the future of manufacturing" *McKinsey Quarterly* (June 2013) http://www.mckinsey.com/insights/business_technology/the_internet_of_things_and_the_future_of_manufacturing.

[13] Anderson J and Rainie L, *The Internet of Things Will Thrive by 2025* (14 May 2014) http://www.pewinternet.org/2014/05/14/internet-of-things.

[14] Rainie L, *The Internet of Things and what it means for librarians* (28 October 2014) http://www.pewinternet.org/2014/10/28/the-internet-of-things-and-what-it-mean-for-librarians.

[15] Office of the Australian Information Commissioner, *What is privacy?* (1 August 2014) http://www.oaic.gov.au/news-and-events/news/privacy-news/what-is-privacy.

services without a clear understanding of how they are exposing themselves. Already, Fitbit data is being used in court cases – in this case voluntarily given up by a user to bolster her claim, however one can imagine a future where this data is requisitioned by an opponent.[16]

While privacy concerns centre around legal access to data, security concerns centre on the illegal hacking of devices and systems. At present, criminals tend to focus on traditional IT systems and opportunities that financial fraud and blackmail present. However, as the IoT massively increases what is connected to the internet, it also increases opportunities for malicious activities – both in terms of property crime and also stalking and harassment. The complex, interconnected nature of IoT systems means that it is often difficult to be completely sure that they are free from security vulnerabilities.

Privacy and security issues are a bi-product of "software eating the world"[17] (digital technology being integrated into everything). The opportunities presented by these new tools come with risks attached.

IoT AND LIBRARIES

"The Internet of Things" is beginning to get attention from those in the library profession:

- Both the International Federation of Library Associations' *Trend Report*[18] and the Australian Library and Information Association's *ALIA Futures* initiatives[19] reference IoT.
- The Pew Research Center has presented their insights into IoT to the library community.[20]
- OCLC ran a well-attended webcast exploring IoT issues.[21]

Given the relative newness of these technologies, it is still unclear how they will be integrated into information provision environments. However, ALIA CEO Sue McKerracher explains where some of this interest may come from:

> Libraries bring together different things – resources such as books, the reference skills of staff and the spaces in which people interact with resources staff and each other. Each of these elements has "competitors" – eg Amazon, Google, parks, cafes. The uniqueness (and therefore the future for libraries) is in the combination of them. The Internet of Things offers us the opportunity to enrich the library as civic and communal space for our patrons and to link resources, people and space together in new ways. The Library at the Dock in Melbourne and The Edge in Brisbane are examples where this is starting to happen.[22]

A lesson from the Nest example is that if libraries implement these technologies by themselves, the impact will be limited. Sensors can be installed in libraries to make the space more responsive and interactive. This will mean that libraries will have to create something approaching application program interfaces (APIs) for themselves to integrate with a range of mobile devices, wearables and sensors. Patrons may also interact with each other in these new spaces. Spaces that are not so much "virtual" as "augmented" or even "enchanted".[23] Lee Rainie[24] talks about the library as a platform. In this scenario, librarians are responsible for both the design of these spaces and facilitation within them. They are also responsible for ensuring the "openness" of these platforms from legal, institutional and technical perspectives.

---

[16] Olson P, "Fitbit Data Now Being Used In The Courtroom" *Forbes* (16 November 2014) http://www.forbes.com/sites/parmyolson/2014/11/16/fitbit-data-court-room-personal-injury-claim.

[17] Andreessen M, "Why Software Is Eating The World" *Wall Street Journal* (20 August 2011) http://www.wsj.com/articles/SB10001424053111903480904576512250915629460 (subscription required).

[18] International Federation of Library Associations and Institutions (IFLA), *Riding the Waves or Caught in the Tide? Navigating the Evolving Information Environment* (2013) http://trends.ifla.org.

[19] Australian Library and Information Association (ALIA), *ALIA Futures* (2013) https://www.alia.org.au/futureoftheprofession.

[20] Rainie, n 14.

[21] Online Computer Library Center, *OCLC Symposium: The Internet of Things: Coming Soon to Everywhere* (27 June 2014) https://oclc.org/events/2014/ALA_Annual_2014/symposium.en.html.

[22] Personal interview with author, 5 December 2014.

[23] Rose D, *Enchanted Objects: design, human desire and the internet of things* (2014) http://enchantedobjects.com.

[24] Rainie, n 14.

The flipside of the API-enabled library is that elements of the library can surface in other spaces – such as civic spaces (eg museums, schools) or private ones. There are obvious legal and economic questions around this: Who owns what intellectual property? Who pays for all this? However if the opportunities are strong enough then these will be answered.

CONCLUSION

The IoT is currently at the top of the hype cycle and interest will quickly die away. The IoT is a fundamental technology transformation that will impact every aspect of our lives over the next 30 years. Both of these statements are true. This collision of stuff, sensors, the internet and data processing tools has started and will continue for the foreseeable future.

The challenge for information professionals is to find ways of incorporating these resources into their work and, conversely, using these tools to express what they have always done in new ways. In many ways, this promises to reverse some of the trends of the last 20 years towards virtualisation. Virtualisation was all about the replacement of physical things with their digital equivalents – books, music, shops, wallets, etc. The IoT brings the focus back to the physical world but in a new way.

One skill set that will be important in this new world is that of design. Many information professionals have spent the last decade developing their competence in user experience and information architecture work to improve the usefulness and usability of their online systems and virtual spaces. The IoT will require information professionals to acquaint themselves with ergonomics, product design and even architecture as critical elements in effective information access and distribution. These changes offer a great opportunity for information professionals to both reinvigorate their existing spaces (eg libraries and archives) and to explore new ones such as public streets, private homes and the increasingly blurred spaces in between.