Building an Internet of Things environment in the Library

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Abstract:
This paper outlines a multi-year initiative to develop an Internet of Things (IoT) environment in Western Michigan University Libraries to support research and development, prototyping, and implementation of IoT applications and services. This would enable a growing hands-on experience with the IoT, using the "Library as Lab" approach. Collaboration and engagement with various campus units were essential.

Introduction

In early 2015, the author started an initiative to develop an Internet of Things (IoT) environment in Western Michigan University (WMU) Libraries to support research and development (R&D), prototyping, and implementation of IoT applications and services. This initiative is a multi-year project, given the rapidly developing IoT field, but will also enable a growing local hands-on experience using the “Library as Lab” approach.

This paper describes the IoT, its potential and challenges, the smart library building, and IoT applications in libraries. The author contends that an IoT environment in the library should encompass the smart library building and its operations as well as building IoT applications that enhance user experience and provide personalised services.

In the smart building, the IoT activities are primarily machine-to-machine to achieve efficiency. IoT applications for service enhancement would involve embedded real-time systems with Bluetooth peripherals as well as ad hoc device-to-device applications. With the growth in smartphone ownership and wearable smart devices, more personalised applications and services can also be designed.

The project background and plan are also presented. In this effort, it was essential to collaborate and engage with various WMU campus units and stakeholders.

The IoT and its potential

The IoT describes a state in which vast numbers of objects, devices or "things" embedded with sensors are interconnected over the Internet. These can gather almost any kind of data about their surrounding environment, including temperature, light, sound, time, movement, speed, and distance. The IoT has its roots in industrial production, where machine-to-machine communication enabled the manufacture of complex items, but it is now expanding in the commercial realm (ELI 2014).

This growth has been fuelled by the availability of inexpensive, low-power sensors and transmitters, emerging standards, ubiquitous Wi-Fi, and the increased use of Bluetooth. The Internet Protocol Version 6 (IPV6) initiative also boosted the IoT, by enabling all objects to have a unique IP address that can be stored and accessed in real time from anywhere. The result is an intensely connected and data-rich environment (ELI 2014). The main motivation, and hope, to connect everything to the Internet is to enhance the value of existing products and services (Kompella 2015).

Gartner has forecast that the IoT will have around 4.9 billion connected devices and objects in 2015, and this number is estimated to grow to 26 billion by 2020 (Gartner 2015). However, the Gartner Hype Cycle for Emerging Technologies, 2014 (Figure 1) has the IoT at the peak of inflated expectations, and potentially reaching the plateau of productivity in 5 to 10 years (Gartner 2014). Similarly, both the Horizon Report 2015 Higher Education Edition (NMC 2015) and the Library Edition (NMC 2014) have listed the IoT in the 4 to 5 year time-to-adoption horizon.

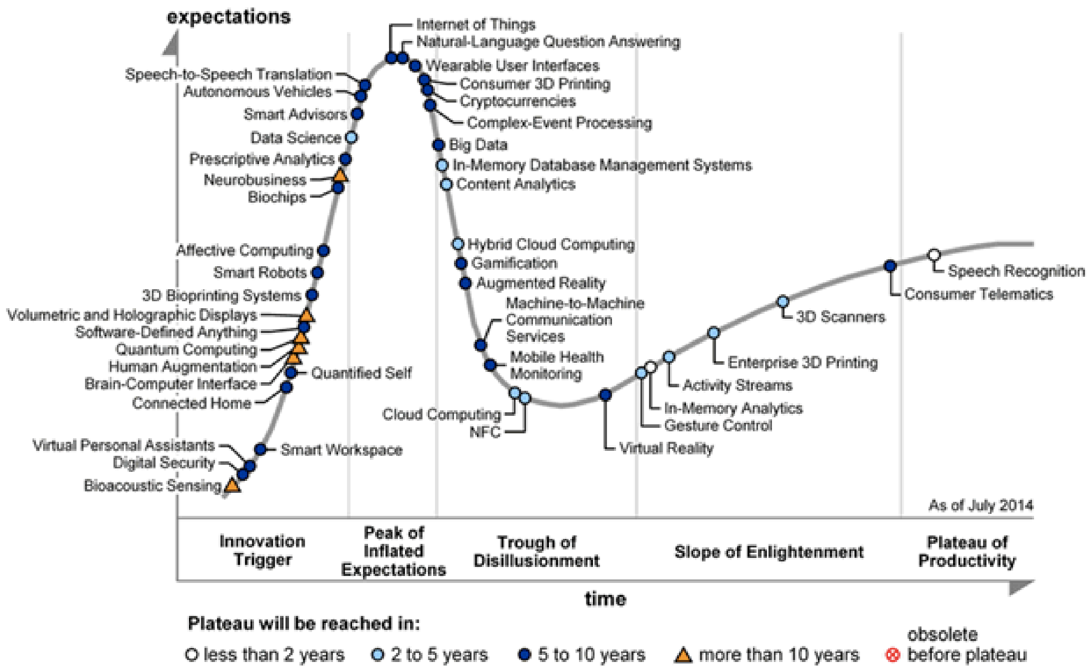

Figure 1: Gartner Hype Cycle for Emerging Technologies, 2014

As devices start to "talk" to each other, rich, real-time data could be collected at different points in workflows and processes, to gain insight. Depending on the situation, the insight could lead to an automated response or provide intelligence for decisions and actions. Such actionable insights from the IoT could help improve customer experience and employee productivity. In one example, a public-safety IoT could combine the web of sensors on highways with traffic management systems, electronic highway signage, emergency broadcast notices, and first-responder deployments. Evans (2011) describes a possible personal IoT scenario in Figure 2.

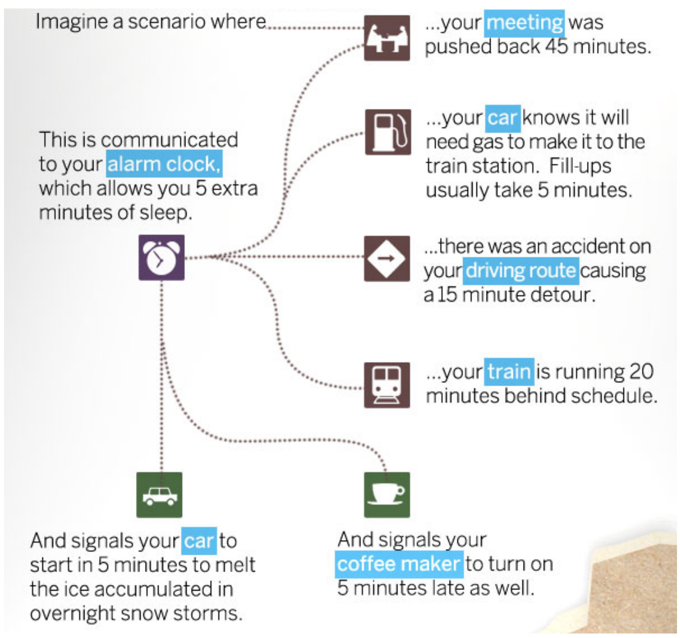

Figure 2: IoT scenario

Real and potential IoT applications are found in many sectors, including:

- Automotive: connected cars.
- Building construction: instrumentation, automation, and environmental management (Smart Buildings).
- City (and campus) management: parking, traffic control, and waste management (Smart Cities, Smart Campuses).
- Consumer services: appliances, home automation, security, and wearables.
- Healthcare: hospital equipment monitoring and health checks via body sensors.
- Manufacturing: equipment monitoring and supply chain management.
- Retail: inventory and shelf management and logistics.
- Transportation: fleet management and remote diagnostics for engines.
- Utilities: smart grids and meters and remote temperature control.

In the education sector, the IoT has tremendous potential in creating a smart campus, and opening new avenues of research and learning by interconnecting all kinds of objects and systems. As educational organisations begin to leverage solutions like cloud computing and Radio Frequency IDentification (RFID) across an IoT platform, they are able to capture, manage, and analyse data, and provide stakeholders with a real-time view of students, staff, and assets (Zebra Technologies 2015).

By leveraging insights gained from data analytics, educational institutions can make more informed decisions on improving operational efficiency, campus security, and student learning experiences. In the same vein, libraries can also benefit from using IoT-generated data to gain insights to make better-informed decisions on operations, collections, resources, and services.

IoT solutions generally involve three core steps: collect sensor data, transmit data to a central location, and, analyse data and generate insights (Kompella 2015). Zebra Technologies (2015) has indicated that a portfolio of technologies is required to deploy an IoT solution that will gain real-time visibility into an organisation’s assets, people, and transactions, and turn data into actionable intelligence, including:

- Devices that are equipped for data sensing, tracking and capturing in order to manage assets, people and transactions.
- Cloud technology that provides the interconnection of smart devices and the hosting of enterprise applications.
- Mobile technology that is extending business processes and information accessibility throughout the workforce.
- Big data solutions that provide the advanced analytics necessary to gain insight from the raw data that is generated by these devices.

However, like many technologies, while the IoT can enable positive uses for improving the environment and human lives, it can also be used negatively. This is similar to the growth of the Internet and the World Wide Web, when the description ‘Wild West’ came to be used to describe the lack of regulations and security (Haber

2008). This is now applicable to the IoT, with its lack of effective legal controls, interoperability, and standards.

IoT challenges

Security and privacy concerns are by far at the top of the list. ELI (2014) stated that the data-rich environment engendered by so many devices sending information (with or without permission) raises serious concerns about privacy, security, and data ownership. In 2014, OCLC surveyed a number of librarians to assess their familiarity with, and views about, the IoT and related technologies, and respondents expressed concerns around privacy, security and hacking (OCLC 2015).

From a business-to-consumer context, the issue of data security is still unresolved, with the recurring large-scale online theft of credit card and other personal data. The loss and misuse of massive amounts of IoT personal data would exacerbate the situation. Unfortunately, hacking over the Internet and disruption of websites and online applications and services has now extended to Internet-connected sensors and devices, for example, hacking into wireless devices installed in vehicles and causing malfunctions. As reported by Timberg (2015), an increasingly vast array of machines – from prison doors to airplane engines to heart defibrillators – have joined the IoT, and are wired into this “borderless, lawless, insecure online world.”

It is essential to ensure security in an environment of pervasive sensing and analytics systems, and to protect and integrate existing data amid the vast data streams relayed from items in the physical world (ELI 2014). Various agencies are addressing the issues, including the National Science Foundation’s partnership with Intel Corporation to support R&D in securing and protecting the emerging IoT (NSF, 2015). This has brought together researchers from University of Pennsylvania, Stanford University, University of California, Berkeley, and others to study and address the issues.

Any IoT deployment has various moving parts, and the challenges are not trivial. The complexities of planning, integrating and testing any proposed IoT ecosystem include support for both legacy and new smart devices, support for multiple connectivity options as well as centralised and remote device management to allow for day-to-day provisioning, device setup and maintenance. To support application connectivity, the system should offer consistent application programming interfaces across a wide range of devices, while affording easy scalability and connectivity to the data centre to process and mine the diverse range and format of data.

A more down-to-earth challenge is that of power management in sensor node design (Wang 2015). Wireless sensor nodes are often located in hard-to-reach places where access to mains power is impractical. Constant monitoring, data acquisition and wireless transmission can quickly drain the sensors’ batteries. Other sensors may have long idle periods interspersed with active peaks or constantly monitoring but only transmit data when some specified anomaly occurs. Effective monitoring is needed to replace or recharge batteries, and also to detect sensor failure. This poses logistical problems when considering the quantity and location of sensors that may be needed for an IoT implementation.

As the IoT connects people, processes, devices, and data, it enhances the volume and value of data that can be collected. This allows stakeholders to turn data into insights for appropriate action or decision. However, this presents the challenge that IoT implementations have the potential to generate a large volume of data, as some sensors may be constantly detecting, monitoring, and controlling activities. The variety of data sources and formats makes it hard to manage all of them while in synchronisation with one another.

Much of the data collected by various systems tend to sit in disjointed data silos. As data sets increase in volume, velocity and variety, it is difficult to process with standard database management systems, making them inaccessible across the organisation (Zebra Technologies 2015). Forrester Research also states that there is no standard to integration across IoT devices, applications and services, and while many devices are capable of connecting to Wi-Fi and similar networks, many devices are still Internet unaware, relying on basic Local Area Network (LAN) connectivity (Kompella 2015).

The smart library building

As described earlier, the author contends that an IoT environment in the library should encompass the smart library building as well as IoT applications for service enhancement. A key reason is that as more smart buildings are created and connected on the smart grid of a city or campus, building management systems can add more data including transportation, safety, and other environmental data. This enables more intelligence and insights to be gained as part of the smart city or campus infrastructure. Various universities are embarking on smart campus initiatives (Bernhard 2015), and a smart library connected on a smart campus grid would allow enhanced customer services, such as connecting transportation and library opening hours and other campus services that complement the library's offerings. Figure 3 shows the smart campus infrastructure at the University of Surrey, UK (2012).

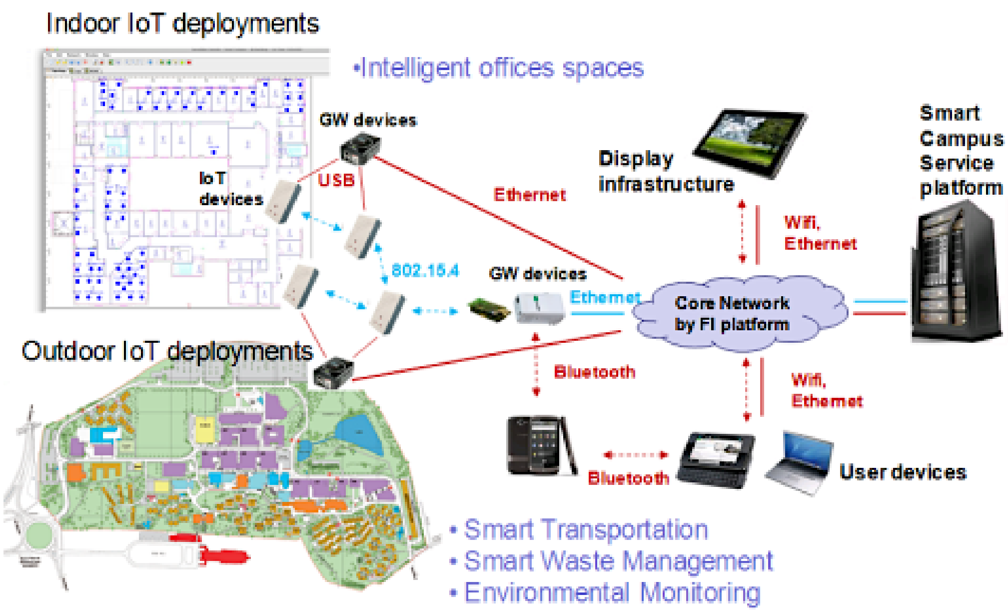

Figure 3: Smart campus (University of Surrey, 2012)

A smart building (Figure 4) integrates disparate systems such as heating, ventilating, and air conditioning (HVAC), lighting, safety, power management, and security (access control, video surveillance, and visitor management) (IBM 2015). These are controlled by a centralised common user interface, and use a shared network for all building-system communications. This integration maximises building performance and efficiency, adds long-term, sustainable value to the property (Madsen 2008).

Figure 4: Smart Building

Sensors and control systems detect and sense various conditions, and emit alerts or responses from many disparate systems (Figure 5). The data can feed insights into the management and process of each of these systems. For example, when the ambient temperature moves above or below a defined threshold, the HVAC system will make adjustments.

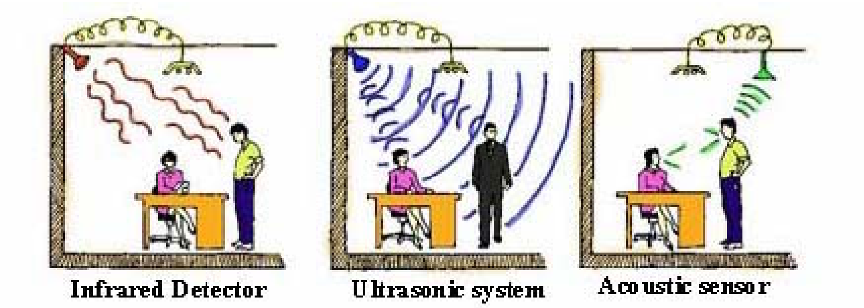

Figure 5: Occupancy sensor technologies (Control Systems 2010)

Newer buildings are built to Leadership in Energy & Environmental Design (LEED) standards, with green features that allow for the design, construction, operations and maintenance of resource-efficient, high-performing, healthy, cost-effective buildings. However, many existing and older buildings face the challenge of adapting or implementing green features or smart instrumentation systems, and are usually considered only during utility upgrades or improvement. Connecting and/or upgrading legacy devices can be costly and a deterrent to wider IoT adoption.

Similar to many older libraries, WMU Libraries' main library, Waldo Library, is faced with the challenges described above. It was built in 1958, with additions and renovations in 1967 and 1989-1991. The latter included the renovation of 99% of the interior building. Energy-efficient lights replaced all older light tubes in 2001, and occupancy sensors in some offices and rooms were only installed in 2013. However, given the expense of these installations, there are no plans to upgrade the utilities in the Library in the near future, and it would not be possible to incorporate a number of current smart building technologies.

IoT applications in libraries

A brief survey of the literature presented in this paper indicated that references to IoT applications in libraries are usually centred around RFID, Near Field Communication (NFC), Quick Response (QR) code, Augmented Reality (AR), and, more recently, the growth of beacons and location-aware technologies. Overall development and adoption is still low and inconsistent, but the author anticipates the situation will change as more fixed and mobile smart devices applications are introduced. This is already evident in the growth of wearable smart devices that can interact with the environment. Examples based on NFC technology include using the smartphone as paperless check-in for air travel, and the Apple Watch and iPhone for payment transactions through Apple Pay.

In the OCLC (2015) survey, the following were listed as what is promising about IoT technologies for libraries:

- Inventory control.
- Mobile payments, ticketing and event registration.
- Access and authentication.
- Climate and room configuration, accessibility and way-finding.
- Mobile reference.
- Resource availability for both content and physical plant (rooms, AV equipment).
- Smart books (features activated/enhanced by other IoT-enabled systems).
- Gaming and augmented reality.
- Object-based learning.
- Assistive technology.

The IoT offers great potential for immersive learning experiences. The increasingly connected network of devices and data streams could coordinate campus physical spaces, integrating information from sensors embedded in objects including library resources, whiteboard writing surfaces, game boards, and robots (Zebra 2015). Of potential for libraries, and with demonstrated uses in retail and marketing, are location-based services using beacons. For example, automated notifications, tracking users, and location-based marketing, could be used to enhance services and user experience.

Sarmah (2015) has also described different implementations in libraries and museums to enhance the user experience, and to enable a more personalised in-building service. The Orlando Public Library uses BluuBeam (http://bluubeam.com), an Orlando-based service that uses Apple's iBeacon technology to send location-triggered information to patrons. It would also inform patrons about services that matched their interests, and send alerts about library offers and events. Another example is a system from Capira Technologies (http://capiratech.com) that sends users reminders about overdue books and items available for pick-up as soon as they enter a participating library. Spotzer (https://cuseum.com) has used beacon technology in museums and galleries to "reinvent the way people interact with art" (Sarmah 2015).

From a library operations point of view, the mibeacon proximity technology (http://mibeacon.net/) is of particular interest and value. It can anonymously track and analyse customers' movements and activity in the premises, using strategically placed beacons, and the data can be displayed as a heat map (Figure 6). This would help determine foot traffic patterns and use of spaces, and could lead to better space planning and distribution of resources.

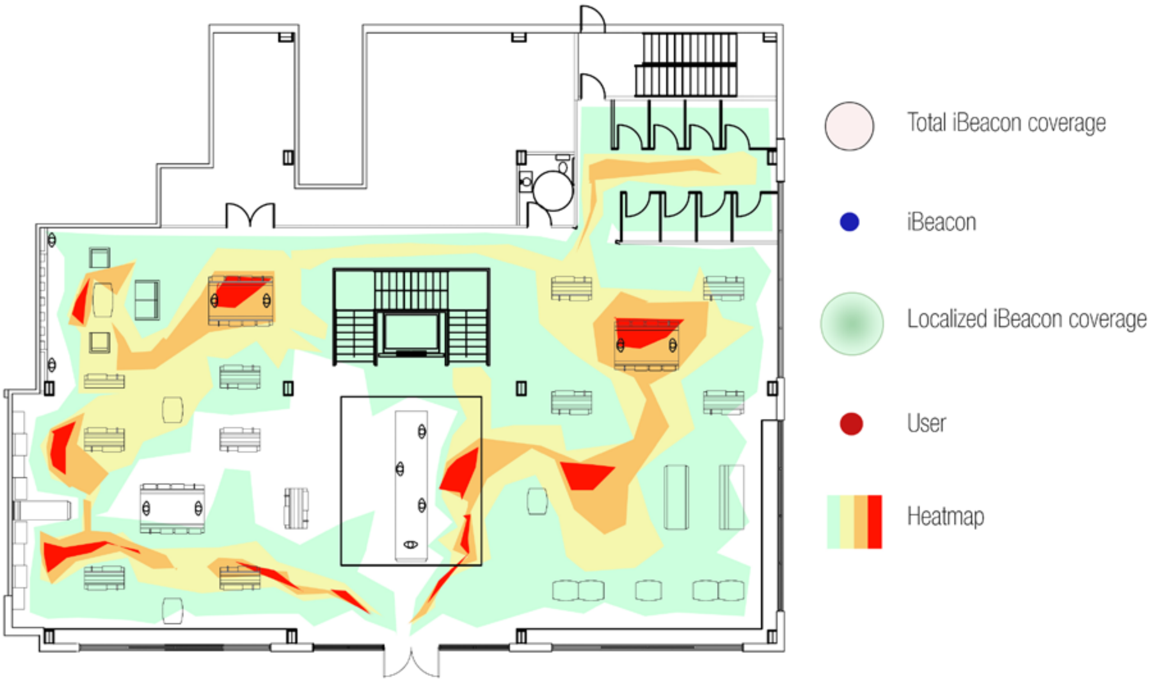

Figure 6: Heat map of customer movements

Another sensor system that is being increasingly used is light-emitting diode (LED) lighting for developing indoor location-based services, for example ByteLight (http://www.bytelight.com). The technology combines Visible Light Communication (VLC), Bluetooth Low Energy (BLE) and inertial device sensors to transform LED lights into indoor location waypoints. ByteLight makes LEDs "talk" to any smartphone and tablet with a camera and/or Bluetooth Smart technology that opts-in to "listen" (Figure 7).

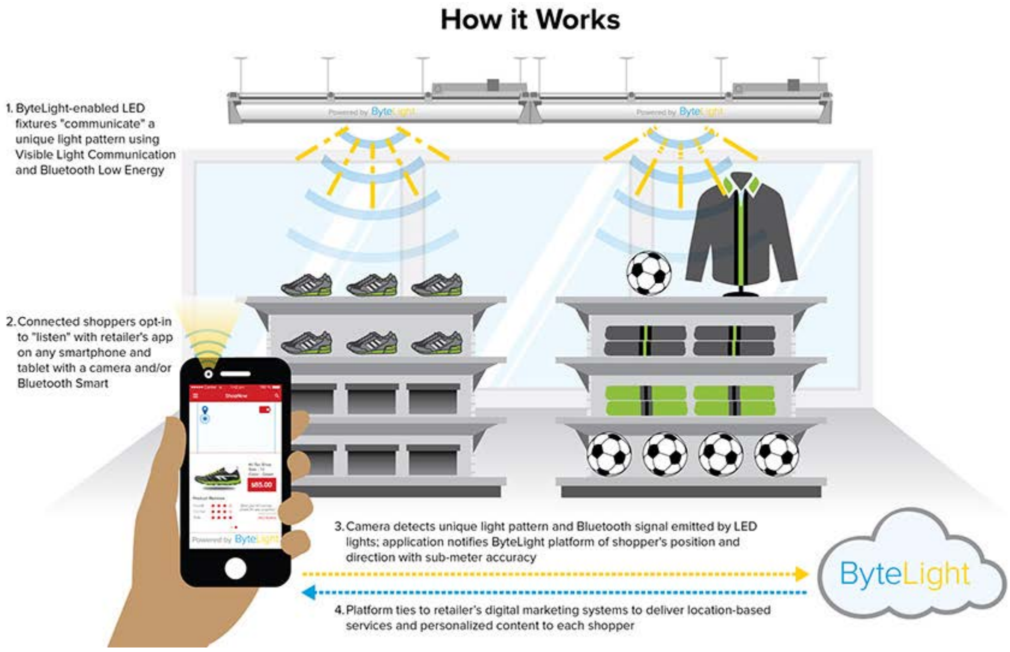

Figure 7: Indoor location-based services using LED Lighting

In another development, Godby (2015) states that for libraries, linked data technologies may play a key role in helping to build smartness into collections and systems. Both the IoT and linked data present major opportunities for libraries to connect their resources and services to more people – and things – in more places than ever before. IoT providers may also look to libraries to provide a “reference layer” to the IoT, connecting objects to resources that inform, explain, or contextualise their use.

In an interview, Berners-Lee stated that “the Internet of Things connects very much with the Semantic Web and with linked data. With linked data you’ve got the ability to give a thing a URI (Uniform Resource Identifier). The Semantic Web is a Web of things, conceptually. Tying an actual thing down to a part of the Web is the last mile” (ReadWriteWeb 2009). The intersection of the Semantic Web, linked data, and the IoT would be a rich area for further research.

Project background and collaborations

When the author first considered this initiative, the potential IoT applications and value from data collected held promise for enhancing library operations and services. From a technology stand point, IoT applications would be innovations that could enhance the user experience in the library, while data collected could reveal facts, patterns, and other insights into library operations for decision making.

However, the list of considerations and tasks, from politics and diplomacy to limited resources, was daunting. As described earlier, developing an IoT environment would also require a portfolio of technologies and technical expertise that the Libraries did not have.

For any chance of success, the process would need to be manageable and sustainable. The following approach was adopted:

- Establish a multi-year initiative for deploying an IoT solution within an R&D framework.
- Gather a campus-wide network of collaborators and partners.
- Use an agile approach for any IoT application implementation (prototype, deploy, scale, iterate).

Against the backdrop of the Horizon Report's 4-5 year time-to-adoption horizon and Gartner's projection of 5-10 years to the plateau of productivity for the IoT, the author started planning for a multi-year collaborative R&D approach to developing an IoT environment at WMU Libraries. This would provide the basis for learning and engaging with IoT applications, and for the Libraries to be better prepared for the anticipated growth in IoT activities.

The author also tapped into WMU's strengths and aspirations, including its mission as a "learner centered, research university, building intellectual inquiry and discovery into undergraduate, graduate, and professional programs in a way that fosters knowledge and innovation, and transforms wisdom into action" (WMU, 2015). As a designated Carnegie High Research Institution, WMU has a strong culture of R&D and teaching as well as enabling success-ready students. Campus sustainability and LEED certification are important to WMU, and it received a 2014 Best of Green Schools award in the higher education category (US Green Building Council, 2014).

The author recognised that such an initiative in a library with limited resources would require engagement with other campus units and colleges as well as interested faculty and students. Below are some of the key stakeholders and collaborators.

1. College of Engineering and Applied Sciences (CEAS)

The CEAS is the Libraries' main collaborator in developing the IoT environment, and associated activities and applications. The CEAS Computer Science (CS) Department has a strong program in embedded and real-time systems. Professors teach in the IoT area and are also engaged in various grant and non-grant funded IoT related projects.

In 2015, CEAS received approval for a new undergraduate course that focused on embedded systems and IoT, and would engage students in R&D from an earlier stage in their degree. They also plan to focus on developing projects for real-world clients. The author started discussions with CEAS stakeholders to house the venture in the more centrally located Waldo Library. This would allow CEAS students to have an R&D base in the library while classes are conducted in the CEAS campus.

In introducing the "Library as Lab" approach for this venture, the prototyping and deployment of applications for real-world clients could be done using Waldo Library as the test bed. These applications may be for different industry sectors but could still be appropriate to consider and modify for library use. As the

Libraries will also be a client for this venture, potential IoT applications could provide IoT use cases for the library and information services vertical sector.

2. Facilities Management (FM)

The FM department is responsible for ensuring that WMU facilities run in the most cost-effective and environmentally responsible manner possible. Energy management is an important activity to help reduce operating costs, and the FM unit is responsible for identifying and installing environment-monitoring sensors across all campus buildings. As the smart building is part of the IoT environment, it was necessary to have FM in discussions and planning, particularly to determine the existing grid of sensors in the library and how data is collected.

Although FM had installed occupancy sensors in various offices, classrooms, and meeting rooms in Waldo Library, these sensors were not installed in many of the stack and open areas as there was no use case justification. FM does not actively collect or store the data, and will only start a tracking report based on need to check on performance or to trace a reported issue. This would mean that, depending on the IoT application, it might be necessary to install additional sensors, and to have a system to collect and store the data for analysis and response or action in real time.

3. Office of Information Technology (OIT)

The OIT is responsible for the efficient and effective use of campus information technology resources. It manages the campus network infrastructure, and provides computing support for enterprise-level applications, such as the learning management system and personnel management. As the network servers are managed by OIT, all data over the network are located on its servers. Permission is required to obtain anonymised archived data, and security concerns make it difficult to obtain a live data stream for analytics in real time.

At an individual level, there were numerous faculty and students with whom the author met, who were keenly interested in participating in the project. Using the “Library as Lab” approach, the author was able to gather a wide selection of participants and IoT related project proposals.

In terms of the working team, three key members were identified: the author as the project lead and representing the Libraries, a CS faculty member who was already engaged in IoT research and who recognised the potential of R&D collaboration, and the Libraries’ IT Graduate Assistant (GA). This GA is also a CEAS doctoral candidate focusing on IoT technologies; his participation helped create a bridge between CEAS and the Libraries.

Project plan

Given the dynamic growth of the IoT, the overall project plan was kept at a broad level with some flexible time lines to enable learning opportunities and potentially revising plans when needed.

Phase 1 started in January 2015, and the focus was to:

- Develop collaborations and support from appropriate campus units.
- Identify key stakeholders and the working team.
- Identify and develop the smart capability of the library building.
- Identify a selected number of IoT applications to prototype.
- Identify the appropriate development framework and platform for application development and deployment, data storage, and data analytics.
- Review and understand the broader IoT environment and developments.

Phase 2, from November 2015, will include:

- Implementing the identified application development framework and IoT platform.
- Prototyping and deploying a selected number of applications.
- Monitoring, assessing, and fine-tuning the applications.
- Developing an understanding of data analytics and identifying skills and tools required.
- Continuing regular discussions and updates with campus units and stakeholders.
- Continuing to monitor the IoT environment and developments.

It was critical to scope the project in terms of location as WMU Libraries is made up of the main Waldo Library and three smaller branches. The 4-storey Waldo Library building has a footprint of nearly 67,000 square feet per floor, and about 60% of the first floor has been repurposed as the Learning and Discovery Commons (LDC). The author decided to create the IoT environment in the LDC as this smaller defined space would make R&D activities, prototyping, and implementations easier to manage before scaling or expanding to other parts of the building.

With the many possibilities and choices in IoT technologies and applications, it was also necessary to scope this aspect of the project and to identify specific use cases and deploy the appropriate application. Kompella (2015) has also stated that despite the hype around the IoT and contrary to the expectations it has created, there is no one-size-fits-all app. More importantly, the point at which the IoT yields insight that people can act on varies with the application.

After reviews and discussions with stakeholders, the author focused on indoor location-based services using either a beacon or LED lighting sensor system interacting with users' smartphones. This would include indoor navigation to selected service or collection locations to supplement the directional signs. The author also recently received a proposal for a project to enable beacon-based navigation in the library for the visually impaired.

While surveying IoT use cases, existing applications and services in Waldo Library continue to be reviewed, to determine whether IoT functionality could be integrated. This includes the in-house developed iKiosk application with touchscreen interactive features, visitor counters, computer availability, and resources scheduling. Another possible enhancement is integrating NFC technology in circulation activities; for example, using a smartphone for transactions instead of the student identity card.

The smartphone is also becoming the logical device to control and manage a variety of IoT applications, including vehicle and home automation systems. Given the ubiquity of smartphone ownership, associating IoT services with the smartphone could enable personalised and unique services. Hahn (2015) has described the implications of the physical Internet in library settings, including a user's smartphone interacting with the library building and smart digital shelving unit or other smart node. In a number of applications, it would be a more seamless approach to make use of the unique media access control address (MAC address) in mobile phones to push notifications, "smart advising", or services, instead of requiring the user to initiate an app.

Based on recommendation from the CS faculty and the GA, application development for different smartphone operating systems such as iOS, Android, and Windows Phone, would follow the model of hybrid mobile application development. An application is developed using web technologies like HTML, CSS, and JavaScript and is then wrapped in a native application to be deployed over several operating systems. Instead of developing native mobile applications for each of these operating systems, using a development framework such as Apache Cordova (https://cordova.apache.org/) would ensure device independent applications, and would also save time and cost.

This deployment of IoT applications would require an infrastructure or platform to integrate all related activities including application development and deployment, devices management and connectivity, and data collection, storage, integration, and analysis. Mineraud et al (2015) reviewed more than 30 available IoT platforms based on various characteristics including support of heterogeneous devices, architecture, open source or commercial, and data access. Research using this list narrowed the choice of platform to ThingWorx (http://www.ptc.com/thingworx) for the project's initial R&D needs. This cloud-based platform provides an application design, runtime, and intelligence environment to build and manage applications for smart, connected devices to aggregating and displaying sensor data. It is also available free for a year.

However, soon after the decision was made, the Google Cloud Platform came to our attention. This platform (https://cloud.google.com/) provides tools for gathering, computing, and storing data, big data analytics, and service APIs. There is also a free usage quota that would be more than adequate for the Libraries' initial needs. A comparison with ThingWorx led to a reconsideration and selection of the Google platform instead.

In terms of data privacy and security, the intention is to ensure a professionally responsible approach in collecting and using any data from IoT applications in Waldo Library. All data collected will be anonymised and the data aggregated for analysis would not identify any individual subject. A set of guidelines would be established to indicate the type of data to be collected, anonymised, and aggregated. For example, the IoT applications could collect basic demographic data like student status, major discipline, zip code, but not personal data like Social Security Number and home address. As well, all initial prototype deployments would involve controlled groups, and all participants would be requested to sign an opt-in form.

Summary

The IoT remains nascent, and it is likely that many of the uses of the IoT – in general, and for higher education specifically – will not be known until users start imagining the possibilities and developing applications (ELI 2014). This also holds true for libraries and information services trying to develop smart services.

The OCLC (2015) survey response indicated that the library's role in supporting users' adoption of IoT included providing general knowledge, training, and demonstrations; education regarding privacy and security issues; and, accessibility, compatible devices and resources. A respondent also suggested that "For now, sit and watch what develops". However, the author felt that would not be beneficial particularly in an academic R&D environment, and that there could be a more proactive role in learning and gaining experience with the IoT, and in bringing interested faculty and students into the R&D process.

The challenges and complexities of planning, integrating and testing any proposed IoT ecosystem cannot be minimised. The buy-in, engagement, and ongoing building of the collaborative relationships are as challenging as the technical aspects of the implementation. As described earlier, the essentials for deploying IoT solutions include appropriate devices, connectivity, account/device management and security, application programming, and analytics and reporting. WMU Libraries IT staff and student assistants are keen to participate in the initiative, and to learn more about the technologies and possibilities for the library, but this comes on top of daily operational activities and responsibilities.

In an IoT world, librarians need to relook at their library buildings, and to develop smart applications with an embedded grid of sensors, actuators, and controllers. As a physical structure, library buildings are anchored in connected communities and cities, and within these, library users are increasingly carrying and wearing smart devices that connect them to the smart environment.

As people, processes, and devices become increasingly Internet connected, the data generated can allow educators, administrators, and librarians to gain insights for data supported decisions and actions. With growing community smartness and connectivity, libraries too must be part of the IoT movement. In particular, data analytics is a growing area for which librarians will need to develop skills and experience in working with data and the tools to derive insights.

In terms of the project time line, Phase 1 is on track in laying the foundations of building partnerships and R&D initiatives with campus units, understanding the technology, and identifying an IoT platform and selected applications. Phase 2, which starts in November 2015, will include prototyping and deploying the platform and applications, and monitoring and assessing the progress of the project.

In making a proactive start, the author was able to establish the role of the "Library as Lab" approach that would benefit faculty and students in engaging with the IoT as well as increasing awareness of both IoT and the Libraries' role. Tapping into the enthusiasm, goodwill, and engagement of campus units also raised the profile of WMU Libraries and created greater awareness of the Libraries' potential in R&D endeavours.

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