Blurring the boundaries between our physical and electronic libraries: Location aware technologies; QR codes and RFID tags.

Introduction

Increasingly since last upgrading my mobile 'phone a quote from Arthur C. Clarke has been bouncing around my head, *"Any sufficiently advanced technology is indistinguishable from magic"*. That 'phone knows where I am through GPS (or triangulation of the mobile 'phone signal if GPS is turned off or unavailable); connects me instantly to friends and colleagues all over the world through email; Facebook and Twitter; effortlessly links me to the sea of information that is the Internet, which increasingly includes serious research databases; acts as a gaming device; electronic book reader; a way of watching or listening to television or radio programmes I've missed; an educational tool for my young children; a music player; and much more. If I'd have been given this device 30 years ago as a nine year old boy I may well have accepted it as working by magic.

Specht (2009) discussed this idea of technology as magic with a reminder that magic like the "Marauders Map" of Hogwarts castle (a map that displayed the position of everyone in the castle) in the Harry Potter books could be achieved using existing technology. He asks us to *"consider technology-enhanced learning as magic enhanced learning"*. As part of this he challenges us to think about the future of learning not just in terms of the technology that we are familiar with today, but to assume that future technology can fill in the gaps, the parts that today we would think of as magic.

A range of technology is coming into everyday use that would have been considered the equivalent of magic in living history. Looking at recent Horizon Reports for 2009 and 2010 (Johnson et al., 2009 & 2010) they have flagged up mobile learning and computing as being imminent technologies to watch, as well as smart objects; location aware devices; and augmented reality in the near future.

But what about these technologies in libraries? How can these sort of technologies blur the boundaries of our physical libraries into places that can continue to ensure the relevance of the library building into the future? Academic library buildings increasingly seem to be moving towards a place for students to use computers and interact socially with each other, with much of the information for study being pulled from online resources, weakening any possible link between physical library space and student achievement. Without introducing technologies that can help move the physical library once more into a place of learning, a place of interacting with information and synthesizing new knowledge, we risk losing that physical space.

This article will address some of these technologies that can help our library users receive context specific help as they move through the library, describing elements of mobile learning; location aware technologies that can work within libraries such as GPS and wireless signal triangulation; and cheaper and easier technologies that can move us towards an "internet of things" which may already be within reach within many libraries such as QR codes and RFID tags.

Mobile learning

Any actual mobile learning activities delivered by libraries such as mobile friendly information literacy materials have tended to be highly structured, typical of most mobile learning projects to date, though Kukulska-Hulme et al (2007, p. 53) argues that *"mobile learning should aim to innovate and discover what is gained through having portable tools that support observations, interactions, conversations and reflections*", perhaps the sort of activity that our learners currently take part in within our physical environments? She also says that many of the changes in the way we use computers, particular those technologies often described as web 2.0 *"have called into question the very idea that it is up to educators to be in charge of designing learning: learners themselves may be better equipped to take the lead."* What better an environment to develop mobile learning technologies than a place that has traditionally been available for students to control their own learning – the library?

It's worth noting that mobile learning does not need to be defined purely as something done on a mobile device, it is learning that that moves with us; is less defined by how you use the technology and is able to take place in a context that allows the learning to make sense to us.

Many of the technologies discussed here can be used to make learning mobile and personal once more rather than constrained by institutional preferences. Specht (2009, p.18) has much to say, for example on using the example of making annotations in a book as we read it.

> *"Annotations make the book unique in which the reflection and learning is documented. When we talk about personal things we think about something that has meaning for us, this includes cognition, emotion and motivation."*

The shared, physical, library book is the antithesis of this. We penalise those that annotate our books and make it difficult or impossible to annotate our electronic collections. If we could make it easy to make electronic annotations of our print and electronic materials, making it easy to access and view those annotations wherever our users are, wouldn't it enrich the learning environment of our libraries? Being able to save and view those annotations would enrich the personalized learning of our users. If we also include the ability to easily view others comments and thoughts as users moved through the library it would help evolve the whole learning environment for all our users. It would create a personal library environment, as well as a place to share ideas and commentary on our resources. Mobile technologies may well, in Kukulska-Hulme's words (2007, p.55), *" have the capacity to take learners and learning back into 'the outside world'. They can structure and scaffold learners' engagement with this world rather than mediate and constrain it.***"**. They can bring their "magic" to bear on bringing the personal learning out of paper book on a students or lecturers desk, away from the computer fixed by cables to a wall, and into the physical space of our libraries.

Augmenting the physical reality

So how can we use existing technology to enable virtual interaction within our physical environments? How can we augment our reality to allow situated learning, that is learning that takes place in the course of an activity, in appropriate and meaningful contexts, (see Lave & Wenger, 1991) as people use our resources?

Augmented reality is normally seen as *"a technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view*", (Soanes & Stevenson, 2005) but the augmentation of reality described below is not pure "augmented reality", but other related ways of blurring the boundaries between the physical and virtual environment to provide context and location appropriate information and interaction.

Most importantly, to augment reality for our users we need to know their location. Two main approaches are discussed here, firstly using a device that can calculate its own location, and secondly using objects that can tell a device where it is and what information would be appropriate.

Locating technologies

The first, devices that know where they are, is the more complicated, but one on which there has been most progress. GPS for outdoor activities has the longest history, for example with Joost Raessens (2007) recently turning Amsterdam into a medieval playing field for groups of children using GPS enabled smartphones.

GPS signals rarely penetrate far indoors, so this tried and tested technology is more difficult to use in libraries. Giaglis et al. (2002) *describes how various indoor locating technology works, including GPS (including signals mimicking GPS for areas where GPS signals do not penetrate from the outside), bluetooth triangulation, RFID and triangulation from wireless network (WLAN) signal. He also argues for the importance of location awareness services in various environments including libraries (p. 416):*

> "... in large indoor environments, such a libraries … location awareness can become a crucial determinant of superior quality of service, deriving from the ability to locate the co-ordinates of a person or an object with reasonable accuracy at all times, and thus provide spatially-aware services."

RFID technology will be discussed further below in terms of it's potential, but Tesoriero et al. (2008) describe nicely *how active and passive RFID can work to locate someone within a museum, covering a project that used both active RFID (where the tag is powered and can be sensed from a distance) to locate an RFID reader equipped mobile as the bearer walks into an area; and passive RFID (where the reader needs to be in close proximity to the tag, which is powered by radio waves from the reader) to provide further information on exhibits.*

An example of a library trying the wireless network triangulation system is the SmartLibrary project in the University of Oulu, Finland (Attiola et al., 2003). They used the varying strength of the six wireless access points in their library to calculate location and combined this with catalogue searches to deliver an interactive map that shows users the route to a book based on their current location in the library. The idea of interactive maps seems to be a popular desired application in the literature, for instance Moradi's (2005) vision of the smart library:

> *"In a Smart library, navigation and book finding should be less of a chore, with a series of systems in place to give you directions when you are on a book search.*
> *Dynamic maps and trails that can be printed or sent to your phone or pda, based on your*

list of searched books. These maps can show you the shortest paths to travel in order to find your books and give directions based on your point of origin, not just a floor number and a triple barrelled bibliographic sequence."

Some research (Jones et al., 2000) however, has shown that this sort of guidance is most suitable for larger libraries such as those spread over more than one location. The Erehwon project at Oxford University (http://erewhon.oucs.ox.ac.uk/) takes this idea on a large scale (in this instance using GPS), providing a location aware interface for members of the University to find the nearest (amongst many!) University library that stocks a book they are interested in, including a route to that library and information about the library itself (for example, opening hours).

Durham University (http://tel1.dur.ac.uk/wiki/) have been experimenting with the ideas of locating users through WIFI triangulation across it's campus, calling it the Technology Enhanced Campus. Software compatible with Windows Mobile phones and PDAs can be downloaded to access the system, which at present has functionality such as:

- Displaying information on the users location.
- Searching for a room.
- Social networking, displaying information on friends location.
- Location specific news feeds.

These approaches have tended to use dedicated devices such as PDAs, though the spread of smartphones which often include GPS, WIFI capabilities, good web access (to allow web based applications) and easily installed third party applications has meant more generic systems can now be built and used. They still require complicated software development, mapping of signal strengths and a great deal of time and effort to make them work. It is hard to see how this true location aware approach can be made to work for most libraries that will lack both the skills and time to develop their own systems.

Smarter objects

The alternative is to use smarter objects that can prompt a device to take action appropriate to that object. These smart objects can be as simple as a code, such as a QR code (Walsh, 2009) placed in an appropriate position that can be decoded by freely downloadable software on a range of mobile devices. QR (or Quick Response) codes are a matrix code, similar to a two dimensional version of a barcode. As such they can embed far more information than a normal barcode within limited space. They were created by Denso-Wave in the early 1990s, which made the standard publicly available without royalty, resulting in international standards such as ISO/IEC18004 (the standard currently in force). Using a freely downloadable application, available for most mobile camera phones, the code itself will prompt the mobile device to perform an activity, such as go to a web address, so in effect can link to video; audio; interactive web pages (such as quizzes); or web pages that display further information on what can be found in an area.

QR codes have been used in the University of Huddersfield library to do deliver information appropriate to the context and location of the user. We've developed mobile friendly information skills materials and linked to them, plus a range of other resources via QR codes on both printed

materials and on appropriate locations in the physical library.

Some key uses we've found for QR codes are:

- **Linking from print to electronic journal holdings.** On the boxes containing back copies of print journals, together with the display stands holding current copies, we stuck QR codes that took users to our link resolver, searching our electronic holdings and linking to the appropriate electronic journals where available.

- **Providing an electronic alternative to physical books.** We selected a number of books that were available in PDF format (seen as more mobile friendly that those that require a proprietary reader) and put next to the physical books a card containing a QR code that linked to the electronic version.

- **Promoting online audiovisual materials.** We keep audiovisual material, such as videos and DVDs, on separate shelving within the library. A QR code on the shelf end linked to our online "Unitube" service, which is replacing the physical collection for newer recorded material.

- **Embedding video help.** We regularly produce online videos to provide help to our students. Some of these were converted to mobile friendly formats and linked to from QR codes from appropriate places in the library. So, for instance, a video on how to use the print credit machine was embedded in a QR code on the print credit machine.

- **Bringing external resources into the library.** Many of the shelf ends display QR codes linking to external resources that may be of use to our students, so for example, we link to the Office of Public Sector Information (OPSI) website (where legislation can be found) from the shelves that contain our print holdings of UK legislation.

- **Finding appropriate help.** QR codes were displayed across the library that linked to our help desks, prompting the users phone to ring IT help; library help; or send an SMS to our "text a librarian", whichever was appropriate for the location.

- **Taking the catalogue record with you.** The first application for QR codes we introduced was on our library catalogue (http://webcat.hud.ac.uk). We've found that sometime our users may write down incomplete information from the catalogue screen and become frustrated when they then fail to find the item. We've heard some evidence that a number of library users have been using their mobile phones to take photograph of the catalogues screen to get over this problem. Therefore as our first use of QR codes, we put a piece of code into our online catalogue that automatically generates QR codes which link to a version of the live catalogue record for each item.

There are alternatives to QR codes that work in the same way. QR codes however follow an international standard and have many freely available applications that users can install on their own phones. As a paid alternative, some educational suppliers are even producing their own versions of such codes with the software pre-installed on gaming devices. ConnectED sell a

system called “Second Sight” on the Sony Playstation Portable, http://www.connectededucation.com).

RFID tags for more than just circulation

As described above, RFID tags can be used to provide location specific information, with Tresoriero et al (2008) describing the u*sed of passive tags on museum exhibits to display further information on a mobile device (PDA with plug in RFID reader). With RFID tags being used in many libraries for circulation and stock control, plus RFID tags often being used in student cards, we have a ready supply of potentially smart objects already.*

The RFID tags themselves provide limited information, but connected to the wealth of information that our libraries hold on our stock and our users and they become smart objects, acting as mobile connectors to a world of usage and behaviour information.

RFID tags in libraries are, as stated before, primarily used to label stock and have tended to be used in much the same ways as barcodes previously. They have made it easier for library users to issue and return items through self service equipment and some libraries have used them to aid stock taking. There is so much more that we could do with them though, using them to display some of the data linked to our physical items that is normally inaccessible to users.

RFID readers are available for mobile ’phones and are rumoured to be standard equipment as part of the next generation of iPhones with Apple filing a related Patent application (2007), but we must be careful not to put unnecessary barriers to use into any systems we develop, so the proposals here all suggest the use of readers linked to fixed computers.

Our own library, in common to most other academic libraries, has computers that are dedicated to the use of the online library catalogue spread through the physical library, so users are never far from easy access to the catalogue. These computers could also be connected to RFID readers to provide the sort of functionality suggested below.

- ***Book recommendations*** *– By placing an RFID tagged book on the reader, the computer could display recommendations for other relevant items. Usage data could be used to show what other items had been borrowed by people who had previously issued the item. It could use subject headings to recommend other books on the same or similar subjects; or show alternative editions of the same book. Scanning a RFID enabled student or staff card could also display recommendations, such as top books borrowed by other people on your course. This could then lead onto the same suggestions as displayed when scanning a book. Similar recommendations displayed on our online catalogue (*http://webcat.hud.ac.uk*) seems to have increased the range of book stock borrowed (Pattern, 2009).*

- ***Comments on a book*** *– An option could easily be given to allow comments and rating of books. Placing an item on the RFID reader could display a comments box an an opportunity to give the item a star rating. The star rating and comments would then allow*

potential borrowers of an item to decide whether that item is suitable for them. Alternatively, this could display automatically on self-return machines, giving those people who have just returned an item an easy and painless opportunity to give feedback on that item to others.

- ***Recommend this book to others –*** *linked to the idea of comments and star ratings on items, when an item is returned users could be given the opportunity to recommend it to others (positive feedback); not leave a rating (neutral); or recommend that others do not use the item (negative feedback). This could give a way of ranking recommended items so that those that receive positive feedback would appear first in a list.*

- ***Personalised help*** *– scanning your card on a reader could interrogate your usage history of online materials and well as your course. It could then give recommendations of other online resources you haven't yet used that may contain relevant information or interactive tutorials that help with the resources you've already used. These are materials that are generally available in academic libraries, but in this case could be targeted at the users who would most benefit from them.*

- ***Social Networking*** *– for students, the RFID stations could provide a way to let friends and colleague know where they are; leave messages for people you have chosen as 'friends'; and for staff or research, perhaps interrogate usage history of books and online resources to suggest possible research partners who are interested in similar topics, helping to break down barriers between academic departments.*

- ***Pick up messages for you or your course –*** *as well as social networking messages; if a user scans their card on one of these proposed stations they could display individual or group messages targeted at those users by course or by individual, for example course information; subject news; or news from the library.*

Conclusion

So, what how can we bring that element of magic into our libraries that takes note of where our users are; possible who they are; and tries to connect them with context relevant information beyond the purely physical?

We can use mobile technologies to track our users through technologies such as GPS; WIFI triangulation; or active RFID tagging, though there are still problems with doing this through users own devices, so most projects to date have used library supplied devices. Alternatively we can use fixed points that link user to information such as QR codes or RFID tags attached to items, utilising users own mobile devices (or library supplied devices) to link to relevant materials held online to provide context or location appropriate help and information.

Perhaps the most accessible of all these would be to use the RFID tags in items such as our own stock, or in users own library cards, to connect to the wealth of data we already hold but rarely use. This could initially be made available through RFID readers attached to existing catalogue computers, though with the next generation of smartphones potentially including RFID readers,

we could shortly make this mobile as the platforms mature.

This paper ends, therefore, on a call for action for libraries that currently use RFID to manage their stock to start to experiment with using them to make their data more visible to point moving through their libraries, moving them onto mobile friendly platforms as soon as possible afterwards. Combining our data with existing RFID tags and mobile technologies, could make enormous strides towards a smarter library, bring the physical library as an information environment (rather than a glorified computer lab) back into the centre of student life. As Hahn (2008, p. 279) says:

"Research which sought to make full use of all cell phone hardware and software capabilities in tandem would be creating a service which did not have a true analog in the physical library ... The development of such a platform provides the library with a way to be an instrumental part of the student's life."

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