Chapter 1

RFID, libraries and the wider world

New to RFID? Curious about how it works? Want to know about RFID in the wider world? This chapter looks at the history and background of RFID technology, and outlines some of its uses in everyday life as well as exploring its main applications in libraries.

Why RFID and libraries?

Few, if any, technologies have had as immediate an impact on libraries as that of Radio Frequency Identification (RFID). From a standing start in the mid 1990s to a position where an estimated 300 sites worldwide were home to 120 million tagged items by 2005, RFID has spread rapidly around the world's libraries seemingly with little to slow its progress.

This would be impressive under any circumstances, but it has been achieved against a background in which, even now, most industries still see RFID as an experimental product, whose return on investment is doubtful. The majority of commercial applications remain restricted to limited aspects of supply chain management, with tags used at the consignment or pallet level rather than on individual items.

At the time of writing, the very few commercial organizations operating RFID at item level on any significant scale are still seen very much as pioneers, with the RFID industry still some distance from even beginning to approach critical mass for item-level adoption.

Consequently, the claim in 2004 that 'libraries are much further along with using RFID in a consumer environment than anybody else' (Lichtenberg, 2004) might have been surprising, but could easily be justified. The main reasons for this are that, for many library managers:

- RFID is ideally suited to library applications; the need to keep track of thousands of individual items involved in millions of transactions in the most efficient way possible is only one of many applications to which RFID is very well suited.
- Additionally, however, RFID has a major advantage over other technologies used in libraries for this purpose: the tag has the ability to combine the functions of a barcode (as a unique item identifier) and a security device (able to indicate that an item is being removed from the library without permission). This by itself would be attractive, but, with the added benefits of the ability to read multiple items and to do this virtually simultaneously without the need for line of sight, RFID clearly has a lot to interest any librarian looking to streamline operations.

Perhaps the reason why people not involved in libraries express surprise at finding them at the forefront of adopting item-level RFID tagging is a perception that libraries are highly risk averse, resistant to both change and the application of technology. However, library managers, having experienced developments since the late 1960s, from manual Browne-type systems, using pieces of cardboard, through to photo-charging, offline disk-based data capture and proprietary online 'integrated library systems', to web-based modular approaches would probably beg to differ.

In fact – being very venerable institutions – libraries have a longer history than most of using technology to adapt both to their changing environments and to the media they provide for their users. Whether coping with the change from papyrus roll to vellum codex or from paper to electronic media, libraries have an excellent record over the centuries of responding to these demands by changing their mode of organization, adopting different approaches to security, and adapting the ways in which their collections can be accessed.

This openness to new ways of working in order to improve the reader's experience perhaps goes some way to explaining the rapid growth in RFID take-up in libraries. RFID not only offers another opportunity to redefine service delivery, but, according to some commentators, has the potential to revolutionize library processes to a greater extent than anything before it.

RFID – the technology: a brief history

The history of RFID is surprisingly contentious, although there is general agreement that the basic technology dates back to at least the Second World War. At that time, the constituent processes of RFID – a transponder, reacting to a signal received by a transmitter, either reflects the signal back or broadcasts one of its own – were used to enable swift differentiation between friendly and enemy aircraft.

However, it was only in 1973 that Mario W. Cardullo received a patent (US Patent 3,713,148) for what is now clearly recognizable as a passive, read-write RFID tag. His description of the development of the concept (Cardullo, n.d.) makes it clear that the idea was to converge different but related existing technologies – the 'friend or foe' aircraft detector system described above, electronic security systems, and a chip with memory capacity – into a smaller and portable format.

This format – the tag – would later become available in a variety of shapes and sizes (some being smaller than a grain of rice, others more like a book in size and weight) but the essential content would almost always consist of two main elements – a memory chip and an antenna, usually made from copper or aluminium – bound together into a single device.

First commercial applications

The patent application also described some of the potential uses for the device, including what was to become one of its earliest and most ubiquitous commercial applications – automated toll payment – which has been a common feature on bridges, tunnels and motorways since the mid 1980s. This, in turn, appears to have been a further development of one of RFID's earliest deployments (like most, emanating originally from the defence industry), which was the tracking of nuclear materials at Los Alamos National Laboratory in the US.

Other commercial applications soon followed, including security cards for controlling access to buildings, the tagging of cattle, and – perhaps most commonly – logistics solutions, particularly the tracking of reusable containers such as beer kegs, which are often both expensive to produce and extremely attractive to a wide range of users outside the supply chain. In contrast, RFID's visibility in everyday life at item level has been fairly limited until comparatively recently, with most common commercial uses of RFID still remaining at the pallet or consignment level in warehousing and transport applications.

The usual explanation given for this comparatively slow commercial take-up of RFID at item level is the relatively high cost of a tag compared with that of a more popular competing device – the barcode. However, accurate comparison of the benefits and disadvantages of RFID to those of barcodes is not always easy, and tends to concentrate on the relative pricing of the tag and the barcode alone, rather than on the costs and benefits of the technologies as a whole.

RFID or barcodes?

Such comparisons also tend to emphasize the advantages enjoyed by the barcode resulting from its early widespread adoption, and as a result – in libraries, as elsewhere – the RFID tag has tended to be seen as a modern usurper of the barcode's role. However, they are much more closely contemporaneous than might first be thought, with barcodes not being commercially available until 1966, while the first instance of a supermarket scanning a barcode (on a packet of chewing gum) did not occur until 1974.

So, the ubiquity of the barcode rather than the RFID tag in everyday applications is not really attributable simply to its having been around longer. Rather, it is partly to do with a perception of RFID's higher cost and the early application (or otherwise, in the case of RFID) of standards. As we shall see throughout this book, these themes recur again and again in the story of the use of RFID in libraries and elsewhere.

RFID – the technology: frequencies

Rather than describing a single entity, RFID is really a shorthand term for a range of technologies which share the same basic physics and components as described in the Second World War application referred to earlier. However, this can be misleading, as RFID is employed at a number of different frequencies and tags can be either active (containing their own battery) or passive (finding their energy from the scanning antenna). The longevity of active tags is effectively determined by the durability of the battery on which they rely (unless it can be easily replaced or recharged), while passive tags clearly do not have such a dependency – although there may be environmental constraints or weaknesses in their construction that may affect their effectiveness over time.

In addition to all of these variations between tags themselves, their readability will also vary considerably according the scanner being used. The power and versatility of these devices is increasing at a rapid pace, and often the source of improvements in RFID systems is the scanner rather than the tag.

These differences are particularly important, as RFID's behaviour and potential applications vary accordingly, and this needs to be borne in mind when discussing both the advantages and problems of using it. RFID is also a technology that is developing all the time, and some things thought impossible only a few years ago are now available as part of functioning systems.

It is, then, a very complicated area, but the main categories, comprising four broad frequency groupings, are described below.

Low Frequency (LF) (up to 148 kHz)

This is used mainly for access control and animal identification, and is particularly well suited to use in hostile environments – the cost of these tags varies considerably according to the conditions in which they are intended to work. This frequency has the advantage of having a high penetration of liquids, and can also be used around metal with some success – although no RFID tag is able to read through metal. It is usually readable up to a distance of 10 cm, but some tags can be read from a greater distance. This frequency was used for the first major applications of RFID in the 1980s.

High Frequency (HF) (13.56 MHz)

This is the frequency used by the great majority of RFID libraries, and is also used for smart cards, access control and vehicle immobilization. It has medium penetration of liquids, but does not work well with metals, and is usually readable up to a distance of one metre. Development of this frequency was prompted by the need for a tag that could be used in very large quantities at a comparatively low cost, and it began to be adopted extensively during the 1990s.

Ultra High Frequency (UHF) (433 MHz and beyond)

Originally used mainly for pallets, UHF is now increasingly used for item-level tagging. It has the advantage of working well around metals but has low penetration of liquids. This limitation is fairly crucial from a library point of view when one remembers that the human body is predominantly composed of water, thus making tags fairly easy to mask. However, the recent development of 'near field' UHF has reduced the effect of this limitation. Read distances can be up to 100 m with active tags, although with passive tags this reduces to less than 10 m. Common applications of tags at 433 MHz include the remote locking of cars and their (often controversial) use by local authorities in refuse collection, where tags are placed in domestic wheeled bins to identify the property using them.

Microwave (2.45 GHz)

This is used mainly by Wi-Fi and Bluetooth applications. All low and high frequency tags are passive, while, as indicated above, UHF tags may be passive or active. To complicate things yet further, some tags can be semi-passive – containing an on-board power source but not communicating actively. Also, there are various options that can make tags operate and behave differently, such as on-tag memory, functionality and sensors. To provide an indication of the range of sophistication involved, not only can on-tag memory be Read Only, Write Once Read Many, or

Read-Write, with some elements being lockable – but also all of these elements can be present in the same tag.

A simple guide to all of this is that, generally speaking, the smaller the tag the shorter the read range; the lower the frequency, the shorter the read range; and that passive tags have a shorter read range than active tags, as they have no power of their own.

Until recently, all library applications were HF (13.56 MHz), but, as previously mentioned, developments in UHF technology have meant that it is now possible to use it more successfully in a library context. As a result, some UHF installations have now been undertaken in libraries in Australia and Japan (where it has been proposed that UHF should be the standard for libraries in the near future), and they also form the basis of the system adopted by the Selexyz bookshop chain in the Netherlands.

RFID – the technology: process

Regardless of frequency and active or passive status, the basic process involved in all RFID transactions is the same: a scanning device detects a radio frequency (RF) signal from a transponder – the tag.

Unfortunately, it seems likely that this shared basic process, which has led to the adoption of RFID as a shorthand term for what is actually a range of differently performing technologies, is the source of much of the concern about its potential for enabling the invasion of privacy in some parts of the world – if tags can be used to track the movement of cattle, then why not human beings?

One of the rare appearances of RFID in the mainstream media to date, a TV advert for IBM (see http://uk.youtube.com/watch?v=oAvQcYcvyaw) showing a secretary at a desk in the middle of a desert road, informing two truck drivers that she knew they were lost because 'the boxes told her', further suggests to the layman that concern about the use of what appears to be the same technology in libraries may not be entirely misplaced. These anxieties are explored further in Chapter 5.

RFID – a disruptive technology . . .?

RFID is frequently referred to as a 'disruptive' technology. This is a term that is used quite widely to cover innovations in general, but it also has a more specific meaning. Clayton Christensen (1997) developed this particular interpretation of the phrase, and although he later amended his description to 'disruptive innovation', recognizing that technology by itself is unable to change anything, it is the original term that has endured. According to Christensen's analysis, some technologies are so radically different from everything else currently available that they either overturn the existing dominant technology in the market or simply create a new market altogether. They contrast with 'sustaining' technologies, which tend to be incremental and are designed to improve existing mainstream products.

Examples of this kind of fundamental shift in everyday life include the change from the horse-drawn carriage to the internal combustion engine; from film to digital photography; and from printing to desk-top publishing. A brief look at some applications for RFID in the world outside libraries certainly suggests that it has the potential to fulfil most of the criteria of a disruptive technology. Although still in its infancy in retail applications, some of the scenarios made possible by linking 'smart' tags to similarly 'smart' domestic goods show how RFID can provide benefits not only in the early phases of the supply chain but also to the end user – the consumer.

For example, the advantages to retailers provided by tagging perishable goods are not too difficult to envisage – more accurate stock control, automatic reordering, and so on. However, if the customer buying the goods possesses a refrigerator with an appropriate scanner – a 'smart fridge' – then they can benefit from a number of potential value-added features. Some of these are simply pragmatic – such as alerts to when the goods have has passed their sell-by date, thus avoiding the possibility of exposure to food poisoning or worse.

More imaginatively, however, the 'smart fridge' could also analyse its own contents and provide recipes or suggestions for meals based on them. Building on that concept, shoppers in possession of a suitably enabled mobile phone could dial their smart fridges from the supermarket, and, having checked the contents, make their purchases in a more purposive manner. Both Samsung and Electrolux have demonstrated that such applications are workable, although it seems doubtful that they can be produced cost-effectively at present (Batista, 2003a).

RFID and the wider world – some existing applications

The use of RFID tags is already quite widespread in some elements of the production of cars and electronic goods, but it could also potentially support servicing and maintenance throughout a product's life, providing mechanics and repair men with a detailed history of any work that has been carried out previously, including replacement of parts.

Some very simple applications of RFID in day-to-day household products are beginning to appear, such as domestic heaters with detachable RFID thermostats. These heaters can be regulated according to the temperature in any part of the house, rather than only that of their actual location. Similarly, RFID-enabled doorbells mean that the placing of the sounder unit can be completely independent of the door, anywhere in the building, without the need for extensive cabling.

Leisure uses

The world of sport offers some of the most inventive uses of RFID – the tag in a 'smart' golf ball means that it need never be lost; tagged sports shoes enable much more accurate timings in athletics events; while tagged footballs may finally result in definitive refereeing decisions in 'did the ball cross the line?' situations.

The use of RFID in ticketing of major sports events has not only become an effective hindrance to counterfeiters but has also provided organizers with the facility to manage large crowds more effectively on the day. In the UK Manchester City, Fulham and Reading are just some of the Premiership football teams to use RFID tickets to reduce queues and increase safety (McCue, 2006), while much of the efficiency of the Beijing Olympic Games stemmed from its use of RFID in a wide range of behind-the-scenes applications.

Alton Towers theme park in the UK offers visitors the facility to wear an RFID-enabled wristband to create a DVD of their day at the park. The 'Your Day' wristband triggers cameras located around the venue and on the rides to create 'a unique personalized movie' to take home at the end of the visit.

Animals and people

However, alongside these comparatively benign applications there are some intrusive, and sometimes controversial, uses of RFID which include the 'chipping' of living beings. This has now become widespread for domestic pets, enabling them to be identified if lost and returned to their owners. It also facilitates their travelling between different countries, as the data on the chip includes details of vaccinations and other medical information, enabling their owners to take them on holiday more easily. (However, this is not always the outcome, as tags used for this purpose in the USA tend to be at a different frequency (125 kHz) from that specified by the International Standards Organisation (134.2 kHz) and as used in most of the rest of the world.)

For human beings, the external attachment of tags to criminals has become an alternative to prison in some instances, and has been generally accepted despite some concerns about its efficiency and effectiveness. However, there is less of a consensus about the use of RFID implants for human beings. While the benefits of health-related tagging are probably fairly widely accepted, the uses made by people such as Amal Grafstra of RFID implants in his hands to open the doors of his house and car, and to log on to his computer (www.amal.net/rfid.html) are perhaps more open to debate. Nevertheless, some nightclubs (Morton, 2004) have successfully persuaded some of their users that an RFID implant is an easy and convenient way to pay for their drinks.

Commercial uses

One of the few examples visible to the customer of large-scale adoption of RFID in the UK retail world is that of Marks & Spencer. The motivation for introducing RFID in this case was to improve stock control, and so improve sales. Aware of the importance of having all items available in the full range of sizes and colours all of the time, Marks & Spencer initially began tagging menswear to try to ensure that no customer seeking an outfit abandoned their purchase due to the unavailability of any one item.

Working on the basis that potential sales lost in this way – a jacket not bought because a matching pair of trousers could not be found in the right size; a suit not purchased because the shirt and tie required to go with it were not available – were a significant opportunity cost, the business case for RFID implementation became much more than a simple supply chain benefit and was soon extended to other categories of stock (Collins, 2004).

However, perhaps the largest RFID application in terms of scale and impact in the UK has been the introduction of Oyster cards by Transport for London, with millions of travellers now used to 'touching in and out', even if they may never have heard of RFID. The popularity of the system is a good example of way in which RFID can be applied to routine and often tedious tasks, in this case making an element of the commuting process much simpler and easier to use. This convenience no doubt explains much of the success and popularity of the scheme, although it should be noted that Transport for London has also used significant financial incentives to lead its customers along this path, and away from the more expensive, human interaction-based alternative of ticketing.

Disrupted libraries?

Probably the definitive disruptive technology in the library world since the early 1990s has been the internet, fundamentally changing traditional approaches to information management in many different ways. Indeed, from the point of view of many members of the public, it has been sufficiently disruptive for them to believe that it has done away with the need for libraries altogether.

So, is RFID also a disruptive technology for libraries? Applying Christensen's definition to the process of locating, borrowing and returning a book, it might be argued that the last major disruptive change in lending libraries was the move from closed to open access. This not only fundamentally changed the nature of the relationship between the reader, library staff and the library's contents, but also necessitated an entirely new technology to deliver the service in a completely different way.

For example, Cotgreve's indicator – the ingenious device developed to show whether an item was available for loan and where it could be found by library staff – suddenly became an irrelevance once library users were able to browse the shelves for themselves. Instead, new methods of library arrangement and navigational aids become necessary to exploit this change in approach, enabling and facilitating browsing and the serendipitous nature of libraries so highly valued by users today.

By extension, most developments in lending-library technology since the introduction of open access can be seen to have been only 'sustaining', providing (usually, but not always) better ways – Browne, photo-charging, barcodes – of recording transactions and devising procedures to provide various added-value services and/or save staff time.

RFID and libraries – a brief summary of the main applications

The disruptive quality offered to libraries by RFID is seen by its proponents to stem from its ability to change yet again the relationship between the customer, library staff and the book. Yet, while RFID's potential for revolutionizing stock management would seem likely to be its main selling point to library managers, its initial attraction has actually been a use to which it is not usually put elsewhere.

Self-service

Although the description of the RFID tag as a combined barcode/security device is not only simplistic and limiting in terms of realizing other potential applications, the customer-friendly self-service made possible by this combination of features is certainly at the heart of the attraction of RFID for most libraries. It also explains why libraries in particular have been so much quicker to adopt RFID than most retailers – the fast and convenient self-service it provides is a 'killer application' for libraries, where individual items are lent and returned possibly hundreds of times. Conversely, shopkeepers generally hope never to see an item again once it has left the premises. This alone means that the cost of the tag – the most expensive element in most systems – can be more easily justified by libraries, as the device will be used over and over again, as opposed to the single front-line transaction application in retail.

Security

The prevalence of RFID self-service installations obscures to some extent the level of use made by libraries of RFID as a security device, fulfilling the role otherwise undertaken by more traditional radio frequency (RF) or electromagnetic (EM) systems. Its use purely for this purpose, independent of self-service, is comparatively rare, mainly because self-service tends to be the main driver for installations, but also probably because there has been a certain amount of publicity suggesting that RFID is less effective in this area than RF or EM devices.

However, there is little firm evidence to support the supposition that RFID performs any less effectively than either RF or EM systems in minimizing loss by theft. One aspect – that it is usually easier to conceal an EM tag within the binding of a book, for example, so making it more difficult to disable – is certainly something that needs to be taken into account. Nevertheless, most library managers will also be aware that the value of such systems is essentially as a deterrent, rather than as a foolproof method of theft prevention. So, supporters of RFID point out that while RF and EM security systems have only limited other benefits to offer (essentially, their role in barcode-based self-service), RFID can also be used in a number of different ways.

Some libraries, however, do use these other security systems alongside RFID; this is particularly true of academic libraries, which often use EM security for non-book materials such as individual copies of journals, resulting in a hybrid approach which requires the introduction of dual-technology scanners to read both types of tag.

Stock control

The benefits that RFID offers the library manager in relation to stock control – particularly inventory and shelf-checking – are potentially equally as substantial as those provided to self-service and security. Perhaps surprisingly, however – especially considering that this is RFID's primary use elsewhere – adoption of these applications has been rather slower to catch on. This is partly due to difficulties in getting the hardware to perform satisfactorily, but perhaps also because the payback is rather less immediate.

In fact, there is a danger that RFID has already become synonymous with self-service for many library managers, to the extent that its potential for improving other library processes is overlooked. Later in this book, we shall explore other potential (and actual) applications of RFID in libraries which demonstrate its pervasive nature, resulting in additional benefits above and beyond that produced by self-service alone.

Summary

RFID has had a rapid impact on libraries, more so than on most other aspects of daily life. It operates at different frequencies, and its behaviour varies accordingly. RFID has been used in libraries mainly for self-service, but has the potential to revolutionize many aspects of library service delivery.