

RFID: What Went Right? What Went Wrong?

Sung Kuan

1. Introduction

The National Library Board (NLB) was established on September 1, 1995 to spearhead the transformation of library services in Singapore in the Information Age. On November 21, 1998, the first application of radio-frequency identification technology was fully deployed in a library environment (Bukit Batok Community Library). By May 2002, 20 libraries were fully equipped with RFID technology enabling the customers to borrow and to return media at any library. The application also had its own supply chain for tagging and re-tagging library items. By 2006, the number of libraries employing RFID had increased to 39 (1 National Library, 3 Regional Libraries, 19 Community Libraries and 16 Children Community Libraries), serving the Singapore population of about 4.35 million. April 14, 2006 marks the end of the first generation RFID library system when all 39 libraries were upgraded with the second generation system.

2. What is an RFID Library System?

In NLB's context, the purpose of RFID technology is to reduce the cycle time for critical business processes in order to satisfy our customers as well as to reduce costs and offer the possibility to extend the e-business model. The latter is made possible because the RFID system is often regarded as an extension to the internet just like a web cam. The web cam allows us to 'see' the internet use whereas RFID allows us to 'feel' it.

3. Why RFID?

A business process re-engineering (BPR) exercise was done in 1997 over a period of seven months. One of the studies focuses on Time-to-check-out and Time-to-shelve aiming to minimize the time for borrowing and returning books. The "time-to-check-out and time-to-shelve" project was carried out to reduce the long queues of customers waiting either to borrow or return books. Prior to 1995, with 5.7 million visitors a year, it took an hour to return a book and also an hour to borrow a book. Thus a stretched target was set that was "zero wait" time. Ideally, this could mean saving 11.4 million hours (assuming each visitor of the 5.7 million borrows a book) a year for our customers.

4. First Generation RFID System

Our first generation RFID system consists of the following items:

1. Borrowing station; for check-out and renewal of library items
2. Book Drop; for returning library items
3. Sorting Station; for back room library items sorting
4. Local Server; for managing all RFID stations (for example; off-line mode when the central host is down)
5. Counter Station; to enable staff to manage the stations from their counter
6. Portable RF reader; to read the books on the shelf
7. Electronic Article Surveillance or EAS gate; to detect armed items.

Except the EAS gate, all stations are designed to communicate with the central host which is located at our data centre. This system has the following features:

1. it enables real time transactions
2. it shortens library items check-out or renewal time
3. it shortens library items check-in time
4. it allows unmanned check-in/check-out/renewal
5. it allows a 24 hour library items check-in
6. it requires only one staff for sorting library items.

By 2000, the number of visitors has increased to 21 million and the number of loans had also increased to 26 million, but there was no increase or decrease in library staff. This means that while our business had grown, our costs had remained relatively stable.

5. So, what went right?

To borrow an item at any NLB library, a customer simply places the book on a pad at the self-check machines and the book is instantly registered as borrowed (see illustration 1). Thus, it takes less than a minute to borrow 4 library items. A customer is able to borrow media at any library, return them at any library and his library account's status is updated in real time. To return books, a customer simply slides the book down a book drop chute, and the book will be registered as returned (see illustration 2) in less than 5 seconds. By installing the book drop outside the library building, the libraries were able to offer a 24x7 return service.

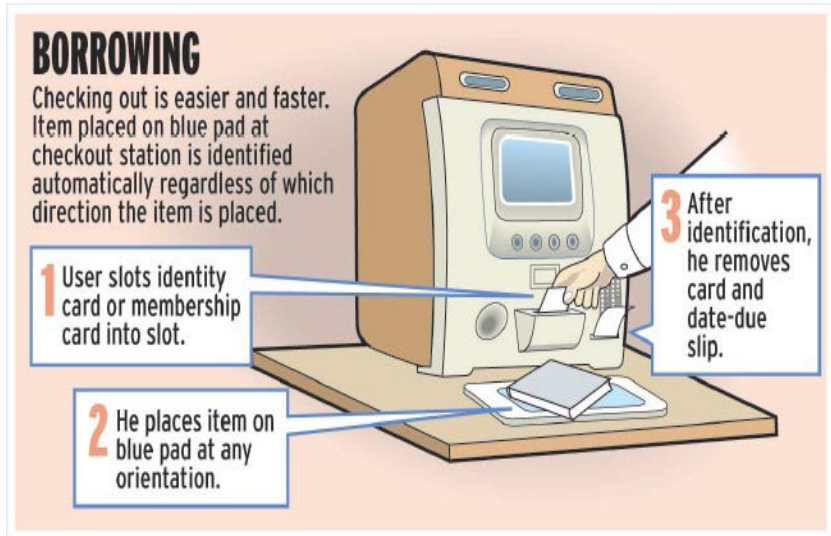


Illustration 1: NLB first generation library system book borrowing station

To achieve a seamless service, a basic component of smart-label technology is adopted. Each book, CD-ROM or videocassette carries a tiny RFID tag containing a transponder chip that is 2 mm square in size and 0.5 mm thick. The antenna attached emits a radio frequency of 13.56 MHz. The chips are also programmed with unique identification or ascension numbers. Every item acquired by NLB is assigned a unique ascension number.

Currently there is a total of eight million items including books, DVDs, CD-ROMs and videocassettes carrying RFID tags. Each RFID tag with its ascension number is attached to an item such as, e.g., a book, and its label acts as a no-contact smart card. The unique information carried by the tags is decoded by radio-frequency readers when a customer places his book on the pad at borrowing stations or when the book slides down the book drop. Additionally, each RFID tag also has a security feature embedded. This will trigger the alarm at the electronic article surveillance or EAS gates at the exit if a customer leaves the library before checking out an item.

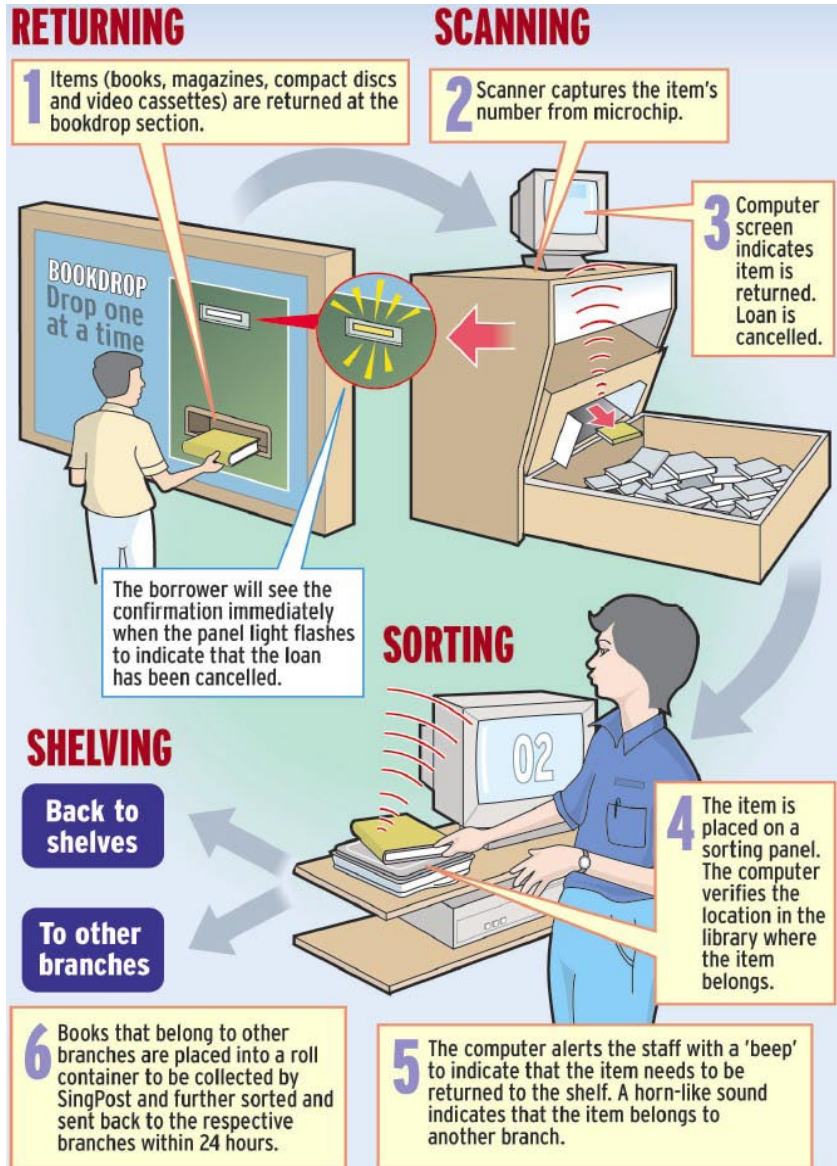


Illustration 2: NLB first generation RFID library system book drop & sorting station

Whereas bar coded items must be closely aligned with the bar code reader, RFID tags transmit information to the reader up to a distance of 25 cm. During stocktaking exercises, items are tracked by sweeping an RF antenna through all the items on the shelves. Reports generated from the data collection not only show which items are available but also which items do not belong to that particular branch. Using bar code technology, a stock-take exercise necessitated a library closure of two to three days. Using RF technology, the tracking of items is completed in less than four hours. The passive RFID technology is also convenient since operating power is generated from the reader and no external power source, such as batteries, is necessary.

6. So what went wrong?

As in any other project, there are some critical issues. I shall list ten of those which are of operational relevance without being unduly technical.

6.1 Where's the bar code scanner?

As libraries serve a wide range of people, no matter how simple the kiosks are designed, some customers will still need assistance to know how to use them. Prior to the RFID library system most customers were very familiar with bar code scanning. Using the RFID system, some were looking for the bar code scanner. It is important for a library that is launching a new RFID system to offer a guide or to assist the customers in other ways. Simplicity may just mean fewer problems rather than no problems at all.

6.2 Now what?

We had designed our first generation RFID system to operate in off-line mode. In other words, if the central host or the network connection are down, the RFID system will still allow the customer to borrow up to his maximum quota (i.e. 4 books in our case). Even when a customer has reached the limit, the RFID system will allow further borrowing. As soon as the central host or network connection are up again, the stored transactions will be uploaded. Those customers who exceeded the limit will not be penalized. We thought this was a perfect system. However, there had been situations when the RFID system, the central host and the network were working as normal, and yet, when the customer tried to check out a book, the RFID check-out screen showed "waiting for response". The customer may ask himself "Now what?" The wait may take several minutes and be intermittent. In such cases, a network analyser would be employed to check the data jam. In one case, it turned out that the RFID kiosk was waiting for the central host to reply,

the central host was waiting for an acknowledgement from the RFID kiosk and the communication appeared to have ceased. Some programming changes were made to deal with such errors (e.g. Time out and Resend) and we also improved the network quality (e.g. reduced the data package collision). In summary, the underlying cause had been a string of minor errors which, when taken individually, were not significant but when put together, caused the system to get stuck.

6.3 Silent and chirpy gate

RFID detection is never 100% secure especially for passive tag. If a customer puts the book in his bag and carries it low while walking past the gate, the gate may not beep. RFID gates are mainly RF antennae very susceptible to environment interference. If your gate is too close a metal wall, the reading detection will be reduced. If your gate's panels are not placed at equal distances from each other, you will have inconsistent reading performances. If there are high power cables running beneath your gate, your gate might just beep a few times every morning when someone turns on the power. Hence, to ensure that your gate performs well, your vendor should have a RF strength measuring device to configure a proper detection field strength. The surrounding of the gates should be conducive. I should like to emphasize that RFID detection is not 100% secure which holds true even at an educational institution where engineering students who studied RFID might consider it both a thrill and a challenge to put your gate to the test. Rather than banning them from using the library you could enlist their help to improve your gates. Library staff will benefit from learning more about RF and be better equipped to deal with RF vendors in cases of problems.

6.4 Wow, a million visitors a day!

The number of visitors is determined by the infra red mechanism installed somewhere in the middle of the gate. Not being a very accurate measurement, it nevertheless does give some indication. Perhaps we had set an incorrect expectation by calling it a 'visitor count' when we should have called it an 'estimated visitor count'. This is because calling it a 'visitor count', some members of staff actually expect a 100% accuracy. One way to settle this is to compare the physical count and the number gathered by the counter over a few days and to develop a mathematical formula to capture the pattern. You will then need to monitor it once a month to ensure that the count is not exceptionally high. In one case, a gate counted over a million visitors a day which was obviously wrong. The problem was due to a faulty infra red sensor.

6.5 Hello anybody there?

When we first implemented book drops, some customers thought there was a person sitting behind the wall doing a manual return. As a result, when returning his books, a customer actually flipped up the book drop cover and said "Hello anybody there? Can you quickly return my books because I need to borrow some books right away." Incidentally, there was really somebody on the other side and was stunned, because she was half way through her lunch.

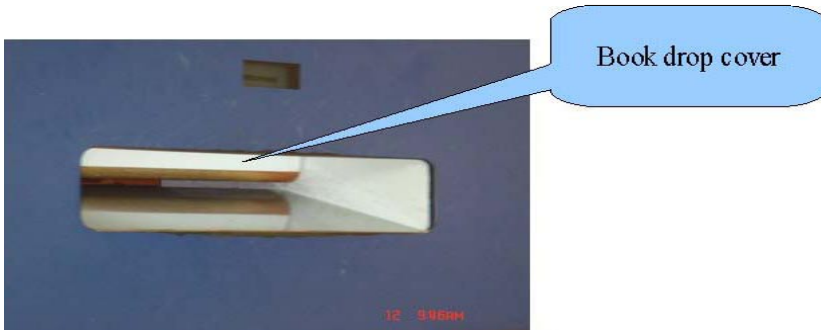


Illustration 3: NLB First Generation RFID Library System Book Drop Front Panel

6.6 Look mom! The wall took my arm!

As the book drop is exposed externally, beware of those children who have the tendency to put their hands into the book drop. Therefore, the design of the book drop should not be straight down and it should not be positioned too low. Some of our libraries are in shopping malls and instances of children playing around the book drop are common. Care should be taken to avoid children being injured.

6.7 Stuck on you.

As a library becomes popular, the loans and hence the number of books being returned during non office hours will increase dramatically. After a massive return in a single night the books will pile up inside the book drop, causing a jam. Books stuck at the opening may be stolen. Similarly, wet books, when being returned, may not slide all the way down but get stuck half way down causing a jam. On bank holidays, a member of staff should be arranged to come early to clear the books and select a 'non-stick' surface for the book drop chute.



Illustration 4: NLB first generation RFID library system book drop (jammed)

6.8 Whose books are these anyway?

Strangely enough, some people will put anything into the book drop even if it does not belong to the library. You will be left with the decision of what to do with these magazines, notebooks, scripts ...



Illustration 5: DVD with booster tag and RFID tag

6.9 Sorry guys, CD-ROMs & DVDs not detectable!

CD-ROMs and DVDs are metallic in nature, hence, when you place a tag in the middle the detection range is less than 10 cm. Although we have placed a 'booster' tag inside the covers of CD-ROMs or DVDs to improve the detection range beyond 10 cm, it still increases the costs. In addition, due to the ways DVDs are created and labels are printed, some DVDs response well while some do not respond at all even with a 'booster' tag. We have tried different ways to place the tag without being successful. This important fact are to be known to all stake holders: RFID tags do not work well on CD-ROMs and DVDs.



Illustration 6: RFID detection is almost zero when the DVD centre is fully metallic

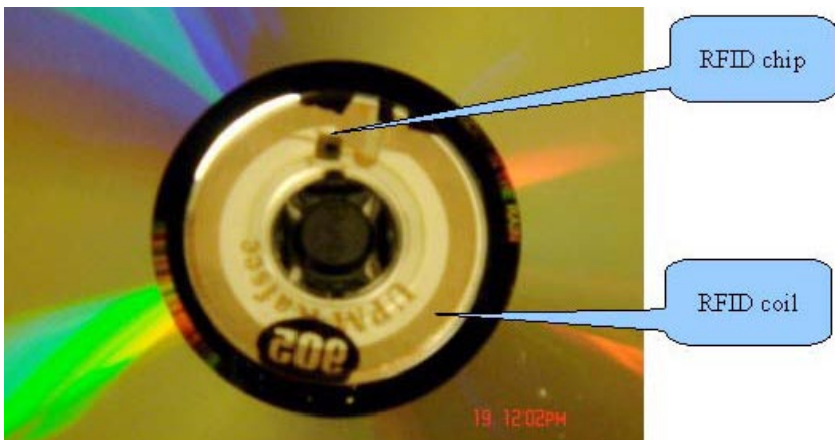


Illustration 7: RFID detection is possible, albeit not 100%, when the DVD centre has no metallic covering

6.10 Approach the counter, please

Multiple items, for example Chinese novels comprising of more than one volume or DVD set, can only be checked out at the counter. RFID check-out kiosks are not able to detect multiple items using passive tags and customers will need to approach the counter to check these items out individually.

7. Conclusion

When NLB first started exploring RFID in early 1998, there were no ISO or international standards to conform to. We were fortunate to have the funding support from the Singapore government to implement this idea. In May 2002, when all our public libraries were fully equipped with RFID, the public's borrowing queue time was reduced, the sorting of returned books was speeded up to enable a shorter turnaround time to reshelve the books. If NLB had aimed at a 'zero wait time' without the RFID library system, more than 2,000 additional staff would have been required. With the process fully automated, library staff can focus instead on providing valuable additional services such as assistance in matters of membership or enquiry, helping readers to find their way to the books of their choice. An unexpected side-effect was the kick-start of the RFID industry in Singapore. Today the directory is full of vendors providing RFID and related services. Therefore, apart from benefiting from an increased operational efficiency, NLB had also helped to stimulate the RFID industry in Singapore. Now there are cafes in our libraries and libraries in our shopping centres – essentially, our libraries have been integrated into the community and are considered havens of rest, places to meet people and to share the company of other book-lovers. With our recently issued second generation RFID library system and our customers getting used to the system, many of the critical issues have been resolved. Of course, using RFID on DVDs and CD-ROMs still remain a challenge for us to be solved.

