1st International Physical Internet Conference

Towards a smart interconnected era
of efficient and sustainable
logistics, supply chains and transportation

May 28-30, 2014 - Québec City, Canada

The Physical Internet concept for libraries: a first set of ideas

Kees Jan Roodbergen[1], Benoit Montreuil[2] and Iris F.A. Vis[1]

1. University of Groningen, Faculty of Economics and Business, Department of Operations, Groningen, The Netherlands
2. CIRRELT Interuniversity Research Center; Faculty of Business Administration, Université Laval, Québec, Canada
Corresponding author: k.j.roodbergen@rug.nl.

Abstract: *Libraries experience a declining readership base due to developments in e-books and the internet. At the same time governmental subsidies are highly reduced. However, cultural and societal constraints enforce libraries to keep up with a high service level and offer a full assortment to its customers. Historically, this was done by offering a full assortment in each library branch. However, floating collections, central storage and other logistics solutions might help libraries to reduce costs and at the same time keep service levels high. We note that potentially the decline of library usage will dampen in the future with the next generation that seems to care less about ownership. It is more about being able to read than to own books. This might improve the attractiveness of libraries. In this paper we study the potential of the physical internet concept for Dutch libraries to enable a smoothly operating library system being able to keep up its standards.*

Keywords: *libraries, floating collections, central storage, logistics, service level, cost reductions*

1 Introduction

Libraries struggle with decreases in governmental subsidies ([1]) and a declining readership. At the same time, libraries aim to continue to offer a full assortment and a high service level in the library system as a whole. Currently, several interesting developments in the Dutch library system can be noted. In 2013 a new IT system was introduced that enlarges the online visibility of books for readers dramatically. Readers are now able to see what title is available in what library in the country. The next step will be to allow online ordering and home delivery of books in a country-wide system. On a local level, libraries that started to share their IT/online system noted that the demand for books from other locations increased strongly, which at the same time created sustainability concerns due to the increased transport of books between branches. A clear advantage of this new IT system is the opportunity to use information on transaction data to

improve book movements, book purchasing and storage by allowing for real time decision making. We will explore the opportunities for the PI concept by using data from this IT system.

Research projects that the authors performed with libraries since early 2000 have shown us that libraries deal with many logistics challenges. In literature, studies typically deal with purchasing decisions and budget allocation (e.g., [2]), customer analyses (e.g., [3]), optimization of logistics operations at a single branch (e.g., [4]), warehouse operations for libraries (e.g., [5]) and transhipment operations between libraries ([6]). In analysing the Dutch public library system we notice a strong analogy with the evolution of supply chains and logistics as graphically represented by [7]. The library system currently unites aspects of different supply chain evolution levels. One of the current ideas in the Dutch system is to introduce one or more central storage facilities which is an idea at the Integrated level of the Supply Chain evolution. For the aspects that are at the atomistic level, a step towards the integrated level could bring advantages in costs and otherwise. However, for the aspects at the Collaborative and Interconnected levels, this may direct developments away from best path. Many companies are currently struggling to change from an Integrated structure to a Collaborative structure. Libraries already have a Collaborative structure that they can easily improve and expand upon. In this light, enhancing collaboration and interconnectiveness is more likely to yield the desired results.

An important constraint in implementing the PI concept is scalability. At this point, it can be concluded that in The Netherlands, borrowing of books has gone down in the past years with 25%. Clearly, the system itself will not disappear, however, the focus and size need to be altered and result in a smaller system designed for storage and reviewing with a high accessibility instead of a system purely designed for lending. Librarians aim for the following aspects: 1) at all times demand of readers should be fulfilled; 2) support should be offered to help readers in finding quality books that readers otherwise may not have found or read; 3) keeping up the societal role in offering a wide portfolio for readers with different interests, both being members of the library as well as visitors. In designing the PI system for libraries those objectives should be met.

The goal of this paper is to formulate a PI-vision towards an efficient and sustainable library system from a social, economic and environmental perspective. From a *social perspective* the aim is to improve by an order of magnitude readership accessibility for each citizen by offering the opportunity for finding and getting the right items in a fast, smart, reliable, convenient and affordable way. Secondly, to exploit the library system to invigorate local communities and the overall society. From an *economic perspective* the aim is to reduce by an order of magnitude the economic burden of maintaining a national library system. From an *environmental perspective*, the aim is to reduce by an order of magnitude greenhouse gas emissions, pollution, energy consumption, materials waste, induced by both the library system and the overall readership.

In section 2 we introduce the library system and potential changes in more detail. In section 3, we propose 12 different ideas varying from purchasing, assortment, inventory management and transportation decisions. In section 4, we report the results of a SWOT analysis that has been performed on several of those ideas by a group of librarians. Section 5 presents conclusions.

2   The Dutch Library system

A library system typically consists of several library organizations scattered throughout the country. Given the size, those organizations are organized at the level of a city, region or province. Every library organization has a group of branches where customers can borrow books, and do other activities. Membership cards enable users to borrow books of all branches of a library organization. If a book is not available in a specific branch, a customer can reserve the item and/or order it from another branch in the same network. Also inter-library-organizations flows of books can be noted for more specific items that are only available at a limited number of libraries. Different types of branches can be distinguished: full service branches, self-service branches, branches at schools, library busses and so on. The type of branch used typically depends on the amount of members and items borrowed, available capacity and staff, costs and available income.

As an illustration of the changes and trends impacting library systems, we summarize some relevant statistics on the Dutch library system [8] :

- In the period 2000-2013 the number of library branches (including service points with limited opening hours) has decreased from a maximum of 1130 in 2002 to 1035 in 2013.
- In the period 2010-2012 8% of the libraries has closed 1 or more branches.
- The average distance between a citizen and a library is currently 1.5 km in a high-density areas and over 2.5 km in lower-density areas [9].
- 79.2% of the inflow of money for libraries consist of subsidies of local government.
- 80% of the Dutch libraries has to deal with reductions in subsidies. Direct impact can be seen in the reduction of the number of activities offered to the public, the size of the assortment and the amount of staff hired in the front office.
- One third of the libraries expects to change some of its branches in self-service branches.
- Approximately 25% of the libraries has decreased the amount of opening hours.
- The total number of items borrowed in 2012 was 39.7 million compared to over 180 million per year in the period 1992-1998.
- The number of visits to a library is decreasing. In 2012 the association of Dutch libraries reported a total number of visits of 64.4 million per year. In 2005 86.1 million visits were counted.

Most of the customers visit a branch of a library to borrow a book. Online borrowing of books has been introduced. Typically, customers visit a library branch to pick-up and return their item. In low-density areas where branches have been closed, we note that pick-up locations at self service libraries and retailers are being introduced. Home deliveries are seldomly made. In The Netherlands online purchase of books already account for 37% of the purchases [10]. This might been an indication that also for online borrowing a market might exist.

We will focus on the following aspects that can be changed in a library system to obtain the objectives mentioned in Section 1.

- Assortment per location
- Number of copies per title in the system and/or at a location

- Introduction of "central" storage facility/i.e. where books are stored and shipped. Typically, customers can not visit those locations. Advantages of central storage include lower costs for land and daily operation.
- Close/shrink/add/expand branches in cities where typically land and building prices are high. Shrinking the assortment in branches might open opportunities for other activities in the building.
- Staffing
- Pricing of services. Different copies have different costs (e.g., waiting for a local book is cheaper than having a book shipped from elsewhere)

Based on those aspects, we formulate a set of ideas which together can be seen as a first PI-vision for the library system.

3 PI for the library system

In this section, we discuss several ideas which together form the base for introducing the physical internet initiative into the Dutch library system. For each idea, we explain the main reasons for implementing the idea as well as the relevant research and implementation issues.

Idea 1. Book purchase based on life expectancy of a book
Library books have a limited life due to wear and tear and readers' interests. We note a strong link with the newsvendor problem. However, in this case a more complex situation exists due to the dependency among book titles. Keeping track of inventories will be important in implementing this concept. Data should be collected for each title and all copies on the books' life expectancy. This can be measured based on borrowing rates and number of borrowing.

Idea 2. Internal book market
If a library branch wants to buy an extra copy of a book, they currently buy a new book and apply binding in hardcover. The life time of this book is approximately 20 times of borrowing. We propose the following new alternatives:

- Check for superfluous copies at other branches and transfer them to the right branch. The maximum *transfer price* can be calculated as follows:
  - *transfer price* = (price of a new book*number of borrows)/(max.borrows), where
  - *max.borrows* equals the expected number of future borrowing (minimum of lifetime, or expected demand).
- Buy second-hand from e-bay and the like

Idea 3. Profiling
Libraries have a lot of information on their customers from transaction data. Additionally, surveys or online questionnaires can be used. Big data analyses on reader profiling can help in managing assortment in branches dynamically and providing (online) advice/tips to the customers (e.g., like Amazon.com: "people who bought this, also bought....."). Matching those transaction data analyses and survey outcomes with Bisnode data enable detecting patterns for geographical areas, which help to predict preferences of people before they can be observed. We suggest to profile readers based on the following information:

- Previous borrowing
- Asking whether they liked the book they read
- Asking what they would like to read
- Social media profiles

Furthermore, we suggest to add an *online voting mechanism* to be used as an additional base for new purchases done by the library. Transaction data analyses can track the quality of the votes of a customer by tracking if a person that voted for a book also borrowed the book. If not, a library might opt to count the vote of the person less the next time that this person votes.

Idea 4. Pricing of services
The type of service a person wants from a library might differ per age group, service level, and customer priority. Libraries already have partly differentiated membership feeds in place based on promised service levels for assortment at a specific branch. However, if a book is not present at the location where the reader is, then a reader can place a request to have the item shipped to the right location. Typically, a fixed price is charged. We suggest to determine the price for shipping books to a reader dynamically, based on:

- Transportation cost
- Expected time of availability of the book at the location (e.g. if currently borrowed)
- Opportunity cost (if available elsewhere, what is probability that someone comes to the branch where the book is and borrows it there, thus giving an equal number of borrowings, at a lower cost)

Idea 5. Assortment planning
Most library branches do their own assortment planning. Operating in a library system provides the opportunity to make assortment decisions on a network level. Each library then will have the option to look at its own assortment and designate books based on three dimensions. Namely, (1) keep (2) try to sell (3) throw away. Secondly, for a book in the first or second category, the location needs to be selected from the following options: (a) here (b) anywhere in network, (c) not here.

Consequently, each book can be categorized as follows:
- Mine; lots of demand; must be stored in my building
- Mine; rare/valuable/specialty; must be stored in my building
- Mine; can be stored anywhere in country; do not throw away (i.e., if nobody wants it, the library is willing to store the book itself)
- Transferable; for the right price any other library can have it; otherwise keep.
- To get rid off; if no other library wants it, then throw away.

To use the outcomes on a network level, each library branch needs to add valuation to books in each category individually, based on librarians interest, and members preferences and profiles. Secondly, a market can be opened to bid for books (refer also to idea 2).

Idea 6: Managing stock versus owning it

Cooperation at a network level enables libraries to keep a variety of stock and enable readers to use stock at other libraries in the network. Key characteristic is that libraries reach a mutual consent on sharing stock and consequently make the shift from ownership of stock to jointly managing stock on a network level. Each library can search for their added value in the network to also reach a level of differentiation. To reach a high service level for customers on a network level, we suggest to distinguish between the following types of stock:

- *Fashion stock*: often borrowed books which are owned by and located at the library branch.
- *General stock:* regularly borrowed books which are owned by and located at the library branch, tailored to local audience (e.g., school books).
- *Specialized stock:* a collection of books about a certain topic (e.g., fantasy books, or books about the Dutch waterworks). Located all together at a certain library. Ownership of books may be diverse.
- *3PL stock*: Floating collection, which is either owned or not. That may be stored at a certain branch or elsewhere, depending on space, cost, and borrowing patterns.

Specialized stock will attract readers to that library. These books are infrequently borrowed when considered from a country perspective, but due to aggregation may constitute a large part of activity at the library.

Idea 7. Add commercial storage facilities to the network

As a direct consequence of the 3PL stock mentioned in idea 6, library networks might consider commercial storage facilities for books that libraries want to keep, but of which demand is low. In other words, studies might be performed if long term storage of slow movers at a central, commercial location is a viable option. For those books, typically customers tend to be patient and do not require short lead times for delivery.

Idea 8. Social transport of books

Transport operations between branches are performed to deliver books to match customer orders and to return books to their owners. Short distances between branches of a single organization as well as longer distances between the main branch of two or more organizations are being executed. Transportation costs are high. Nationwide transport typically is being outsourced to a mail company or logistics service provider. We suggest to involve readers in this transportation process and to dynamically assign transport jobs to service providers. To this end we see the following potential elements as part of *social transport of books*:

- Putting out open requests for moving books from one location to another or for moving books closer to their destination in the network.
- Requests for free transportation can be posted to volunteer readers or volunteer companies/organizations.
- Requests for paid transportation can be posted to transport companies or readers, offered price may vary based on urgency (price may consist of reader benefits).

Refer to [11] for more information on potential options for social transport.

Idea 9. Distributed pick-up and return
New types of library branches are being introduced. To enable online ordering and borrowing books, locations have to be introduced where reserved books can be picked up and returned. Interesting opportunities lay in extending the traditional library network with, for example, grocery stores, railway stations, post offices, school and so on. In the province of Zeeland in the Netherlands, a small network has been set-up where customers can pick-up items at the local grocery store. In Haarlem a railway station library has been opened for commuters to pick-up books to read on their way to work [12]. On a broader scale, typical network design questions as what are good locations, what are opening hours desired and how to transfer books, need to be answered. Next to that, the function of the location need to be determined (see also idea 10). Just a pick-up/return location for reserved items, fashion stock available (e.g., top 10 in stock), or a wider assortment to also enable selection of a book at the spot.

Idea 10. Unbundling service offerings at locations
Currently, most locations offer all options, namely:

- books stored to browse and borrow by readers
- Reading materials available for all citizens.
- Pickup of reserved books
- Book returns
- Personal advice
- Reading areas

From a network perspective the type of services offered in branches might differ. An important question from this perspective is what is the best set of offerings at which locations? Next to that, the question arises how to transform each current location to, or introduce new locations for these offerings?

Idea 11. Exploit service automation
Several initiatives for service automation can be noticed. AS/RS systems for storage and sorting systems in library warehouses can be used. Next to that, vending machines can be introduced in the library network to dispense books to readers at shopping centers, supermarkets, railway stations and so on. Drop-box locations for returns need to be located at the same location to enable an easy return process. E-books usage is expected to increase and library customers see a high potential for libraries offering e-books borrowing to read at home. Another option might be to offer an electronic copy of books (as ebook or Google books style) at each library for browsing or reading purposes.

Idea 12. Temporary Exhibits

Librarians can start temporary exhibits of themed books, like museums have exhibits to extend their added value to the network. Books can be temporarily sent to the exhibiting library and sent back after the exhibit, if desired, or remain there since an increased demand may be expected at that location. Readers may borrow exhibited books, or may order them from the network if multiple copies are available in the country, as to keep the set of books intact for the exhibit.

4 SWOT-analysis

The ideas described in Section 3 have been presented to an audience of Dutch librarians at November 1, 2013 in Apeldoorn, The Netherlands. A SWOT-analyses was performed where by means of group-wise discussion, three out of the 12 concepts were analyzed. Each group presented the results to enable responses of the other groups. The outcomes are presented below.

Idea	Strengths	Weaknesses	Opportunities	Threats
Idea 6. Managing stock versus owning it	Customer will be more successful in a shorter time	Might result in a network with branches that cannot offer a collection to a customer	Increased access to a broader assortment	All directors need to be aligned Budget owners (i.e., local government) might not like the idea that "their" books are not stored in "their library"
Idea 2. Internal book market	Changing ownership of books can already be supported by the IT system	Organization of the concept Local government is not ready for such a concept	Assortment to offer to customers much larger Digitalization of fast-movers at first	Digitalization might make this concept excessive
Idea 5. Assortment planning	Right books at right location for the right users	At the same point in time customers might ask for similar books which specifically for frequently asked items might be a problem	Better service for a customer	Way how financial structure is being organized

5   Conclusion

In this paper we presented our vision on aspects of the Physical Internet concept for Dutch libraries by proposing 12 ideas. Implementation of one or more of these ideas might contribute to meet social, economic and environmental goals and to enable a smoothly operating library system which is able to keep up its standards. A SWOT analyses has been performed by Dutch librarians on several of the presented ideas. It can be concluded that the librarians expect that customer service will increase with the mentioned concepts. The main bottleneck for introducing ideas for the PI concept for libraries seem to be in the current financial structures. About 80% of the budget of libraries is made available via local governments. These governments measure the spending of the subsidies partly through the visibility in the local library branches of the books that were actually purchased from the subsidy, which hinders free exchange of books between libraries on a national scale. Methods and convincing arguments should be derived to show the added value of sharing stock among a large network of libraries to reach higher service levels against lower costs.

References

[1]   Rowlands, I., D. Nicholas (2010): *The economic downturn and libraries: an international survey,* Learned Publishing, 23, 144-156.
[2]   Chan, G. (2008): *Aligning collections budget with program priorities: a modified zero-based approach,* Library Collections, Acquisition and Technical Services, 32, 46-52.
[3]   Boter, J., M. Wedel (2005): *User categorization of public library collection,* Library and Information Science Research, 27, 190-202.
[4]   Reisman, A., X. Xu (1994): *Operations Research in libraries: a review of 25 years of activity*, Operations Research 42(1), 34-40.
[5]   Wruck, S., I.F.A. Vis, J. Boter (2013): *Batching Management in Warehouses with High Product Returns: Development and Discussion of Approaches and Models*, Journal of the Operational Research Society, 64(10), 1505-1516.
[6]   Van der Heide, G., K.J. Roodbergen (2013): *Transshipment and rebalancing policies for library books*, European Journal of Operational Research, 228(2), 447-456.
[7]   Montreuil, B., J.C. Dufour (2013), Evolution of Supply Chains & Logistics, in: The Physical Internet: Toward Efficient, Sustainable, Interconnected Logistics Enabling Trade Corridors, Presentation at NASCO Meeting, Montréal, Québec, Canada on 2013-04-24, slide 13.
[8]   http://www.siob.nl/bibliotheekmonitor/trends-bibliotheken/item4
[9]   CBS data
[10]   http://www.siob.nl/media/documents/Rapportage-boekenbranche-meting-mei-2013.pdf
[11]   Vis, I.F.A., K.J. Roodbergen, M. Veenstra, T. Steffens, P. Buijs (2014): *Library operations in low-density areas*, paper 1st International Physical Internet Conference.
[12]   http://tenaanval.wordpress.com/2011/08/08/de-stationsbibliotheek-is-open/