# Algorithm Research on the Best Placement of Books in University Libraries

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**Abstract.** With the advent of the era of big data, libraries are facing many challenges. Inspired by the problem of queuing to fetch water and its solution, this paper puts forward the problem of book placement in the library. This paper studies the optimal placement of books in the library, puts forward the optimal placement model of single bookshelf, multi bookshelf and medium-sized books, and gives various optimization schemes. It also extends the problem of book placement in the library to the problem of commodity placement in the supermarket, and gives the solution.

**Keywords:** Book placement · Best · Fetch water problem · Algorithm

## 1 Introduction

There are millions of books in large libraries. When looking for the books they need, each borrowing needs to waste a lot of time looking for books. In order to facilitate borrowing, books are classified and placed according to disciplines. Due to the differences of disciplines, some discipline books are popular and have more books, while some disciplines are narrow and have less books.

In China, any library basically puts books according to the Chinese book classification. From Marxism Leninism, philosophy, politics, law, economy, language education, literature, biography and geography, they are classified by letters, from A to K. These are generally classified as liberal arts (some libraries will classify K categories, that is, biography, history and geography, into Science). Then, from L to Z, it is generally classified as science, and Z category is also regarded as comprehensive category. If placed, they are placed on the shelf from top to bottom and from left to right. Each book has a classification number and is placed in order. YU Xiangqian [1] points out the problems of reserved collection existed and puts forth the necessity and the measures and significance to reform. The efficient way to reform the reserved collection is to change it into characteristic storage. Yuan Yumin [2] analyzes the necessity for university library to reform the reserved collection, and expounds the concrete ideas for the reform of reserved collection in university library. The reform and innovation of collection institution in university libraries and the reasonable dynamic regulation of books collection


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should be made in accordance with all kinds of statistical data [3]. With the rise of academic resource database vendors in the big-data era, several important vendors in Chin are developing rapidly in the resource construction in respect to the academia, education and culture [4].

Obviously, it takes less time to borrow books close to the entrance than to borrow books far away from the entrance. How to place these collections so that readers spend less time and improve service efficiency is a very constructive research.

## 2 Queuing to Fetch Water Problem

Firstly, we study the problem of queuing to fetch water. Ten people each brought a container and came to draw water at the same time. The volume of their containers was not equal. There is only one faucet. They had to line up to fetch water in turn. The time consumed by each person from to when he finishes fetching water and leaves (including the time he waits and the time he takes to fetch water). Because the container volume of each person is different and the water outlet speed of the faucet is constant, the time for 10 containers to fill with water is different. Ignoring the replacement time, what kind of queuing order can minimize the total time consumed by 10 people (the sum of time consumed by each person)?

The situation of 10 people is discussed below. Because each person has and only has one container, and the container capacity is different, people correspond to containers one by one. Therefore, let's only mention containers, not people. We number the containers from small to large: 1, 2, 3, …, 10. Suppose that the time taken for filling the 10 containers with water from small to large is as follows:

$$t_1 < t_2 < \cdots < t_{10} \tag{1}$$

The lower corner marks 1, 2, 3, …, 10 are the number of the container respectively. Then, if the water is pumped from small to large according to the container capacity, the total consumption time is:

$$10t_1 + 9t_2 + 8t_3 + \cdots 2t_9 + t_{10} \tag{2}$$

The sorting problem can be regarded as the size problem of the sum of the products of the corresponding terms of two arrays with the same length in mathematics. If two arrays (of course, all numbers in them are required to be positive), one in order and one in reverse, the sum of the products of the corresponding terms is the smallest. Both arrays are arranged in order or reverse, and the sum of the product of the corresponding terms is the largest [5, 6]. For other permutations, the sum of the product of the corresponding term is between the above two extreme cases. This shows that the total time consumed by pumping water from small to large container capacity is smaller than that of any other pumping sequence.

## 3 Optimal Placement Model of Single Bookshelf

The problem of book placement is somewhat similar to the problem of queuing to fetch water, which is inspired by it. For the convenience of discussion, first study the simple case with only one bookshelf. Suppose there are $n$-class books $b_1, b_2, ..., b_n$, the length of class $i$ books placed together is $l_i$, and the probability of being borrowed is $p_i$ ($i = 1, 2, ..., n$). If such books are placed in order $b_1, b_2, ..., b_n$, the average time for readers to find a book is (Fig. 1)

$$\begin{aligned} M_T &= p_1 l_1 + p_2(l_1 + l_2) + ... \\ &\quad + p_n(l_1 + l_2 + ... + l_n) \\ &= \sum_{i=1}^{n} (p_i \sum_{j=1}^{i} l_j) \end{aligned} \tag{3}$$

Assuming that the books are placed in order $b_1, b_2, ..., b_n$ is the best, that is, after exchanging the positions of the two types of books, the time spent becomes larger. If class $k$ books are exchanged with class $k + 1$ books, the following requirements shall be met

$$\begin{aligned} &p_k(l_1 + l_2 + ... + l_{k-1} + l_k) \\ &+ p_{k+1}(l_1 + l_2 + ... + l_{k-1} + l_k + l_{k+1}) \\ &\leq p_{k+1}(l_1 + l_2 + ... + l_{k-1} + l_{k+1}) \\ &+ p_k(l_1 + l_2 + ... + l_{k-1} + l_{k+1} + l_k) \end{aligned} \tag{4}$$

Obtained by simplification

$$p_{k+1} l_k \leq p_k l_{k+1} \tag{5}$$

Namely

$$\frac{l_k}{p_k} \leq \frac{l_{k+1}}{p_{k+1}} \tag{6}$$

Therefore, the best placement strategy is to give small priority $l_k/p_k$ to the front. Put them in order from the top row of the bookshelf.

Discussion:

(1) If there are as many kinds of books, that is $l_1 = l_2 = \cdots = l_n$. From (3), then $p_k \geq p_{k+1}$. It shows that the best placement strategy is to give priority $p_k$ to the large ones in front and the popular books in front;
(2) If the probability of being borrowed is the same, that is $p_1 = p_2 = \cdots = p_n$. From (3), obtained $l_k \leq l_{k+1}$. It shows that the best placement strategy is to give priority $l_k$ to small ones.

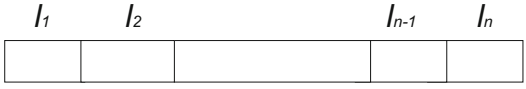


**Fig. 1.** Schematic diagram of single bookshelf placement

## 4 Multi Bookshelf Optimal Placement Model

There are many books in the library, so many bookshelves must be needed. How to place books is worth optimizing (Figs. 2 and 3).

Due to the large number of books, it is obvious that one shelf cannot meet the requirements. Suppose there are $m$ book shelves $T_0, T_1, ..., T_{m-1}$ to place these books. According to the results of the single shelf model, the similar best strategies are as follows:

**Fig. 2.** Bookshelves in the library

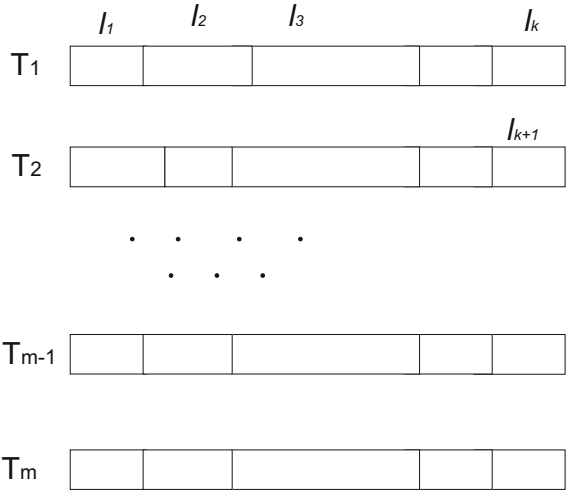


**Fig. 3.** Schematic diagram of multi bookshelf placement

First, the books are $l_k/p_k$ sorted in ascending order. If the order is $b_1, b_2, ..., b_n$, they are placed on the first shelf first, and then placed from the top row of the bookshelf. Then the second shelf, the head of the second shelf is connected with the tail of the first shelf, and so on.

## 5 Classification of Chinese Library Placement Model

The best placement model of single bookshelf and the best placement model of multiple bookshelves above do not consider book classification. In order to manage, the library adopts "Chinese book classification". "Chinese book classification" is a classification compiled on the basis of scientific classification and combined with the characteristics of books. It divides disciplines into five categories and 22 categories. The basic sequence is: Marxism Leninism Mao thought, philosophy, social science, natural science and comprehensive books.

The optimized placement process is as follows:

(1) Count the number of copies of 22 categories of books. The number of $i$ copies of category books placed together can approximate its total length of $l_i$;
(2) Through the background of the borrowing system, the number of borrowed frequencies of 22 categories can be counted. The number of borrowed frequencies is divided by the total number of borrowed frequencies, and the probability of borrowing of category $i$ is $p_i$.
(3) First, the books $l_k/p_k$ are sorted in ascending order, first on the first shelf, then on the second shelf. The head of the second shelf is connected with the tail of the first shelf, and so on.

For each major category, you can also count small categories, and then make detailed optimization placement. The characteristic of this arrangement is that the books are not placed in alphabetical order, but are placed according to the needs of readers, so that readers spend less time and improve service efficiency.

## 6 Supermarket Goods Placement Model

As an important marketing management means of supermarkets, goods placement mainly focuses on placing within a certain modeling range according to the needs of consumers, so as to show the overall environmental beauty of product placement. Due to the needs of business development and market demand, the needs of all users are taken into account. To a certain extent, this is also a development and continuation of the comprehensive construction of product placement. Learn from the book placement model to improve service efficiency (Fig. 4).

**Fig. 4.** Supermarket shelf placement

The placement method of goods is as follows: according to the number of goods sold, count the probability $p_k$ of goods sold. If the size of goods is not considered, the best placement strategy is to give priority $p_k$ to large goods in front and popular goods in front.

## 7 Conclusion

Library is a library resource management library and a place to obtain knowledge. Library management and placement are very important, which determines the utilization effect of information resources. This paper gives the placement scheme from the perspective of quantification for the reference of relevant personnel, and the idea can be extended to the commodity placement of supermarkets.

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