Integer Programming Approach For Optimization Of Library Loan Policy

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Abstract: In the Library system, main objective is to provide the best services to the users. The purpose of this research is to develop a library system that house, implementing integrated procurement flow, return and borrowing books, so that the inter-library loan dealing can be done in an integrated manner, with the hope to facilitate members to borrow variety of books, thereby increasing library transactions. Interlibrary management system, library loan policy have been formed by using integer programming technique. This paper is prepared with a view to facilitate to users with loan period and maximum number of books can be borrowed.

Index Terms: Books, Integer programming, Landing-borrowing books, Maximum members facilitated

1 INTRODUCTION

LIBRARY management system is a difficult task. Library accounts are created for all currently enrolled students and employed faculty and staff after their registration. The purpose of this policy is to provide information about accessing and borrowing books from the Library. This policy applies to all staff and university students. University staff and students are registered to borrow books from the Library. For the purpose a card will be issued to the individuals by the library management. Staff and students of other institutions may also apply for registration and card may also be issued to them accordingly. The Library collects stores and uses borrower information for administrative purposes only. The information collected is confidential and will not be disclosed to third parties without the borrower's consent. A borrower is responsible for the safe keeping and return of all items or books borrowed from the Library and for the cost of repair or replacement of any item damaged or not returned. Restrictions are placed on the number of loans a user may have at any one time. Library staff and students are responsible for maintaining accurate contact details. The student/researcher email accounts are the main channel for communication concerning library borrowing. It is the responsibility of the management to control and monitor this account. All other borrowers need to notify the Library of any change of address (postal and email) at the earliest opportunity.

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2 METHODOLOGY

Integer Programming Model:

General integer programming model can be written as

Optimize

$Z = C_1X_1 + C_2X_2 + \ldots + C_iX_j + \ldots + C_nX_n$

Subject to

$$a_{11}x_1 + a_{12}x_2 + \ldots\ldots + a_{1j}x_j + \ldots\ldots + a_{1n}x_n \ (\leq, =, \geq)\ b_1$$

$$a_{21}x_1 + a_{22}x_2 + \ldots + a_{2j}x_j + \ldots\ldots + a_{2n}x_n \ (\leq, =, \geq)\ b_2$$

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$$a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mj}x_j + \ldots\ldots + a_{mn}x_n \ (\leq, =, \geq)\ b_m$$

$x_j \geq 0,\ j = 1, \ldots, n$, x_j are all integers.

The goal of every library is to facilitate maximum number of its members, but it is directly proportional to the number of resources they have, including many kinds of moderating factors like (time duration, number of books, memberships, members). This research include a general case of library for model development i.e A public library has two categories of books say x_1 and x_2. Both can be borrowed by two kinds of memberships, Premium and Ultimate. A Premium member can be borrowed P_1 books of category x_1 and P_2 books of category x_2. An Ultimate member can borrow U_1 book of category x_1 and U_2 books of category x_2. Premium membership has limit of 'A' books and Ultimate has limit of 'B' books to be issued per month. A book of category x_1 can be borrowed by M_1 members while book of category x_2 can be borrowed by M_2 members in a month, as shown in the following table.

	Book x_1	Book x_2	Number of Books Availability
Premium Membership	P_1	P_2	A
Ultimate Membership	U_1	U_2	B
Number of Members to borrowed each Book	M_1	M_2	

Therefore IP model for general problem is

Maximize $Z = M_1X_1 + M_2X_2$

Subject to $P_1X_1 + P_2X_2 \leq A$

$U_1X_1 + U_2X_2 \leq B$

$X_1, X_2 \geq 0$ is an integer

The above model is conducive to handle library management system in an effective manner and to the entire satisfaction of the users.

Validity of Model:

In order to check the validity of model, library of Asian Institute of Technology (AIT) Bangkok, Thailand visited for the purpose. Moreover the required data for the model has been collected and is as follows.

Number of books of Arts subjects:
A=104
Number of books of Science subjects:
B=76
Premium membership of library (includes science students only): P_1=2
Premium membership of library(includes Arts students only): P_2=1
Ultimate membership of library staff (includes science only)
U_1=1
Ultimate membership of library staff(includes Arts only):
U_2= 2
Number of members to borrow one book each of X1 category M_1=6
Number of members to borrow one Book each of X2 category M_2=11

Different categories of books borrowed by the members are indicated in the following table.

	Book X1	Book x2	Number of Books Availability
Premium Membership	2	1	104
Ultimate Membership	1	2	76
Number of Members to borrowed each Book	6	11	

Now the IP model for the above case is

Maximize $Z = 6x_1 + 11x_2$

Subject to $2x_1 + x_2 \le 104$

$x_1 + 2x_2 \le 76$

$x_1, x_2 \ge 0$

Solution of the Problem

Step1. A basic feasible solution

Standard Form: Use slack variables S_1 and S_2 in the first and second constraint, we get

Maximize $Z - 6x_1 - 11x_2 + 0.S_1 + 0.S_2 = 0$

Subject to $2x_1 + x_2 + S_1 = 104$

$x_1 + 2x_2 + S_2 = 76$

$x_1, x_2, S_1, S_2 \ge 0$

Basic Solution:

No. of variables: $n = 4$; Basic variables: S_1 and S_2.

No. of constraints: $m = 2$; Non-basic variables: x_1 and x_2.

By setting $n - m = 4 - 2 = 2$ non-basic variables equal to zero.

So, put $x_1 = 0,\ x_2 = 0$ in the constraints.

We get $S_1 = 104,\ S_2 = 76$. Both values are non-negative (positive). Thus a basic solution is a basic feasible solution.

Step2. Optimality Test

Write coefficients of all variables from standard form in the following table.

Table 1

Iteration	Basis	x_1	x_2	S_1	S_2	Solution	Ratio
1	Z	-6	-11	0	0	0	
(Starting)	S_1	2	1	1	0	104	104
	S_2	1	2	0	1	76	38

In z-equation there are still –ve numbers so solution is not optimal and go to step 3.

Step 3. Entering variable

The most –ve number is -11. So, x_2 is an entering variable.

Step 4. Leaving variable

From ratio, 38 is the smallest number. So, S_2 is a leaving variable.

Step 5. Pivot equation

Divide old pivot equation by 2, we get new pivot equation in the following table.

Table 2

Iteration	Basis	x_1	x_2	S_1	S_2	Solution	Ratio
2	Z						
x_2 enters	S_1						
S_2 leaves	x_2	$\frac{1}{2}$	1	0	$\frac{1}{2}$	38	

To complete the table we carry out the following type-2 computations.

1. New Z-equation

Old Z-equation:	-6	-11	0	0	0
- (-11) × Pivot equation:	$\frac{11}{2}$	11	0	$\frac{11}{2}$	418
New Z-equation =	$-\frac{1}{2}$	0	0	$\frac{11}{2}$	418

2. New S_1 equation

Old S_1-equation:	2	1	1	0	104
- (1) × Pivot equation:	$-\frac{1}{2}$	-1	0	$-\frac{1}{2}$	- 38

New S_1- equation = $\frac{3}{2}$ 0 1 $-\frac{1}{2}$ 66

The complete new table thus looks as follows:

Table 3

Iteration	Basis	x_1	x_2	S_1	S_2	Solution	Ratio
2	Z	$-\frac{1}{2}$	0	0	$\frac{11}{2}$	418	
x_1 enters S_1 leaves	S_1	$\frac{3}{2}$	0	1	$-\frac{1}{2}$	66	44
	x_2	$\frac{1}{2}$	1	0	$\frac{1}{2}$	38	76

Step 2. There is still –ve number in Z-equation. So, go to step 3.

Step 3. Entering variable

The most –ve number is $-\frac{1}{2}$. So, x_1 is an entering variable.

Step 4. Leaving variable

From ratio, 44 is the smallest number. So, S_1 is a leaving variable

Step 5. Pivot equation

Divide old pivot equation by $\frac{3}{2}$, we get in the following table.

Table 4

Iteration	Basis	x_1	x_2	S_1	S_2	Solution
3	Z					
x_1 enters S_1 leaves	x_1	1	0	$\frac{2}{3}$	$-\frac{1}{3}$	44
	x_2					

To complete the table we carry out the following type-2 computations.

1. New Z-equation

Old Z-equation: $\frac{-1}{2}$ 0 0 $\frac{11}{2}$ 418

- ($\frac{-1}{2}$) × Pivot equation: $\frac{1}{2}$ 0 $\frac{1}{3}$ $-\frac{1}{6}$ 22

New Z-equation = 0 0 $\frac{1}{3}$ $\frac{16}{3}$ 440

2. New x_2 equation

Old x_2 e equation: $\frac{1}{2}$ 1 0 $\frac{1}{2}$ 38

- ($\frac{1}{2}$) × Pivot equation: $-\frac{1}{2}$ 0 $-\frac{1}{3}$ $\frac{1}{6}$ -22

New x_2 equation = 0 1 $-\frac{1}{3}$ $\frac{2}{3}$ 16

The complete new table thus looks as follows:

Table 5

Iteration	Basis	x_1	x_2	S_1	S_2	Solution
3 (Optimum)	Z	0	0	$\frac{1}{3}$	$\frac{16}{3}$	440
	x_1	1	0	$\frac{2}{3}$	$-\frac{1}{3}$	44
	x_2	0	1	$-\frac{1}{3}$	$\frac{2}{3}$	16

Step2. Optimality Test: There is no negative number in Z-equation. Stop the iterations and current solution is opyimal.

Therefore, the optimal solution is

$x_1 = 44$

$x_2 = 16$ and

$Z_{\max} = 440$

4 CONCLUSION

The library loan and borrow management system model for optimal user satisfaction has been developed. This model considers both the elements of the loan policy. That is loan period and maximum number of books a user may be borrowed. The user satisfaction is gauged by his satisfaction with these two fundamentals. The model also tender a more comprehensive and rational representation of the problem. More over the solution of the model may be easily acquired with the help of available soft ware.

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