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T2 ________________		F2 ________________
T3 ________________	Problem Chosen	F3 ________________
T4 ________________	**A**	F4 ________________

2018
MCM/ICM
Summary Sheet

Camping on the Grand River

Summary

With the rise of rafting and the growing economic benefits it generates, river management urgently needs a viable solution to capitalize on river resources. Therefore, it is very necessary to make reasonable arrangements for the travel itinerary.

Firstly, we first define the river carrying capacity as the maximum number of river reception tours each year. To allow the river to accommodate as many tours as possible we set the first optimization goal, which is to maximize the number of trips per year. Secondly, we clarify the specific meaning of the contact of tour groups, followed by the construction of the second optimization goal, that is, to minimize the number of tour groups contacts. We then define the unit camping matrix, the camping matrix and the total camping matrix.Next,we take the use of camping sites for each tour, the use of arbitrary camping sites throughout the drift season, the use of all camping sites at any one night, and the number difference for two consecutive nights of camping in any group of tourists as the constraints. Considering the complexity of the solution, we weaken the second optimization target into a constraint condition, and it can relax or tighten the constraint to adjust the scheme according to the concrete effect of the scheme implementation.

Finally, we use JAVA as a programming tool to find X = 918 for Y = 38, which means 918 trips can be made throughout the rafting season when 38 campsites are evenly distributed along the Great River. In other words, the 918 specific travel plans that are available through our model.Then, the schedule of each plan is presented in the appendix At the end of this paper, we analyze the sensitivity of the model. By changing the maximum drifting time per day to $7h7.5h8.5h9h$, we find that the change in the carrying capacity of the river is $\pm9\%$, which shows that our model has better sensitivity. And by increasing the number of camps, we find that the carrying capacity of the river is generally increased by exponential, which meets the objective law.

Keywords: bi-objective; optimization;0-1 matrix ; Poisson distribution

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1 Introduction

1.1 Background

Now more and more choices of outdoor travel, especially the selection of water drifting, are of great importance for how to solve the problem of optimal utilization of camping sites and not exceeding the maximum river carrying capacity along the "Great River" camping. At present, the plan of river transport administration is not reasonable. The planning of travel time and type of travel team is static. There are numerous choices for tourists. There are more occupation conflicts in campsites on river banks, and the utilization rate of rivers and camps is not utilized. Maximum. We transform the practical problem into a mathematical model, and use dynamic programming, task assignment model and matrix decomposition to propose to maximize the use of campsites under the maximum carrying capacity of rivers and reduce the number of encounters between drifting ships, as compared with the original number of traveling teams.

1.2 Restatement of the problem

When travellers drift on a long river of 225 miles, they can enter at the only entrance and leave the only exit. Passengers take either oar-powered rubber rafts, which travel on average 4 mph or motorized boats, which travel on average 8 mph. The journey lasts from 6 to 18 nights, during which time the tourists can camp on the river bank and are deemed to be evenly distributed along the river corridor. Due to weather reasons, the river opens to people only six months a year (assuming 30 days per month), During this six-month period, there are altogether x trips.And there are Y camp sites on the Big Long River.

Now the administration hires us to provide a new plan. This programme requires that the number of travel tours (river carrying capacity) be maximized to the maximum extent possible, and that there should be a minimum number of contacts among the tour teams, and it is noteworthy that a camp site can accommodate only one tour group per night.

1.3 Our works

We assume that the behavior of travelers is random and that their choice of travel time, means of transport, and campgrounds is in accordance with a certain probability distribution. In order to determine the parameters of the probability distribution, we first determine the mean and variance of the three alternatives.

We assume that the behavior of travelers is random and that their choice of travel time, means of transport, and campgrounds is in accordance with a certain probability distribution.And we think that once a tour group chooses the means oftransport (oar- rafts or motorboat), it will not change throughout the journey. Then we consider the type of travel time and mode of promotion, the type of trip plan is divided into 25 kinds, respectively, recorded as $p_1, p_2, p_3, ..., p_{25}$,Let i

denote the number of days camping in the travel plan,where $i = 6, 7, ..., 18$. After that, we define the unit camping matrix U_i^k , camping matrix C_i, total camping matrix A, and departure date matrix D_i. Among them,the unit camping matrix ($U_i^k k = 1, 2, 3, ...$) reflects the occupation of thecamping sites along the river bank when the trip plan p_i is executed on the k th time, it is a $n_i \times Y$ matrix, The camping matrix C_i reflects the case of travel plans p_i occupying camps or not throughout the rafting season. We aggregate the matrix U_i^k to get a matrix of $(i \times k) \times Y$ and then we add the zero matrix of $1 \times Y$, and these zero matrices correspond to the night when travel plan p_i is not executed, so we get a matrix of $179 \times Y$ and define it as C_i(there are 25 such matrices in total).Total Camp matrix shows the utilization of the campsite throughout the drifting season, which is the sum of the matrix C_i and has a dimension of $179 \times Y$ the departure date matrix A records some cases of the travel team within 180 days.

Secondly, we need to build optimization goals, and based on the requirements, our model should allow more tourist teams to drift and maximize the utilization of campsites and minimize the number of trips between tour groups. Considering the extreme state: during the 179 nights of the rafting season, all campsites live full of packages each night, which is ideal situation for rivers to accommodate the most tours, so we determine that the first optimization goal is to maximize used time of campsites in 180-day drifting season the second optimization objective is the least number of tours contact .

Then we consider the constraints of the model. Fully consider the use of camping sites at night for tours of acertain travel plan, the number of camps for two consecutive nights is limited by the maximum drift of the day, the occupation of any campsite throughout the drift season, and the use of all the camping sites at any one night, we construct these as the constraints of the two-objective optimization model. Considering the complexity of solving the bi-objective optimization, we weaken the second optimization objective into the constraint condition, and adjust the scheme by changing the size of its constraint value for the river management department to adopt according to the actual situation.

Finally, considering that the constraint conditions are random and the choice of travel days accords with the Poisson distribution, we use Java as the solution tool to get the total campmatrix and the unit camping matrix when the optimal targets met.Based on the definition of the unit matrix, we can get the number of days of travel and camping campsite per night for each travel plan. Then, according to the travel plan, we use the camping site every night to get the travel plan (oar-draft or motorboat).next, according to the time position of the unit camping matrix we can determine the start date and the end date of any travel planand.

2 Assumptions and Justification

- **Each month is 30 days in Drifting season, that is, the total number of days people can drifting is 180.**To simplify our model we assume 30 days per month, and this assumption is reasonable.

- **The tourists' choice of travel time complies with the Poisson distribution.**Since the choice of tourists for travel dates is unknown, the Poisson distribution is a good way to model this process and to facilitate our model building.
- **The demand for drifting is always greater than the supply.**which is a assumption based on the facts set by the context of the incident.
- **All travel teams are drifting during the day and their maximum daily drifting time is 8 hours.**According to Reference 1, we assume that the maximum daily drifting time for a tour group is 8 and the tour group can only go downstream.
- **The daily travel distance and rafting times chosen by the tour group for the same number of travel days are up to themselves.**This assumption is very realistic, river management companies will not be fixed tourist travel itinerary.
- **Assuming that for any tour group, once they have chosen the mode of transport, they will not change their means of transport for the entire journey.** We assume that the river management department to take into account the efficient use of the efficiency of the vessel, for any tour only to provide a means of transport.
- **The total number of camping sites unchanged.**According to Reference 1, we assume that there are 38 camps evenly distributed along the bank.
- The total number of campsites remains unchanged, reference 1, and we assume that there are 38 camps evenly distributed along the bank.

3 Symbols and Definitions

In the section, we use some symbols for constructing the model as follows:

4 Models

We consider the travel time and travel methods, a total of 26 kinds of programs are proposed, that is, two kinds of travel patterns and thirteen kinds of travel time permutations and combinations. According to our hypothesis, the maximum daily drifting tour time is 8, which is determined by inequality:

$$\begin{cases} \frac{S}{v_1 \times 8} \leq T_1 \\ \frac{S}{v_2 \times 8} \leq T_2 \end{cases} \tag{1}$$

We can calculate that for rafts and motorboats, the number of drifting days satisfies $T_1 \geq 7 T_2 \geq 6$,respectively. Therefore, we will exclude the option of

Table 1: Symbols and Definitions

Symbol	Denition
X	Trips travel down the Big Long River each year during a six month period
Y	Camp sites on the Big Long River
S	The total length of the river
v_1	The speed of oarpowered rubber rafts
v_2	The speed of motorized boats
p_i	Travel options
U_i^k	Unit camp matrix
C_i	Camping matrix
A	Total camp camp matrix
J	The launch date of a given tour group
n_i	The number of days the th travel option lasts
λ	the ith dam in a series of small dams

including oar-raft and six-day modes of transport, leaving 25 travel options, followed by $p_1, p_2, p_3 ... p_{25}$, The specific content of the program is shown in Table 6 3.

Table 2: Travel programme

Travel days/days	6	7	8	9	10	11	12
Rubber		p_1	p_2	p_3	p_4	p_5	p_6
Motorboat	p_{13}	p_{14}	p_{15}	p_{16}	p_{17}	p_{18}	p_{19}

Table 3: Travel programme

Travel days/days	13	14	15	16	17	18
Rubber	p_7	p_7	p_9	p_{10}	p_{11}	p_{12}
Motorboat	p_{20}	p_{21}	p_{22}	p_{23}	p_{24}	p_{25}

As shown in Table 6 3,we fixed the travel options into 25 categories, that is, the river management companies have a total of 25 travel plans for tourists to choose from.

To show our optimization model more clearly and clearly, we sketch the modeling flowchart as follows:

4.1 Optimize the use of camping sites

Firstly, we define the carrying capacity of a river as the number of tours a river can accommodate each year. Secondly, we set the number of campsites as fixed value. In order to maximize the utilization of campsites, we use mathematical programming model to ensure the maximum number of camps to use as the goal. In addition, our model is required to ensure that the tour groups do their best during drifting may not touch each other.Considering both the two we create a dual-objective optimization model.

In order to facilitate the establishment of our model will define and explain some of the concepts below.

4.1.1 Some necessary preparation

1) Unit camp matrix

   The unit camp matrix U_i^k represents the case where each campground is utilized when the travel plan p_i is executed for the k time, which is a matrix of $n_i \times Y$, n_i indicates the travel days corresponding to the plan p_i, and the elements in U_i^k are defined as u_{mn}^i follows:

$$u_{mn}^i = \begin{cases} 1 & \text{The n} - \text{th camp was occupied on the m} - \text{th night} \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

2) Camping matrix

   The camping matrices indicate occupancy of campsites when the travel plan p_i is executed throughout the drifting season, and we add up the matrices U_i^k on the basis of which the zero matrices complement corresponding to night when the travel plan is not implemented and are expanded to matrices The elements of the matrices in the matrix are defined as follows:

$$c_{mn}^i = \begin{cases} 1 & \text{The n} - \text{th camp was occupied on the m} - \text{th night} \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

   According to the definition of camping matrices and camping matrices we can see:

$$c_{mn}^i = \begin{cases} u_{mn}^i & \text{When travel plan } p_i \text{ is executed} \\ 0 & \text{otherwise} \end{cases} \tag{4}$$

   In this section we make some necessary preparations for the following model establishment, which is very helpful for us to establish a good model.

3) Total camp camp matrix

   The total camp matrix A represents the utilization of the entire drifting season camp, which is the sum of the matrices $C_i(i = 1, 2, 3, ..., 25)$ and whose element a_{mn} is defined as follows:

$$a_{mn} = \begin{cases} 1 & \text{The n} - \text{th camp was occupied on the m} - \text{th night} \\ 0 & \text{otherwise} \end{cases} \tag{5}$$

   It is clear from its definition of $a_{mn} = \sum_{i=1}^{25} c_{mn}^i$. In this section, we make some necessary preparations for the following model establishment, which is very helpful for us to establish a good model.

4.1.2 Utilization of camping sites

As we explained in the Problem Analysis section, we use the number of campsites as the goal of optimization. According to the definition of preparation part can get the first optimization objective function, as follows:

$$\max \sum_{m=1}^{179} \sum_{n=1}^{Y} a_{mn} \tag{6}$$

In the following section we will determine the constraints of the model.

For unit camping matrices, each tour group occupies only one camp overnight and thus:

$$\sum_{n=1}^{Y} u_{mn}^{i}=1 \tag{7}$$

On request, the same camp can only accommodate one tour group on the same night, so there:

$$\sum_{i=1}^{25} c_{mn}^{i} \leq 1 \tag{8}$$

And we take that how many the camping site could accommodate the total number of tours per night into count,we have:

$$\sum_{i=1}^{25} \sum_{n=1}^{Y} c_{mn}^{i} \leq Y \tag{9}$$

At the same time, we consider that any tour group is free to choose the daily trip, but according to our assumption that the maximum drifting time can not exceed 8h, so it has the following restrictions on the itinerary:

$$\begin{cases} 0 < t_j^i v \leq 8v, \text{ the first day of the travel plan } p_i \\ 0 < \frac{S}{Y+1}(q-p) \leq 8v, \text{ Rest} \\ 0 < S - \sum\limits_{j=1}^{n_i} vt_j^i \leq 8v, \text{ The last day of the travel plan } p_i \end{cases} \tag{10}$$

There $v = v_1, v_2$,we let t_j^i indicate that the time when the tour group carrying out the travel plan p_i drift on the jth day, q, p respectively indicate the number of campsites where the same group will be camping on two adjacent nights. From this we can get the following constraints:

$$\begin{cases} c_{mp}^{i} = 1 \\ c_{(m+1)q}^{i} = 1 \end{cases} \quad i = 1, 2, ..., 25 \tag{11}$$

The above formula shows that the distance between two campsites for any two consecutive nights can not exceed the maximum daily drifting distance.

4.2 Reduce the number of contacts

First, we clarify the specific meaning of contacts in the subject, that is, which situations can be called contacts. According to the subject, we define the same point where we reach the river at the same time as the rafting process. Second, we define the departure date matrix for the tour within 180 days. Its element d_j is defined as follows:

$$d_j = J + n_i \tag{12}$$

Where J indicates that the launch date of the tour group choosing travel plan p_i is the j th day of draft season, n_i is the number of nights camping on a travel plan p_i.

When the two tours meet, according to the definition of encounter we may have:

$$\begin{cases} v\sum_{j=1}^{\beta} t_{ij} = v\sum_{j=1}^{\beta^*} t_{ij}^* \\ J + \sum_{j=1}^{\beta} t_{ij} = J^* + \sum_{j=1}^{\beta^*} t_{ij}^* \end{cases} \quad 0 < \beta\beta^* \le n_i \tag{13}$$

Where $v = v_{1,}v_2$, and t_{ij}, t_{ij}^*represents drifting the time of a tour on j-th day.

Defined λ as the number of contacts, whose expression is as follows:

$$\lambda = \begin{cases} \lambda + + & \text{(14) Form set up} \\ \lambda & \text{otherwise} \end{cases} \tag{14}$$

So we get the second optimization Goal λ:

$$\min\{\lambda\} \tag{15}$$

4.3 Itinerary Plan

Below we use the **two-objective optimization model** built in Sections 4.1 and 4.2 to find out the best travel arrangements under the premise of ensuring the most frequent use and the minimum number of contacts in the campsite, and the management can provide the tourists with our scheme select. To ease the solution, we weaken the weaker target in the dual-objective into a constraint, and by adjusting it we can relax or tighten the constraint. Finally, our mathematical model is as follows:

$$\max \sum_{m=1}^{179} \sum_{n=1}^{Y} a_{mn} \tag{16}$$

$$s.t\begin{cases}\sum\limits_{n=1}^{Y} u_{mn}^{i}{=}1 \\ \sum\limits_{i=1}^{25} c_{mn}^{i} \le 1 \\ \sum\limits_{i=1}^{25}\sum\limits_{n=1}^{Y} c_{mn}^{i} \le Y \\ c_{mp}^{i} = 1 \\ c_{(m+1)q}^{i} = 1 \\ \lambda \le M \end{cases} \tag{17}$$

Considering that the number of campsites Y is a fixed value, our model is valid for different Y values. According to the literature we find that the Lees Ferry (Mile 0) to Diamond Creek (Mile 225) section of the Grand Canyon in the United States is very similar to the description of the title requirement, whereby we may wish to take the Y value of 38 and the number of contacts between the tours is between Less than 10 times, that order $M{=}10$.

By the formula $0 < \frac{S}{Y+1}(q-p) \le 8v$, when $v = v_1$ we can calculate:

$$0 < q - p \le 5.55. \tag{18}$$

This means that for any group choosing a dinghy for transportation as their means of transport, the number of their camping sites for two consecutive night stays is less than 5, and similarly for tour groups who choose a motorboat as a means of transport, Night camping numbers differ by less than 11, both of which are part of the optimization model constraints (5-6), and we can initially determine the vehicle based on the difference between camping site numbers for two consecutive nights. Taking into account the expansion of camping matrices matrix camping matrix zeroing arbitrarily, the use of MATLAB and LINGO programming are not convenient, we use JAVA as a tool to optimize the objective model to solve, and finally get each unit camp matrix is a trip Program, **its specific content including travel time and camping sites.** According to the location of the unit camp matrix we can get each trip plan start time. In order to facilitate the narrative, we use the form Wi-j said program, for example, M-2 said travel plan 2, motorboat sailing 8 nights. Below we will give the itinerary of April 1 to April 2 based on the results of our model:

5 Sensitivity analysis of the model

Since a good mathematical model should have good sensitivity, we conduct a sensitivity analysis of the model we built. In this section, we will conduct a sensitivity analysis of the maximum daily drifting time, the number of campsites evenly distributed along the banks, the minimum number of collisions during the drifting season.

5.1 Sensitivity analysis of the maximum drifting time of a day

In the hypothetical part, we assume that the maximum daily drifting time for a tour group is 8h, whereas the different maximum daily drifting durations will change the maximum number of trips. We have substituted the maximum daily drifting durations 7h, 7.5h, 8.5h, and 9h into our model The results are as follows: The rate of change of the carrying capacity of the river by the table:

Table 4: The results

Daily maximum drifting time/h	7.0	7.5	8.0	8.5	9.0
Raiver carrying capacity/times	842	874	918	931	948

$$\begin{aligned} &\Delta_1 = \tfrac{842-918}{918} \times 100\% = -8.2\% \\ &\Delta_2 = \tfrac{948-918}{918} \times 100\% = 3.2\% \end{aligned} \tag{19}$$

According to the result of sensitivity test, we find that the variation range of river carrying capacity does not exceed, proving that our model has better sensitivity.

5.2 Sensitivity analysis of the total campsite

Obviously, the carrying capacity of a river is positively related to the number of campsites. In order to study the relationship between the increasing trend of the maximum number of trips X during the drift season and the total number of campsites Y in our model, we ensure that the number of fleet contacts will not change , Change the number of campsites and observe the growth trend of the maximum number of trips, and then use function fitting to roughly determine the change of the maximum number of trips with the total campsite growth. Suppose the total number of campgrounds is 26, 30, 34, 38, 42, 46, 50 and enter the model to get the result as follows:

Table 5: The results

Number of camps	26	30	34	38	42	46	50
Raiver carrying capacity/times	805	880	892	918	927	932	934
The rate	-8.54%	-4.21%	-2.78%	0%	1.06%	0.52%	0.21%

Where, the growth rate

$$\Delta = \begin{cases} \frac{Y_n - Y_{n+1}}{Y_{n+1}} & n < 38 \\ \\ \frac{Y_{n+1} - Y_n}{Y_n} & n > 38 \end{cases} \tag{20}$$

It is easy to find through analysis of R that X and Y are roughly in exponential relation with the increase of the total number of camping sites evenly distributed along the bank, the maximum number of trips in the drifting season will increase less and less and eventually may show a saturated trend.

5.3 Sensitivity analysis of contacts frequency

In the process of solving the model, we weaken the second optimal objective(the number of contect into the constraint condition, next we change the minimum contact number M to ensure the total number of the camp, and observe the change of the maximum travel times of the drift season, that is, the river carrying capacity X. We will take M in the sequence of 8,10,12,14,16, and the result is as follows:

Table 6: the sequence of 8,10,12,14,16, and the results

Number of contacts	8	10	12	14	16
river carrying capacity / Times	907	918	928	937	942

Our analysis of the above table shows that the maximum number of trips increases when the number of contacts with the group is allowed to increase. Taking into account the number of campsites and the number of contacts on the maximum number of trips, it is not difficult to find that the two optimization objectives in this model are contradictory. Therefore, we should conduct an in-depth study on the relationship between the two. Unfortunately, due to time constraints, we failed to accomplish the task. If there is a chance later, we must make up for this great regret

6 Strengths and weaknesses

6.1 Strengths

- The model ensures maximum utilization of campgrounds and the concept of minimizing exposure quantifies the concept of "touch";
- Put forward many maths to solve the problem matrices: unit camping matrices, camping matrices, materiel battalion matrices, and the establishment of dual-objective optimization model;
- The carrying capacity of rivers is defined by the number of campsites, and the number of campsites is a constant. Inspired by the definition of tourism carrying capacity, we introduced the number of encounters to quantify the carrying capacity of rivers.

6.2 weaknesses

- Model operation is more difficult, so we can only draw approximate results;
- Ignore the fact that some plans are implemented more than once. If you want to make the model more realistic, consider the case where the number of planned executions is greater than 1;
- The model has some limitations in practice.

7 Future Improvements

Etiam euismod. Fusce facilisis lacinia dui. Suspendisse potenti. In mi erat, cursus id, nonummy sed, ullamcorper eget, sapien. Praesent pretium, magna in eleifend egestas, pede pede pretium lorem, quis consectetuer tortor sapien facilisis magna. Mauris quis magna varius nulla scelerisque imperdiet. Aliquam non quam. Aliquam porttitor quam a lacus. Praesent vel arcu ut tortor cursus volutpat. In vitae pede quis diam bibendum placerat. Fusce elementum convallis neque. Sed dolor orci, scelerisque ac, dapibus nec, ultricies ut, mi. Duis nec dui quis leo sagittis commodo.

- **Applies widely**
  This system can be used for many types of airplanes, and it also solves the interference during the procedure of the boarding airplane,as described above we can get to the optimization boarding time.We also know that all the service is automate.
- **Improve the quality of the airport service**
  Balancing the cost of the cost and the benefit, it will bring in more convenient for airport and passengers.It also saves many human resources for the airline.

8 memorandum

References

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[4]

Appendices

Appendix A First appendix

Aliquam lectus. Vivamus leo. Quisque ornare tellus ullamcorper nulla. Mauris porttitor pharetra tortor. Sed fringilla justo sed mauris. Mauris tellus. Sed non leo. Nullam elementum, magna in cursus sodales, augue est scelerisque sapien, venenatis congue nulla arcu et pede. Ut suscipit enim vel sapien. Donec congue. Maecenas urna mi, suscipit in, placerat ut, vestibulum ut, massa. Fusce ultrices nulla et nisl.

Here are simulation programmes we used in our model as follow.

Input matlab source:

```
function [t,seat,aisle]=OI6Sim(n,target,seated)
pab=rand(1,n);
for i=1:n
    if pab(i)<0.4
       aisleTime(i)=0;
    else
        aisleTime(i)=trirnd(3.2,7.1,38.7);
    end
end
```

Appendix B Second appendix

some more text **Input C++ source:**

```
//===========================================================================
// Name        : Sudoku.cpp
// Author      : wzlf11
// Version     : a.0
// Copyright   : Your copyright notice
// Description : Sudoku in C++.
//===========================================================================

#include <iostream>
#include <cstdlib>
#include <ctime>

using namespace std;

int table[9][9];

int main() {

    for(int i = 0; i < 9; i++){
        table[0][i] = i + 1;
    }
```

```
    srand((unsigned int)time(NULL));

    shuffle((int *)&table[0], 9);

    while(!put_line(1))
    {
        shuffle((int *)&table[0], 9);
    }

    for(int x = 0; x < 9; x++){
        for(int y = 0; y < 9; y++){
            cout << table[x][y] << " ";
        }

        cout << endl;
    }

    return 0;
}
```