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Combine Duration and “Select the Priority trip” to Improve the Number of Boats

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Abstract**—**Our goal is to effectively increase the number of boats in the river during a six month period. The main factors of determining the number of boats are duration and “select the priority trip”. In the microcosmic simulation model, the best result is 4 to 24 nights with DSCF, and the number of boats is 812 with an increasing ratio of 9.0% related to the second best result. However, the number of boats is related to 31.6% less than the best one in 6 to 18 nights with FCFS. In the discrete duration model, we get from 6 to 18 nights, the numbers of boats have increased to 848 with an increase ratio of 29.7% than the best result in model I for the same time range. Moreover, from 4 to 24 nights, the numbers of boats have increase to 1194 with an increase ratio of 47.0% than the best result in model I for the same time range.

Keywords**—**Discrete duration model, “select the priority trip”, microcosmic simulation model.

I. Introduction

THE river rafting is becoming more and more popular at present, and more and more people participate in this sport. In recent years, the demand for this activity has increased, resulting in a high rate of waiting for participating in it. “Trips are typically scheduled two years in advance. Crowding and congestion along the river at campsites is often extreme and has been shown to affect the character and quality of visitor experience” [3]. In order to enhance the economic efficiency of the scenic management department, how to improve the number of travel under various constraints, which has been an important issue. In this essay, we researched the optimal management solutions for river rafting campsite on the way.

The big long river in USA regarded as the research background. The only way to visit the big long river is to take a river trip from First Launch to Final Exit, 225 miles downstream. There are two types of boats (oar-powered rubber rafts & motorized boats) which can be selected for participants, and their average speeds are 4 mph & 8mph. Trips can choose their travel time (range from 6 to 18 nights) to camp on the river, rest in some campsites. One campsite only accommodates one group at night. Every campsite is distributed fairly uniformly throughout the river corridor. Due to the climate reason, most of the recreational about camping along the river is concentrated during a six month every year. In order to provide a wilderness experience, we develop two models to calculate the number of boat trips in the river. One is the microcosmic simulation model, and the other is discrete duration model.

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II. Details of Model

We develop two models to calculate the number of boat trips in the river and analyze some main factors influence the number of boats. One is the microcosmic simulation model to analyze main factors which influence boat trips, and the other is discrete duration model by using fast searching arithmetic to get the most number of boats without any contact.

A. Model I: The Microcosmic Simulation Model

Through analyzing known and unknown information (Table I), we adopt a simulation.

TABLE I
Unknown and Known Information

Unknown information	Known information
The distance of two near campsites The range of boats (motor & oar) daily travel time The proportion of both boats (motor & oar) The number of participants	The length of the big long river Taking a river trip is the only way to go sightseeing The type of boat (motor & oar)

Using this model to simulate the whole process of travel, and achieve our goal that more and more boats are arranged in the river during a six month period by changing managements[2]-[4].

1) The Simulation Rules

Way of traveling:

The only way to visit the big long river is to take a river trip from First Launch to Final Exit. Trips can select boats which are the oar-powered rubber raft and the motorized boat [1].

The Arrangement of Campsites:

During the travel day, trips have a rest in a campsite. In order to avoid contact, no more than two trips will choose the same campsite as their site in the same night. Campsites are distributed fairly uniformly throughout the river. We consider the distance of near campsites (d) is all equal.

In order to have enough time to go sightseeing, so the daily distance of trips is equal as soon as possible. As the number of a campsite is *Y*, the length of travel time is *day*, so passing the number of campsites is less than *m*

$$m=\left[\frac{Y+1}{day}\right]$$

[ ] means round-off number, passing the number of (m+1) campsites spends (Y+1-m×day), and passing the number of (m) campsites spends (m+1)×day-(Y+1).

Open time:

During a six month per year, trips can camp along the big long river. For simplicity, every month has 30 days. Here, we discuss the range of travel time is 6 to 18 nights (in other words, 7 to 19 days), which includes 13 types. Thus, from the 1th day to the 162th day, trips are allowed to choose any type. However, from the 163th day to the 174th day, trips' choices are limited in the scope. Moreover, from the 175th day to the 180th, boats only can exit, instead of entering（Table II).

TABLE II
CHOOSE THE LENGTH OF TRAVEL TIME

Range (days)	Choose the length of travel time
the 1th day to the 162th day	6 to 18 days
the 163th day to the 174th day	Choices are limited in the scope
the 175th day to the 180th	Not available

For example, when trips choose the 170th day as the beginning of time, they are only allowed the length of travel time is 6 (or 7, 8, 9, 10) days.

Daily paddle time:

We estimate the range of the oar-powered rubber rafts' daily paddle time by utilizing actual data. The range of daily paddle time of the oar-powered rubber raft is 2.23 h to 4.33 h.

On the other hand, consider the daily paddle time of the motorized boat. Combined with real life, we believe the minimum daily distance of the motorized boat is longer than the minimum daily distance of the oar-powered rubber raft.

For the minimum daily paddle time of the motorized boat is 1.113 h. The detail process is that: Firstly, we know the minimum daily distance of the oar-powered rubber raft is 8.9 miles. Secondly, the minimum daily distance divides by 10 days (9 nights). Finally, we get the minimum daily paddle time of the motorized boat is 1.113 h. For the maximum daily paddle time of the motorized boat, we ensure the adequate time period for trips to go sightseeing. We assume the adequate time period is 6 hours. The more accurate and reasonable time period needs to go in-depth study.

Based on the minimum & maximum daily paddle time of the oar-powered rubber raft (2.23 hours to 4.33 hours), and the motorized boat(1.11 hours to 6.00 hours). The average of the oar-powered rubber raft is 4 mph, and the motorized boat is 8 mph. Thus, the daily distance about two type boats are 9.32 miles to 17.32 miles, and 8.88 miles to 48.00 miles respectively. Moreover, we can get the following Table III.

TABLE III
THE RANGE OF TRAVEL TIME BASED ON THE RANGE OF DAILY PADDLE TIME

The type of boats	The range of travel time (days)
oar-powered rubber raft	13 to 25
motorized boat	5 to 25

2) The Simulation Process

The Main Process

- According to the beginning of time (day) about travel and length of travel time (T), managers can judge trips can participate in this activity or not. If it is okay, update information about trips in the river (M, A matrix includes current information about trips in the river); on the contrary, output it.
- "Selecting the priority trips" which includes two ways① FCFS and ②DCFS & LCFS.
- Add one day into the beginning of time (day) about travel (day=day+1). Then, return to the Judging Criteria. Finally, keeping doing it.

"Select the Priority Trip"

For the Microscopic Process, we formulate two methods (① FCFS and ②(DSFS & DLFS)) to allow trips to participate in the river. FCFS means "First come first service", DSFS means "shorter travel time has priority", and DLFS means "longer travel time has priority". For instance, the length of 7 days travel is superior to the length of 19 days in DSFS.

①FCFS Process

Increasing the number of trips(S) randomly as {1, 2, 3 …, K, K+1,…S}, and generating vectors of the length of travel time (T) as {day(1), day(2), day(3) …,day(K), day(K+1), …, day(S)}. The proportion of the oar-powered rubber raft and the motorized boat are a% and b% (a%+b%=1). In addition, if trips satisfy the Criteria (according to Table VI), they will arrange to the Trips' waiting queue to enter the river, otherwise they will get some advice from managers. However, we believe that the probability of trips receive advice is 50%. Thus, if trips agree with advice, they also arrange to the Trips' waiting queue to enter the river, or cancel this activity. In the whole process, there are no more than two trips to choose the same campsite in the same night.

- Trip's number is K is allowed to enter this process, from K is equal to 0.
- Determine whether to satisfy the criteria (According to Table VI). If trips satisfy the Criteria, they will arrange to the Trips' waiting queue to enter the river, otherwise they will get some advice from managers. And, if trips agree with advice, they also arrange to the Trips' waiting queue to enter the river, or cancel the activity.
- If K>S, selecting trips from the trips' waiting queue to enter the river (Q), and trips' number as num, from num is equal to 0.
- Judging the vector of the length of travel time is matched to M (a matrix includes current information about trips in the river). If it is okay, update information about trips in the river; otherwise, num=num+1.
- Judging trip's number is maximal or not. If it is okay, day=day+1; otherwise, return to the Trips' waiting queue to enter the river (Q).

②DSFS & DLFS Process

- Trips choose the length of travel time by their minds. According to DSFS (or DLFS) to select trips travel in the river and update information about trips.
- Judging a contact occurs or not. If it will happen, updating information about trips in the river; otherwise, consider the next day, T =T+1 (T, the length of travel time).
- Judging from the range of T, if min {18,180-day}<T<max {6,180-day}, output day=day+1; otherwise, turn to update information about trips.

3) Results

Based on the "select the priority rules", we simulate about the number of boats during 180 days. Due to the fluctuation of simulation, the more precise results need to calculate the average value of trips for more simulation times. The value in the table above is calculated for 20 times. In Table IV, we get the number of boats with different priority rules.

TABLE IV
The Trips With Different Varying Duration

The number of boats	The range of travel time (days)						
	6to18	4to18	8to18	6to16	6to24	8to16	4to24
FCFS	617	639	593	704	472	718	483
DSFS	641	718	634	658	745	603	812
DLFS	654	717	565	537	635	518	677

From the table above, the best result is 4 to 24 nights with DSCF (the queuing priority of day shorter coming first), and the second best result is 6 to 24 nights with DSCF (the queuing priority of day shorter coming first). The number of boats is 812, with an increasing ratio of 13.1% related to the second best result, and 31.6% related to the result of 6 to 18 nights with the queuing priority of first come first serve.

Analysis of the laws

Through analyzing the Table IV, we have found some laws between priority rules and varying duration (measured in nights on the river). With a fixed upper bound of the varying duration of 18 nights, we can get Figure (a); with a fixed lower bound of the varying duration of 6 nights, we can get Figure (b); with a changing interval, we can get Figure (c). (Fig. 1)

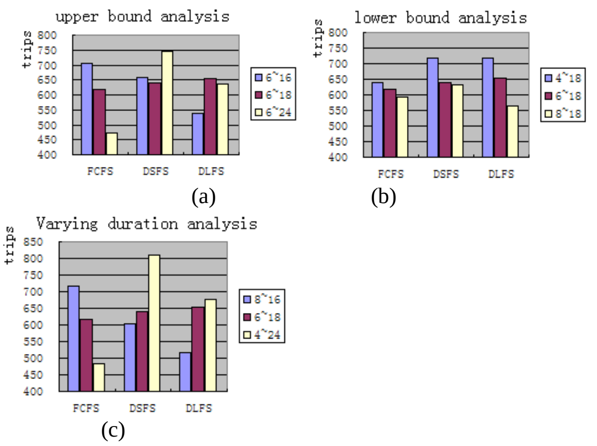

Fig. 1 Analysis of the laws

From the figures above, we can get some conclusion:

- From the Figure (a):

With the priority rule of FCFS, the increasing of the upper boundary of the duration of travel, the trips will decrease.

With the priority rule of DSFS & DLFS, they are not certain, but they present an increasing trend with the increasing of varying duration.

- From the Figure (b) :

We can find that with the decreasing of the lower boundary of the duration of travel, the trip will increase, but FCFS is not sensitive to the decreasing.

- From the Figure (c):

With the priority rule of FCFS, the longer the duration of travel, the less the trip will be.

With the priority rule of DSFS & DLFS, boats will be more.

Therefore, when managers come to decide the varying duration of travel, they can consider the impact of priority rules. If they consider more about the fairness among tourists, cut short the varying duration of travel will be a better choice for carrying more trips. But if they consider more about the options tourists can choose, the entry priority rule of DSFS is better.

The percentage of oar-powered rubber rafts

Through calculating the number of oar-powered rubber rafts with different varying duration, we can get the Table V as follow.

TABLE V
The Percentages Of Oar-Powered Rubber Rafts With Different Varying Duration

Oar-power percentages	The range of travel time (days)						
	6to18	4to18	8to18	6to16	6to24	8to16	4to24
FCFS	60.3 %	58.3 %	62.9 %	55.2 %	68.1 %	58.0 %	66.1 %
DSFS	49.3 %	44.4 %	50.3 %	68.8 %	44.2 %	73.7 %	40.6 %
DLFS	50.9 %	47.2 %	47.8 %	71.4 %	46.5 %	73.5 %	44.0 %

According to the data above, we can give our suggestion about the ratio between oar-power rubber rafts and motorized boats, when it comes to decide how to distribute the boats in advance. With the ratio, the government agency can arrange the number of boats with different propulsion, avoiding redundant waste of boats without using.

B. Model II: The Discrete Duration Model

The main factor for the number of boats in the big long river during a six month period is contact. In model II, we consider how to effectively avoid contacts and increase the number of boats in the river during a six month period.

1) Analyzing of model

In fact, in order to avoid contacts, trips receive detail information about the campsite location from the agency in advance. Thus, we consider regulating the daily distance of trips.

From experience of life, we believe because of the physical exertion, the daily distance of trips becomes shorter and shorter. For simplicity, the daily distance of trips which choose the motorized boat is also shorter and shorter. In the following analysis, we do not distinct type of boats (motor & oar). Consequently, trips pass the daily number of campsite (m) is:

$$\{m+1, m+1, \ldots, m+1, m, m, \ldots, m\}$$

and, the number of campsites (m+1) is $[(Y+1)-m\times day]$, the number of campsites (m) is $[(m+1)\times day-(Y+1)]$.

Through the assembly line process, we can obtain some combinations which include the most number of boats during a six month period.

2) The Assembly line process

Step one: *Trips Classified*

According to the length of travel time (T1 to T2), we can divide trips into (T2-T1+1) groups. For example, if the length of travel time is 7 days to 19 days, it has 13 types.

Step two: *Fast searching arithmetic*

We describe our fast search arithmetic as follows:

- We choose any type of trips randomly, and express a location of the campsite from a vector.
- Then, we select any type of trips randomly again, and also express its as a vector. In addition, comparing two vectors, if they have no contact, so update the detail information about trips in the river; otherwise, we choose a new type trip.
- Keeping doing it, until we obtain a combination.

As an example, if the length of travel time is 7 days to 19 days, it has 13 types. Firstly, we randomly choose a type as 8 days, so get a vector as (33, 65, 97, 129, 161, 193); Secondly, choosing another type 10 and getting a vector as (23, 46, 69, 92, 115, 137, 159, 181, 203); Finally, we can judge no contact between them, and obtain a combination.

3) The results of this model

The maximal feasible solutions without overlap campsites with the variation range of 6 to 18 and 4 to 24 nights (Table VI).

TABLE VI
SOME COMBINATIONS OF THE MAXIMAL FEASIBLE SOLUTIONS WITHOUT OVERLAP CAMPSITES

	Variation range of travel time	
	7 to 19 days	5 to 25 days
Some combinations of the maximal feasible solutions without overlap campsites	(7,8,9,10,13)	(5,6,7,8,9,10,13)
	(7,8,9,13,17)	(5,6,7,8,9,13,17)
	(7,8,10,11,13)	(5,6,7,8,10,11,13)
	(7,8,13,15,17)	(5,6,7,9,10,13,16)
	(7,9,10,12,13)	*(5,6,7,9,13,16,17)*
	(7,9,10,13,16)	(5,6,7,10,11,13,16)
	(7,9,13,16,17)	(6,7,8,10,11,13,24)
	(7,10,11,12,13)	
	(7,10,11,13,16)	
	(7,10,12,13,15)	
	(9,10,12,13,14)	
	(10,12,13,14,15)	

In order to satisfy two demands:

One: The range of travel time of oar-powered rafts and motorized boats are 13 to 24 nights and 4 to 24 nights.

Two: The proportion of oar-powered rafts and motorized boats are 32% and 68% respectively.

We can find solutions with italic types are better than others. Combined with the practical demands for travel days, we can get better results:

- For 6 to 18 nights, the maximal feasible solution without overlap campsites is (7, 10, 12, 13, 15). The numbers of boats have increase to 848 with an increase ratio of 29.7% than the best result in model I for the same time range.
- For 4 to 24 nights, the maximal feasible solution without overlap campsites is (5, 6, 7, 9, 13, 16, 17). The numbers of boats have increase to 1194 with an increase ratio of 47.0% than the best result in model 1 for the same time range.

Further consideration

Although the number of trips of this method is much more, the utilization rate of campsites is still low. The total number of campsites is 244, but the real utilized campsites are 71 for 6 to 18 nights and 80 for 4 to 24 nights. Respectively, the utilization rates of campsites are 35.6% and 31.6%. So there is still much room for improvement. The rest of campsites can allow more tourists to enter.

III. SENSITIVITY ANALYSIS

We analyze the sensitivity by running the program with modified the distance of near two campsites. We accept the smaller or larger value of space in different durations with FCFS, DSFS, and DLFS. Through modified the distance of near two campsites to 2miles, we can get the number of boats compare to the primary (Table VI), the result below (Table VII & VIII).

TABLE VII
SENSITIVITY TEST OF SIMULATION MODE FOR MODEL I

The number of boats	The range of travel time (days)			
	6to18	4to18	6to24	4to24
FCFS	-34.5%	33.9%	-47.9%	-54.8%
DSFS	-40.3%	33.9%	-47.7%	-19.0%
DLFS	-37.1%	-16.1%	-33.5%	-13.4%

From the above Table VII, we find all of the decrease percentages of trips exceed 10%. The reason of this phenomenon is that with the increase of distance of near two campsites, the number of campsites has declined significantly.

TABLE VIII
SENSITIVITY TEST OF SIMULATION MODE FOR MODEL II

	Variation range of travel time	
	7 to 19 nights	5 to 25 days
Some combinations of the maximal feasible solutions without overlap campsites	(7,8,10,12)	(5,6,9,11,15)
		(5,6,9,11,19)

From the above Table VIII, the maximal feasible solutions without overlap campsites have decreased immensely for the two situations. For the variation range of 6 to 18 nights, the maximal number of elements has decrease from 5 to 4. For the variation range of 4 to 24 nights, the maximal number of elements has decrease from 7 to 5.

Above all, the number of trips is sensitive to the number of sites.

IV. Conclusion

There are many factors to influence the carrying capacity of river. In order to allow more trips to travel down the river, we propose two models. One is a simulate model, the other is discrete duration model. We get that under continuous durations with 4 to 24 nights and DSFS, the maximum trips is 812. Under discrete durations 4 to24 nights, the maximum trip is 1194.

There are three shortcomings:

1. According to our model, some campsites (about 79~100) will be wasted if the distance of near two campsites is 1 mile. For the managers, they can find the certain duration trip for these campsites.
2. The assumption that the visitors are infinite is too ideal.
3. The everyday distance of visitors is hard to measured, for almost visitors like the attraction sites which has better scene [2][4].

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