Optimization design for the needs of multi-level Xi'an tourism line

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Abstract

This paper focuses on the summer vacation parents lead children to Xi'an tourism, travel route optimization problems are studied, the Xi'an fifteen spots as a tourist attraction, tourist routes through the analysis of cost, time, number of tourist attractions, according to the different demand for tourism, is divided into five types: (1) the cost is not restricted spend the least time, (2) no time limit, cost the least cost (3) limit cost, actually may be more attractions (4) limited time, as much as possible attractions (5) limited time and cost, as much as possible to visit scenic spots.

To solve the problem (1), first of all, carries on the analysis to the total travel time consumption, which is mainly composed of traffic time, residence time and stay time spots in 3 parts. In view of saving time, choose the more fast taxi as tourists travel transport. The Hamilton loop is established to minimize travel time as the objective function of the optimization model based on. Finally, through the Lingo programming to solve the optimal tour packages, the minimum travel time is 4 days 17 hours 30 minutes.

Problem (2) requires the least cost, primarily by the cost of transportation, tourism accommodation, attractions tickets cost and meals and other expenses of 4 parts, this paper choose cheaper bus as tourists travel transport. Because the problem is essentially and demand (1) problem is consistent, use and demand (1) the same method to obtain the minimum total travel cost is 2080 yuan / person.

For the problem (3) no time limit, so choose buses as tourists travel in order to save transportation fee. The problem based on (2) to travel cost as constraint conditions, this paper established the travel cost constraint, to maximize the number of attractions for the objective function of the optimization model. The final calculated restricted travel costs 400 yuan, 900 yuan of tourists can visit the 5 and 9 spots, and for the formulation of the itinerary.

The travel time constraints of problem (4) on the basis of (1) , this paper establishes the travel time constraint, to maximize the number of attractions for the objective function of the optimization model. The final are restricted travel time is 2 days, 3 days and 4 days, visitors can tour 8, 12 and 14 spots, and in 3 days as an example, the development of tourism itinerary.

Aiming at the problem (5),which based on(3) and (4) increased the binding of travel time and cost constraints. Therefore, the same set to maximize the number of attractions for the objective function of the optimization model. Finally solving the different time and cost constraints travel routes, and gives 4 days 1300 yuan travel itinerary, the only tour of the 12 spots.

At the end of the paper, the advantages and disadvantages of the model are analyzed, the improvement scheme is proposed, which makes the model more consistent with the actual.
Key words: tourism route different needs cost time number of attractions

1 Restatement of the problem

Summer vacation is coming, many parents will choose this time to take the children to the city tourism, but different families have different needs (number, cost constraints, time constraints), please choose a tourism city (such as your city), considering the travel route, cost, time and other factors do you think more important, design a best travel packages for the different needs of the family.

（1）The ancient city of Xi'an as one of the cradles of Chinese civilization, tourism resources be richly endowed by nature, is a famous historical city in the world. Therefore, we choose the ancient city of Xi'an is modeled as a tourist city, tourists visit Xi'an to Xi’an Railway Station as starting point, Mausoleum of the First Qin Emperor, Huaqing Hot Spring, Terracotta Army has been selected the Ban po, Mount Li scenic area, Shaanxi History Museum, Tang Paradise, Qu Jiang marine Museum, Xi'an city wall, the big wild goose pagoda square, Bell Tower and Drum Tower, Qujiang cold kiln ruins park, Datang sleepless city, Hui street, Qinglong temple and Cui Huashan fifteen most Xi'an Representative of the tourist attractions as the place to visit, as shown in figure 1. Considering the cost of time and travel routes, scenic spots number of these factors, according to the different needs of people travel, make travel play different packages of Xi'an, concrete is mainly to solve the following five problems:

（2）The cost is not restricted, spending time at least needs, establish the corresponding mathematical model, design tourism itinerary and give the corresponding package.

（3）In no time limit, cost the least cost requirements, establish the corresponding mathematical model, design tourism itinerary and give the corresponding package.

（4）Aiming at the limited time, as much as possible attractions needs, establish the corresponding mathematical model and design tourism itinerary.Visitors of only 3 days of travel time develop the best travel packages.

（5）According to the time limit and the cost, as many scenic spots, establish the corresponding mathematical model and design tourism itinerary. And defining a 4 days 1300 yuan tourists to develop the best travel packages.

Figure 1　xi 'an attractions map

2 Model assumptions

During the summer holiday is the golden period of parents to lead children to travel, Xi'an tourist attractions to attract a large number of tourists sightseeing. Considering the tourist route still exist some uncertain factors. In order to facilitate research, we propose the following hypothesis:

(1)Passengers were the first to arrive Xi’an Railway Station, namely from the train station to start sightseeing, left Xi'an is also from the train station. Return the original city.

(2)Xi'an Metro is in construction, leading to the attractions of the line is few, so the city transportation assumptions to bus (including the shuttle bus, minibus) and taxi.

(3)Members of the same family travel route, the time required and costs are the same.

(4)Travel expenses including transportation, accommodation, attractions tickets. 20:00 in the evening to the morning between 7:00, if you stay more than 6 hours, in a place to stay, accommodation costs no more than 150 yuan / person / day. Eating and other costs 60 yuan / person / day.

(5) the scenic spots have a hotel to hotel.

(6) the hypothesis on the trail no accidents, no blocking, no traffic jam.

(7) suppose waiting for a bus or a taxi time is very short, negligible;

(8) hypothesis spots open time of 8:00 to 20:00; Including da tang city that never sleeps to 24:00.

(9) the hypothesis in the process of tourism weather conditions are good, does not affect the schedule.

3 Symbolic description

Symbol	instructions
i,j （i，j=0,1,2 ••••••• 15）	Represents the i or j attractions
m	Represents the total cost plan during the trip
c_{ij}	Transportation costs between the i scenic spot to j attractions
t_{ij}	Traffic time required the i sites to the j sites
Z_i	Article i attractions accommodation costs
T	The total time travel spending.
t_i	The residence time in the i spots
y_i	In the i attractions accommodation time
n	The number of tourist attractions
$r_{ij}=1$	Represents directly from i to j attractions attractions
$r_{ij}=0$	Not go to the attractions directly from i to j attractions
$S_i=1$	Represents in the article i attractions accommodation
$S_i=0$	Not in the i attractions accommodation

4 Analysis of the problem

4.1 Analysis of problem one

Problem one requirement in the no limit cost, visiting fifteen spots, and make cost least time travel packages. Travel time by traffic time, 3 parts attractions residence time and stay, while taxi is far faster than the bus, so in this problem, we try to choose the taxi as a means of transport. This problem belongs to the typical TSP (traveling salesman problem), so we set up the minimum travel time as the objective function of the optimization model, through the LINGO programming for the optimal scheme.

4．2 Analysis of problem two

Problem two requirements in under the condition of limited time, visiting 15 spots, and to develop a cost minimum travel packages. Total travel cost by traffic expenses, accommodation cost, attractions tickets and eating, and other expenses of 4 parts, the taxi fees generally higher than that of the bus, so in this problem, we choose to use the bus as a means of transport. The problem in essence is a problem with a consistent, also belong to the typical TSP problem, only optimization objective function is a cost minimum, with a similar problem solving methods.

4.3 Analysis of problem three

Question three is based on the limited travel expenses, as much as possible tourist attractions. From the two analysis, the total travel costs included in the cost of transportation, but the problem there is no restriction on the travel time, but also meet the requirements of travel expenses. In view of the bus and taxi cost significantly cheaper, therefore, in this issue, we as a means of transportation to the bus. The problem is the problems on the basis of the two, add to the travel cost constraints, therefore, we establish the constraint conditions in the travel costs, and use Lingo to solve the largest number of attractions for the objective function of the optimization model.

4.4 Analysis of problem four

Question four is based on the limited travel time, as much as possible tourist attractions. From problem analysis, travel time generally includes traffic takes time, but the problem there is no limit to the cost of travel, and travel time is limited. In view of the taxi fast is better than a bus. Therefore, in this problem, we take taxi as the gateway to the attractions between the traffic tools. The problem is essentially based on the problem of a, join the travel time constraints, therefore, we establish the constraint conditions in the travel time, to scenic spots number as the objective function of the optimization model is solved for different travel time, travel packages are given the corresponding.

4.5 Analysis of problem five

Question four is based on the travel time limit cost, as many scenic spots. The problem is essentially further restrictions on questions three and four, at the same time constraints on the travel time and travel cost. Therefore, we establish the constraint conditions in the travel time and travel costs, to the largest number of attractions for the objective function of the optimization model, different time and cost constraints of travel packages.

5 Establishing and solving the model

5.1 The cost is not restricted, spending time at least problem

5.1.1 The establishment of objective function

The passengers were the first to arrive Xi'an Railway Station, from the train station to start sightseeing. Description clearer and programming more convenient to make, we will Xi’an Railway Station, Mausoleum of the First Qin Emperor, Huaqing Hot Spring, Terracotta Army, the Banpo, Mount Li scenic area, Shaanxi History Museum, Tang Paradise, Qujiang aquarium, Xi'an city wall, the big wild goose pagoda square, Bell Tower and Drum Tower, Qujiang cold kiln ruins park, Datang sleepless city, Hui street, Qinglong temple and Cui Huashan these fifteen spots to number, respectively numbered 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15. The topology of Xi’an Railway Station and fifteen spots of traffic route form shown in Figure 2.

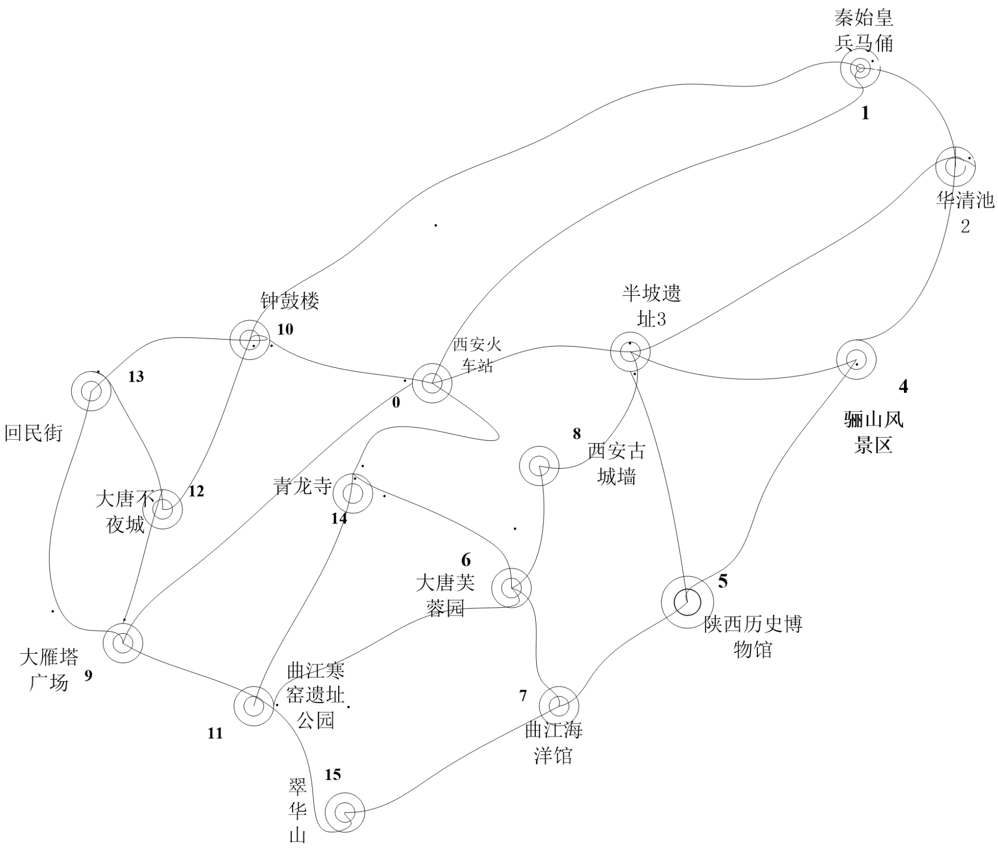

Figure 2 train station and the site topology

Don't limit in the cost, visiting fifteen spots, required to spend the least time demand, the demand is not restricted travel costs, and visiting the fifteen spots in the shortest time. The problem is a typical TSP (traveling salesman problem) problem. The total time to travel by the attractions of the traffic between take time, residence time and stay time spots in 3 parts.

T ——Represents total travel time；

T_1——Stands for the total transportation time required between sites；

T_2——Represents the total time attractions stay；

T_3——Stands for the total time of accommodation；

Therefore, for visiting tourists attractions in fifteen conditions, makes the traffic time, residence time and the residence time of the scenic spots and the least, the objective function can be expressed as

$$\mathrm{Min\,T} = \mathrm{T_1} + \mathrm{T_2} + \mathrm{T_3}$$

(1)The total transportation time required between sites

t_{ij} represents transportation time from i to j attractions， $\mathrm{r_{ij}}$ is 0 - 1 variables to judge whether the tourists directly from i to j attractions，So we can easily get the total transportation time：

$$T_1 = \sum_{i=0}^{15}\sum_{j=0}^{15} r_{ij} \times t_{ij}$$

（2）The total time in attractions

t_i represents the total time in i attractions， $\mathrm{r_{ij}}$ is 0 - 1 variables to judge whether the tourists directly from i to j attractions ，So we can easily get the total time in attractions :

$$T_2 = \frac{1}{2}\sum_{i=0}^{15}\sum_{j=0}^{15} r_{ij} \times (t_i + t_j)$$

（3）The total time of accommodation

s_i is judge whether visitors from the first I Scene accommodation for 0 - 1 variables，while y_i represents i attractions accommodation time，assumption each spot stay time $\mathrm{y}_i \le 8$ （hour），So we can easily get the total time accommodation :

$$T_3 = \sum_{i=0}^{15} y_i s_i$$

Through the above analysis, the objective function of this demand conditions can be expressed as：

$$\begin{aligned}\mathrm{Min\,T} &= \mathrm{T_1} + \mathrm{T_2} + \mathrm{T_3} \\ &= \sum_{i=0}^{15}\sum_{j=0}^{15} r_{ij} \times t_{ij} + \frac{1}{2}\sum_{i=0}^{15}\sum_{j=0}^{15} r_{ij} \times (t_i + t_j) + \sum_{i=0}^{15} y_i s_i\end{aligned}$$

5.1.2 Constraint conditions:

（1）The constraint of the 0-1variable $\mathrm{r_{ij}}$

We will all the attractions are joined in a circle, and each of the spots as the last point circle. For each point, only allow up to one side to enter, also only allowed one edge, and as long as there is a side to have an edge out, the formation of a Hamilton loop. So the available constraints：

$$\sum_i r_{ij} = \sum_j r_{ij} \le 1 \qquad (i, j = 0, 1, 2, \cdots, 15)$$

when $i = 0$,because it is from the train station as a starting point，so $\sum_{i=0} r_{ij} = 1$；

when $j = 0$,because tourists must eventually return to the train station，therefore, $\sum_{j=0} r_{ij} = 1$.

Comprehensive above knowable，

$$\sum_{i} r_{ij} = \sum_{j} r_{ij} \le 1 \qquad (i, j = 0,1,2,\cdots,15)$$

$$\sum_{i=0} r_{ij} = 1$$

$$\sum_{j=0} r_{ij} = 1$$

similarly，$i, j \ge 0$，According to the question is never to appear $r_{ij} = r_{ji} = 1$，That is not possible in between two tourists and tourism, because it obviously does not meet the attractions as many principles. So we can get constraint:

$$r_{ij} \times r_{ji} = 0 \qquad (i, j = 0,1,2,\cdots,15)$$

(2)The number of constraints of tourist attractions

According to the hypothesis, the travel route is circular, which would eventually return to the Xi'an Railway Station, the train station is not as tourist attractions，therefore, $\sum_{i=0}^{15}\sum_{j=0}^{15} \mathrm{r_{ij}} - 1$ is the number of tourist attractions，Here we assume to tourist attractions number n（n=1，2，3，……，15）.So the number of constraints as tourist attractions：

$$\sum_{i=0}^{15}\sum_{j=0}^{15} \mathrm{r_{ij}} - 1 = \mathrm{n} \qquad （\mathrm{n} = 1,2,3,\cdots\cdots 15）$$

5.1.3 Model establishment

From what has been discussed above, we can know any cost case, visiting 15 spots, mathematical model can be required to spend at least time：

$$\begin{aligned} \mathrm{Min\,T} &= \mathrm{T_1} + \mathrm{T_2} + \mathrm{T_3} \\ &= \sum_{i=0}^{15}\sum_{j=0}^{15} r_{ij} \times t_{ij} + \frac{1}{2}\sum_{i=0}^{15}\sum_{j=0}^{15} r_{ij} \times (t_i + t_j) + \sum_{i=0}^{15} y_i s_i \end{aligned}$$

The constraint conditions are：

$$
s.t.\begin{cases}
\sum_{i=0}^{15}\sum_{j=0}^{15} \mathrm{r_{ij}} - 1 = \mathrm{n} \qquad （\mathrm{n}=15） \\
\sum_{i} r_{ij} = \sum_{j} r_{ij} \le 1 \qquad (i, j = 0, 2, \cdots, 15) \\
\sum_{i=0} r_{ij} = 1 \\
\sum_{j=0} r_{ij} = 1 \\
r_{ij} \times r_{ji} = 0 \qquad (i, j = 1, 2, \cdots, 15) \\
y_i \le 8
\end{cases}
$$

5.1.4 Solving the model

Considering the reality, fast taxi, it spent time is far less than the bus, so we in this requirement, we choose the taxi as a means of transport, collected between fifteen scenic spots and train station a total of sixteen locations taxi schedule, as well as schedule attractions stay, respectively, as shown in Table 1, table as shown in figure 2:

Table 1: between sixteen sites (taxi time unit "hour")

unit (h)	T S	T A	HHS	Ban po	Mou nt Li	ST	TP	QJ aqu	Anc Wall	B W GP	BD Towe	CK K park	DT City	Hui Str	QL temp	CH Mou
T S	0	1.5	1.2	0.5	1.5	0.4	0.5	0.3	0.1	0.3	0.2	0.4	0.3	0.2	0.3	1.4
T A	1.5	0	0.5	1	0.5	1.5	2	1.5	1.5	1.5	1.5	2	1.5	1.3	1.5	2.5
HHS	1.2	0.5	0	1	1.5	1.5	1.5	1.4	1.2	1	1	1.1	1.2	1	1	2.5
Ban po	0.5	1	1	0	0.5	0.5	0.4	0.5	0.5	0.6	0.6	0.8	0.5	0.4	0.4	1.5
Mount Li	.5	0.5	1.5	0.5	0	1.6	1.7	1.8	1.5	1.5	1.4	1.6	1.5	1.2	1.5	2.6
ST	0.4	1.5	1.5	0.6	1.6	0	0.2	0.4	0.4	0.2	0.6	0.2	0.4	0.3	0.5	1.5
TP	0.5	2	1.5	0.4	1.7	0.2	0	0.1	0.5	0.2	0.4	0.2	0.2	0.4	0.3	1.2
QJ aqu	0.4	1.5	1.4	0.5	1.8	0.4	0.1	0	0.4	0.2	0.4	0.2	0.2	0.4	0.2	0.9
Anc Wall	0.1	1.6	1	0.5	1.6	0.5	0.5	0.4	0	0.3	0.1	0.5	0.2	0.3	0.4	1.5
BWGP	0.4	1.5	1	0.6	1.5	0.2	0.2	0.2	0.4	0	0.4	0.3	0.1	0.4	0.3	0.8
BD Tower	0.2	1.5	1	0.6	1.4	0.6	0.4	0.4	0.2	0.4	0	0.4	0.4	0.1	0.4	0.9
CKR park	0.4	2	1.1	0.8	1.6	0.2	0.2	0.2	0.4	0.3	0.4	0	0.3	0.5	0.3	0.6

Notes:Train stationTerracotta Army ,Huaqing Hot Spring ,Banpo Museum,Mount Li scenic area, Shaanxi Museum of history, Tang Paradise ,Qujiang aquarium ,the Xi'an city wall,Big Wild Goose Pagoda,Bell Tower and Drum Tower,Qujiang cold kiln ruins park,Datang sleepless city,Hui Street,,Qinglong temple ,Cui Hua Mountain respectively short for TS,TA,HHA,Banpo,Mount Li,ST,TP,QJ aqu,Anc Wall,BWGP,BD Tower,CKP park.

Table 2 the fifteen tourist attractions residence time

Attractions	Spots of the most short residence time/hour
Terracotta Warriors and horses	4
Huaqing Hot Spring	4
Banpo site	1s
Mount Li Scenic Area	4
The Shaanxi History Museum	3
Tang Paradise	4
Qujiang Aquarium	3
Xi'an city wall	1
Big Wild Goose Pagoda	1
Bell Tower and Drum Tower	1
Qujiang cold kiln ruins park	3
Datang sleepless city	4
Hui Street	3
Qinglong Temple	2
Cuihua Moutain	8

Through the above mathematical model, using the LINGO programming to determine the optimal scheme is: 0 → 1 → 2 → 4 → 3 (accommodation) → 15 → 11 → 7 → 6 → 12 (accommodation) → 9 → 5 → 13 → 10 (accommodation) → 14 → 8 → 0: Xi’an Railway Station, Terracotta Army, Mausoleum of the First Qin Emperor Huaqing Hot Spring, Mount Li scenic area (accommodation), Banpo, Cui Huashan, Qujiang cold kiln ruins park (accommodation), Qujiang aquarium, Tang Paradise, Datang sleepless city (accommodation), the big wild goose pagoda square, Shaanxi Museum of history, Hui Street, Bell Tower and Drum Tower (accommodation), Qing long Si, Xi'an city wall, the Xi’an Railway Station. Total time: 4 days 17 hours 30 minutes. Combined with the practice, the specific itinerary can be formulated as follows:

Schedule	
Time	Route
The first day	At 7:00 cab ride to visit Mausoleum of the First Qin Emperor in Terracotta Army, Huaqing Hot Spring and Mount Li (accommodation).Visit Banpo Museum and Cui Huashan, and arrived in Qujiang (accommodation).
The	As early as 7 cab ride to visit Mausoleum of the First Qin Emperor

second day	in Terracotta Army, Huaqing Hot Spring and Mount Li (accommodation). Visit Banpo Museum and Cui Huashan, and arrived in Qujiang (accommodation).
The third day	Tour of the Qujiang cold kiln ruins park began at 8 :00, Qujiang aquarium, night tours Datang sleepless city (accommodation)
The fourth day	At 8:00 take a taxi to the wild goose pagoda, after the provincial history museum, street, and the tower (accommodation).
The fifth day	Visit the Qinglong Temple started as early as 8 points, then visit the Xi'an city wall. And then on the ride home on the train station.

5.2 No time limit, cost the least cost problem

5.2.1 The establishment of objective function.

Not limited time, visiting fifteen spots, the least cost, the problem is with the problem, but also a typical TSP (traveling salesman problem) problem. Since the total travel costs to visit by the traffic expenses, accommodation and meal fee, and other expenses of 4 parts，

m ——Each person's total tourism expenditure；

m_1 ——The total cost of each person's traffic；

m_2 ——The total tourism attractions tickets per person；

m_3 ——Each person's total cost of accommodation；

m_4 ——Everyone's table and other fees；

While the door to visit fifteen attractions tickets cost is determined, only in the tourists visiting the fifteen spots on condition that the transportation, accommodation and meals and other expenses. Therefore, our objective function for:

$$\mathrm{Min}\, \mathrm{m} = \mathrm{m}_1 + \mathrm{m}_2 + \mathrm{m}_3 + \mathrm{m}_4$$

(1)The total cost of transportation

c_{ij} represents transportation costs from i to j attractions，r_{ij} is 0—1 variables to judge whether the tourists directly from i to j attractions，So we can easily get the traffic cost:

$$m_1 = \sum_{i=0}^{15}\sum_{j=0}^{15} r_{ij} \times c_{ij}$$

(2)Fee total tourism attractions tickets

A total of fifteen attractions tickets cost is constant, by finding relevant data, indicated that the fifteen attractions tickets as shown in Table 3：

Table 3: Fifteen attractions tickets cost (unit: yuan / person)

Attractions	Ticket
Terracotta Warriors and horses	150

Huaqing Hot Spring	110
banpo	65
Mount li Scenic Area	105
ShaanxiHistory Museum	free
Tang Paradise	90
Qujiang Aquarium	100
Xi' an	45
The big wild goose pagoda square	free
Bell temple and temple	35
Qujiang cold kiln ruins park	50
DaTang sleepless City	95
Hui street	free
Qinglong Temple	10
Cui hua Mount	75

So the total fee of tourist attractions

$$m_2 = \sum_{i=1}^{15} G_i = 930$$

(3)The total cost of accommodation

Introduce 0 — — 1 Variables s_i representing whether in i attractions accommodation, while Z_i represents i attractions accommodation costs, so we can easily get accommodation:

$$m_3 = \sum_{i=0}^{15} z_i s_i$$

(4)Meals and other expenses

Per capita food and other expenses that are for 60 yuan, by introducing time variable representation travel days, so we can easily get dinner and other fees:

$$m_4 = 60t$$

Through the above analysis, our objective function can be expressed as:

$$\begin{aligned} \mathrm{Min\,m} &= \mathrm{m_1 + m_2 + m_3 + m_4} \\ &= \sum_{i=0}^{15}\sum_{j=0}^{15} r_{ij} \times c_{ij} + 930 + \sum_{i=0}^{15} Z_i s_i + 60t \end{aligned}$$

5. 2. 2 Model establishment

By the analysis of constraints demand model, constraints and problems of two model is consistent with a model constraint. To sum up, we can know, does not limit the time, visiting fifteen spots, the mathematical model for the cost of the least:

$$\begin{aligned}\text{Min m} &= \text{m}_1+\text{m}_2+\text{m}_3+\text{m}_4\\ &= \sum_{i=0}^{15}\sum_{j=0}^{15} r_{ij}\times c_{ij} + 930 + \sum_{i=0}^{15} Z_i s_i + 60t\end{aligned}$$

The constraint conditions are：

$$s.t.\begin{cases}\sum_{\mathrm{i=0}}^{15}\sum_{\mathrm{j=0}}^{15}\mathrm{r_{ij}}-1=\mathrm{n} & （\mathrm{n}=15）\\ \sum_{i} r_{ij}=\sum_{j} r_{ij}\le 1 & (i,j=0,1,2,\cdots,15)\\ \sum_{i=0} r_{ij}=1 & \\ \sum_{j=0} r_{ij}=1 & \\ r_{ij}\times r_{ji}=0 & (i,j=1,2,\cdots,15)\\ Z_i\le 150 & \\ t=[\dfrac{T}{24}]^{+} & (\text{向上取整})\end{cases}$$

5. 2. 3 Model solving

Considering the reality, the taxi cost is much higher than the bus, so we in this requirement, we choose buses for transport, collected between fifteen scenic spots and the train station sixteen sites of bus fare table, as shown in Table 2：

Table 2: Sixteen place bus fees (unit "Yuan")

nit （yuan ）	TS	TA	HHA	Ban po	Mount Li	ST	TP	QJ aqu	Anc Wall	BWGP	BD Towe	CKR park	DT City	Hui Str	QL temp	CH Mount
TS	0	20	10	3	5	4	4	6	1	5	3	4	5	2	4	16

TA	20	0	2	15	2	15	8	20	20	18	25	23	20	24	23	30
HHA	10	2	0	12	25	30	16	18	10	18	16	12	12	15	14	30
banpo	3	15	2	0	15	6	8	9	3	6	2	8	10	6	5	18
Mount Li	5	2	25	15	0	15	15	16	5	6	14	5	14	13	15	30
ST	4	15	30	6	15	0	2	3	4	2	2	4	4	6	4	10
TP	4	18	16	8	15	2	0	2	4	5	6	4	2	4	3	10
QJ	6	20	18	9	16	3	2	0	6	4	5	5	3	4	6	15
Ancient Wall	1	19	10	2	6	4	5	5	1	5	5	4	5	3	5	15

B WGP	5	18	18	6	6	2	4	4	5	0	4	4	4	5	8	18
B D Tower	2	25	16	2	14	2	6	5	2	3	0	4	5	0	3	15
CKR park	4	23	12	8	15	4	4	5	4	4	4	0	3	4	6	15
DT City	5	20	12	10	14	4	2	3	5	4	5	3	0	5	7	14
Hui Street	2	24	15	6	13	2	4	4	2	5	1	4	5	0	4	15
QL temple	4	23	14	5	15	4	3	6	4	8	3	6	7	4	0	17
CH Mount	16	30	30	18	30	10	10	15	16	18	15	15	14	15	17	0

Through the above mathematical model, using LINGO programming, the optimal scheme is: 0 → 8 → 10 → 13 (accommodation) → 14 → 5 → 9 → 7 (accommodation) → 11 → 6 → 12 (accommodation) → 3 → 4 → 2 (accommodation) → 1 → 15 → 0 (accommodation). That is :Xi’an Railway → Station,namely → Xi'an city wall → Bell Tower and Drum Tower → Hui Street (accommodation)→Qing long Temple→Shaanxi History Museum→ the wild goose pagoda square→ Qujiang Maritime Museum (accommodation)→ Qujiang cold kiln ruins park→Tang Paradise→Datang sleepless city (accommodation)→ Banpo site→ Mount Li scenic area→ the Huaqing Hot Spring (accommodation)→Mausoleum of the First Qin Emperor Terracotta Army (accommodation)→Cui Huashan→Xi'an Rail

Schedule	
Time	Trip
The first day	The morning before 8:00 from xi'an Railway Station by bus to the Xi'an city wall entrance (45 yuan tickets), from 14 bit to start the tour after 3 hours by bus to the Bell Tower and Drum Tower (35 yuan tickets) watch 1 hours at night, after dinner, walk to the street snacks, night stay.
The second day	8:00 in the morning from the hotel of travel road to the Green Dragon Temple (10 yuan tickets) Tour 2 hours, after the bus ride to the Shaanxi History Museum (holding identity cards free tickets) for 2 hours, lunch, after the lunch break, arrived at 15:00 p.m. the big wild goose pagoda square to see Asia's largest fountain to stay 1 hours by car, visit to Qujiang ocean hall, when this accommodation.
The third day	As early as 8:00 starting to Qujiang cold kiln ruins park (50 yuan tickets) for 3 hours, lunch, after the lunch break, the 15 ride to Tang Paradise (90 yuan tickets) for 3 hours, after dinner, went to Datang sleepless city (95 yuan tickets) for 4 hours and watched the show, night stay.
The fourth day	As early as 8 point to Banpo Museum (65 yuan tickets) 1 hours after the bus ride to the Mount Li scenic area (105 yuan tickets), then head to the Huaqing Hot Spring stops play 3 hours, night stay.
The fifth day	Start at 8 in the morning to go to the Qin Shihuang visit the Terracotta Army (150 yuan tickets) and 4 hour tour in the vicinity of scenic spots, that night in the accommodation.
The sixth day	The 8:00 bus of the green Huashan (75 yuan), is expected to 8 hours down the mountain. After the return to the train station.

5.3 Limit cost, as many scenic spots

5.3.1 The establishment of objective function and constraint conditions

Three according to the time limit, cost is not restricted, under such conditions as much as possible attractions condition. We use single objective optimization model, with the largest number of attractions as the goal, based on the needs of two model plus the total cost constraints, such as limited cost as constraint conditions is less than $M_{\max}$, and change the target function, establish model as follows, the objective function can be expressed as:

$$\max \ n=\sum_{\mathrm{i=0}}^{15}\sum_{\mathrm{j=0}}^{15}\mathrm{r_{ij}}-1$$

The constraint conditions are in demand for the two model plus the total cost constraint，

$$m=\sum_{i=0}^{15}\sum_{j=0}^{15}r_{ij}\times c_{ij}+930+\sum_{i=0}^{15}Z_i s_i+60t\le M_{\max}$$

5.3.2 Model Building

The demand for the two models and the analysis above, to limit the travel cost, time is not restricted conditions, the best route model as much as possible for most tourist attractions：

$$\max \ n=\sum_{\mathrm{i=0}}^{15}\sum_{\mathrm{j=0}}^{15}\mathrm{r_{ij}}-1$$

The constraint conditions are：

$$s.t\begin{cases}\sum_{i=0}^{15}\sum_{j=0}^{15}r_{ij}\times c_{ij}+930+\sum_{i=0}^{15}Z_i s_i+60t\le M_{\max}\\ \sum_{i}r_{ij}=\sum_{j}r_{ij}\le 1 \qquad (i,j=0,2,\cdots,15)\\ \sum_{i=0}r_{ij}=1\\ \sum_{j=0}r_{ij}=1\\ r_{ij}\times r_{ji}=0 \qquad (i,j=1,2,\cdots,15)\\ Z_i\le 150\\ t=[\dfrac{T}{24}]^{+} \qquad (\text{向上取整})\end{cases}$$

In this problem, because no time limit, and the cost is limited, considering the reality, the taxi cost is much higher than the bus, so we in this requirement also choose buses for transport. Bus fare table as shown in table 2. Through lingo programming to determine the optimal scheme：

The number of tourist attractions N	4	5	6	7	8	9	10
The total cost (yuan / person)	280	368	420	580	625	820	1200
Route	0	0	0	0	0	0	0

	→5→3→9→8→0	→13→5→9→3→8→0	→10→6→11→7→5→8→0	→13→10→5→9→11→3→8→0	→13→10→5→6→11→7→9→3→0	→13→5→6→12→11→9→10→3→8→0	→5→6→11→12→7→9→15→14→3→8→0

From the table we can see, for travel costs only 400 yuan of tourists, the most can only browse 5 spots. Travel to：0→13→5→9（accommodation）→3→8→0，Combined with the concrete practice, making travel schedule is as follows：

Schedule	
The first day	Morning 8 o'clock bus to Hui Street (free) tour, go to the History Museum of Shaanxi province after the (free), afternoon take a bus to the big wild goose pagoda (free). Night live near a small hotel.
The second day	Morning 8 o'clock bus to the Banpo Museum (60 yuan tickets), and then go to Xi'an city wall (45 yuan tickets), afternoon return home.

For tourists traveling costs only 900 yuan, it at most can only browse the nine spots. Schedule for：0→13→5→6（accommodation）→12→11→9（accommodation）→10→3→8→0， Combined with the concrete practice, making schedule is as follows：

Schedule	
The first day	Morning 8 point bus to Hui Street (free) tour, go to the History Museum of Shaanxi province after the (free), to visit the Datang Furong garden in the afternoon (90 yuan tickets). At night in a small hotel near.
The second day	Morning 8 point bus to Datang sleepless city (95 yuan tickets), and then to Qujiang cold kiln ruins park (50 yuan tickets), to visit the wild goose pagoda square in the afternoon (free), accommodation in the evening, near the small hotel.
The third day	8 in the morning to go to the Bell Tower and Drum Tower (35 yuan tickets) tour, then take the bus to the Banpo Museum (60 yuan tickets) visit, finally return to the train station .

5.4 Limited time, as much as possible tourist attractions

5.4.1 The establishment of objective function and constraint conditions

Four according to the time limit, cost is not restricted, under such conditions as much as possible tourist attractions. Therefore, we are still a single objective programming model in order to scenic spots number as the target, and time on the basis of the demand model with the total is not more than $T_{\max}$ constraints hours, and change in the number of tourist attractions as the objective function, the objective function can be expressed as:

$$\max\ n=\sum_{i=0}^{15}\sum_{j=0}^{15}\mathrm{r}_{ij}-1$$

Constraint conditions as the restraint plus the total time in the demand model,

$$T=\sum_{i=0}^{15}\sum_{j=0}^{15}r_{ij}\times t_{ij}+\frac{1}{2}\sum_{i=0}^{15}\sum_{j=0}^{15}r_{ij}\times(t_i+t_j)+\sum_{i=0}^{15}y_i s_i\le T_{\max}$$

5.4.2 Model establishment

The demand model and the above analysis, the mathematical model of time limit, as much as possible attractions best route cost does not limit the conditions is：

$$\max\ n=\sum_{i=0}^{15}\sum_{j=0}^{15}\mathrm{r}_{ij}-1$$

The constraint conditions are：

$$s.t\begin{cases}\sum_{i=0}^{15}\sum_{j=0}^{15}r_{ij}\times t_{ij}+\frac{1}{2}\sum_{i=0}^{15}\sum_{j=0}^{15}r_{ij}\times(t_i+t_j)+\sum_{i=0}^{15}y_i s_i\le T_{\max}\\ \sum_{i}r_{ij}=\sum_{j}r_{ij}\le 1 \qquad (i,j=0,2,\cdots,15)\\ \sum_{i=0}r_{ij}=1\\ \sum_{j=0}r_{ij}=1\\ r_{ij}\times r_{ji}=0 \qquad (i,j=1,2,\cdots,15)\\ y_i\le 8\end{cases}$$

In this problem, because the costs are not limited, and the limited time, considering the reality, the taxi time much faster than the bus, so we in this requirement also chose the taxi as a means of transport. Taxi schedule as shown in table 1. Through lingo programming to determine the optimal scheme：

The number of tourist attractions N	8	10	12	14
Time（hour）	40	63	70	103

Route	0→8→ 13→14→5→ 9→7→11→6 →12→0	0→8→ 10→13→14 →5→6→7→ 12→9→10→ 0	0→8→10 →13→5→7→ 14→6→9→11 →12→3→4→ 0	0→8→10 →14→5→7→ 13→6→12→9 →11→3→4→2 →1→0

From the table we can see, the travel time was 2 days, 3 days, 4 days of passengers, the most were able to tour 8, 12, 14 spots. We have to travel only 3 days of travel time as an example, combined with the actual development of the tourist itinerary is as follows:

Schedule	
The first day	8 in the morning by car to visit Xi'an city wall, then go to Bell Tower and Drum Tower tour, and then went to the street, and then go to the Shaanxi History Museum, and finally to Qujiang ocean hall that night live near the hotel.
The second day	At 8 o'clock in the morning go to Qinglong temple, and then went to Tang Paradise, then went to the square of the big wild goose pagoda tour, and finally to Qujiang cold kiln ruins park to play, night live nearby hotel.
The third day	8 in the morning to Datang sleepless city tour, then go to the Banpo Museum, after lunch go to Mount Li to play, and return home after the Xi’an Railway Station。

5.5 Limit the time and expense, as many scenic spots

5.5.1 The establishment of objective function and constraint conditions

Demand the five time limit and expenses, under such conditions as much as possible tourist attractions. This requirement is three and four combined, therefore, we are still in the scenic spot number as optimization target, the travel restrictions on travel costs $M_{\max}$ and travel time $T_{\max}$ adding constraints, the objective function can be expressed as:

$$\max\ n = \sum_{i=0}^{15}\sum_{j=0}^{15} \mathrm{r_{ij}} - 1$$

The new constraint conditions of the cost and time are:

$$T = \sum_{i=0}^{15}\sum_{j=0}^{15} r_{ij} \times t_{ij} + \frac{1}{2}\sum_{i=0}^{15}\sum_{j=0}^{15} r_{ij} \times (t_i + t_j) + \sum_{i=0}^{15} y_i s_i \le T_{\max}$$

$$m = \sum_{i=0}^{15}\sum_{j=0}^{15} r_{ij} \times c_{ij} + 930 + \sum_{i=0}^{15} Z_i s_i + 60t \le M_{\max}$$

5.5.2 Model establishment

The demand for the three or four models and the analysis above, according to the time limit and cost, mathematical model as much as possible for the best route attractions:

$$\max\ n=\sum_{i=0}^{15}\sum_{j=0}^{15}\mathrm{r}_{ij}-1$$

The constraint conditions are:

$$s.t\begin{cases}\sum_{i=0}^{15}\sum_{j=0}^{15}r_{ij}\times t_{ij}+\frac{1}{2}\sum_{i=0}^{15}\sum_{j=0}^{15}r_{ij}\times(t_i+t_j)+\sum_{i=0}^{15}y_is_i\le T_{\max}\\ \sum_{i=0}^{15}\sum_{j=0}^{15}r_{ij}\times c_{ij}+930+\sum_{i=0}^{15}Z_is_i+60t\le M_{\max}\\ \sum_i r_{ij}=\sum_j r_{ij}\le 1\qquad (i,j=0,2,\cdots,15)\\ \sum_{i=0}r_{ij}=1\\ \sum_{j=0}r_{ij}=1\\ r_{ij}\times r_{ji}=0\qquad (i,j=1,2,\cdots,15)\\ y_i\le 8\\ t=[\frac{T}{24}]^{+}\qquad (\text{向上取整})\end{cases}$$

In this problem, due to cost and time is limited, so we combined taxi and bus two traffic tools, through the lingo programming to determine the optimal scheme:

The number of tourist attractions (N)	9	10	12	13
Time （hour）	69	50	90	120
Spend （yuan）	880	1120	1300	1700
Route	0→8→13→5→9→11→7→14→6→12→0	0→8→10→9→14→5→10→7→12→13→6→0	0→8→10→13→5→9→6→12→14→11→7→3→4→0	0→8→10→14→5→11→9→6→12→13→7→3→2→4→0

From the table we can see, the 4 days of travel time and travel expenses 1300 yuan limit passengers, recommend the tourist route：0→8→10→13（accommodation）→5→9→6→12（accommodation）→14→11→7（accommodation）→3→4→0，Combined with the actual development of the tourist itinerary is as follows：

Schedule	
The first day	8 in the morning by car to visit Xi'an city wall, after lunch take a tour to Bell Tower and Drum Tower, walk to the street to eat dinner snacks and afternoon. That night in the hotel near the.
The second day	8:00 the morning bus to the Shaanxi Museum of history, then go to the wild goose pagoda square fountain, afternoon to Tang Paradise, Datang sleepless city at night to play, after the local hotel accommodation.
The third day	By 8 o'clock in the morning to Qinglong temple, then travel to Qujiang cold kiln ruins park to play, the afternoon ride to Qujiang ocean hall, night tour of local scenery, live in the local hotel.
The fourth day	By 8 o'clock in the morning to the Banpo Museum, then went to the Mount Li scenic spot. Night bus ride back to the train station.

6 Analysis of model results

Demand（1）：The cost is not restricted, visiting fifteen spots, spending time at least demand.

Packages for：Xi’an Railway Station→Mausoleum of the First Qin Emperor→Huaqing Hot Spring→Mount Li scenic area (accommodation)→Banpo sites→Cui Huashan→Qujiang cold kiln ruins park (accommodation)→Qujiang aquarium→Tang Paradise→Datang sleepless city (accommodation)→the big wild goose pagoda square→Shaanxi Provincial Museum→Hui Street→Bell Tower and Drum Tower (accommodation)→Qinglong temple→Xi'an city wall→the XiAn Railway Station. Total travel time: 4 days 17 hours 30 minutes.

Demand（2）：At no time limit, visiting fifteen spots, spend the least cost requirement.

Packages for：Xi’an Railway Station→Xi'an city wall→Bell Tower and Drum Tower →Hui Street（accommodation）→Qinglong temple→Shaanxi Provincial Museum→the big wild goose pagoda square→Qujiang Aquarium (accommodation)→Qujiang cold kiln ruins park→Datang Furong garden→Datang sleepless city (accommodation)→Banpo site→ Mount Li scenic area→ the Huaqing Hot Spring→Mausoleum of the First Qin Emperor→ Terracotta Army (accommodation) →Cui Huashan→Xi’an Railway Station. Travel a total cost of 2080 yuan / person

Demand（3）：Aiming at the limited travel costs, as much as possible attractions demand.

For the cost of 400 yuan, package: 0 → 13 → 5 → 9 (accommodation) → 3 → 8 → 0, spot number is 5.

For the cost of 900 yuan, plans for：0→13→5→6（accommodation）→12→11 →9（accommodation）→10→3→8→0，Spot number is 9.

For other cost limit set, can refer to 5.3 model.

Demand（4）：Aiming at the limited travel time, as much as possible the attractions of demand。

Results: 2 days, 3 days, 4 days of passengers, the most were able to visit 8 tourist attractions, 12,14. With only 3 days of travel time as an example，

The plan is：0→8→10→13→5→7（accommodation）→14→6→9→11（accommodation）→12→3→4→0

Demand（5）：Aiming at the limited travel time and cost, as much as possible the attractions of demand.

For defining a 4 days 1300 yuan tourists, it can only travel 12 spots.

The plane is：0→8→10→13（accommodation）→5→9→6→12（住宿）→14→11→7（accommodation）→3→4→0，

Through the above calculation results, consistent with the actual, and therefore verify the correctness of this model. Based on the tourist route cost, time and number of tourist attractions, tourist route is based on the idea of Hamilton loop, the introduction of 0-1 variables are planning, an optimization model for five kinds of requirements, obtains five kinds of demand plan in line with the actual, to some extent to meet the needs of tourists. This also verify the effectiveness of our models and feasibility. Therefore, the model has certain reference significance to formulate the summer family travel scheme.

7 Model evaluation

(1)Advantages: This paper gives a reasonable hypothesis according to the tourists travel routes, simplifies the secondary factors, consider the travel expenses, three main effects of travel time and travel routes, the number of factors of tourist attractions. Modeling from five different demand. Clear thinking, an appropriate model, the scheme is relatively reasonable.

(2)Disadvantages: due to the model made many assumptions, such as traffic, weather and visitors to their own physical quality are assumed in the relatively simple conditions, which have some difference with real life. Model from three aspects of cost, time and scenic spots number on demand are discussed, in practice, because the occupation or different hobbies, different family on the attractions of the degree is different, therefore, this model can add weight to the attractions of the degree of expansion.

8 Reference

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9 Appendix

The main code：

sets:

jingdian/1..16/:c,t;

Where: 1,2,..., 16, Mausoleum of the First Qin Emperor, Terracotta Army, Huaqing Hot Spring said the Xi’an Railway Station, Banpo site, Mount Li scenic area, Shaanxi History Museum, Datang Furong garden, Qujiang aquarium, Xi'an city wall, the big wild goose pagoda square, Bell Tower and Drum Tower, Qujiang cold kiln ruins park, Datang sleepless city, Hui Jie, Qinglong temple and Cui Huashan 16 places

C, t were expressed in various scenic spots and tourist time consumption and stay;links(jingdian,jingdian):r,cc,tt;

!Where: R 0-1 variable (0 said the two spots is not connected, 1 said that the two spots are communicated); CC two spots between transportation costs; TT two spots between transit time;

endsets

data；

！The taxi schedule between the sixteen locations

tt＝

0	1.5	1.2	0.5	1.5	0.4	0.5	0.3	0.1	0.3	0.2	0.4	0.3	0.2	0.3	1.4
1.5	0	0.5	1	0.5	1.5	2	1.5	1.5	1.5	1.5	2	1.5	1.3	1.5	2.5
1.2	0.5	0	1	1.5	1.5	1.5	1.4	1.2	1	1	1.1	1.2	1	1	2.5
0.5	1	1	0	0.5	0.5	0.4	0.5	0.5	0.6	0.6	0.8	0.5	0.4	0.4	1.5
1.5	0.5	1.5	0.5	0	1.6	1.7	1.8	1.5	1.5	1.4	1.6	1.5	1.2	1.5	2.6
0.4	1.5	1.5	0.6	1.6	0	0.2	0.4	0.4	0.2	0.6	0.2	0.4	0.3	0.5	1.5
0.5	2	1.5	0.4	1.7	0.2	0	0.1	0.5	0.2	0.4	0.2	0.2	0.4	0.3	1.2
0.4	1.5	1.4	0.5	1.8	0.4	0.1	0	0.4	0.2	0.4	0.2	0.2	0.4	0.2	0.9

0.1	1.6	1	0.5	1.6	0.5	0.5	0.4	0	0.3	0.1	0.5	0.2	0.3	0.4	1.5
0.4	1.5	1	0.6	1.5	0.2	0.2	0.2	0.4	0	0.4	0.3	0.1	0.4	0.3	0.8
0.2	1.5	1	0.6	1.4	0.6	0.4	0.4	0.2	0.4	0	0.4	0.4	0.1	0.4	0.9
0.4	2	1.1	0.8	1.6	0.2	0.2	0.2	0.4	0.3	0.4	0	0.3	0.5	0.3	0.6
0.3	1.5	1.2	0.5	1.5	0.4	0.2	0.2	0.3	0.1	0.4	0.3	0	0.4	0.2	0.8
0.2	1.3	1	0.4	1.2	0.3	0.4	0.4	0.2	0.4	0.1	0.5	0.4	0	0.4	0.9
0.3	1.5	1	0.4	1.5	0.5	0.3	0.2	0.3	0.3	0.4	0.3	0.2	0.4	0	0.7
1.4	2.5	2.5	1.5	2.6	1.5	1.2	0.9	1.4	0.8	0.9	0.6	0.8	0.9	0.7	0

! Sixteen locations between the bus fee schedule

cc=

0	20	10	3	5	4	4	6	1	5	3	4	5	2	4	16
20	0	2	15	2	15	18	20	0	18	25	23	20	24	23	30
10	2	0	12	25	30	16	18	10	18	16	12	12	15	14	30
3	15	2	0	15	6	8	9	3	6	2	8	10	6	5	8
5	2	25	15	0	15	15	16	5	6	14	15	14	13	15	30
4	15	30	6	15	0	2	3	4	2	2	4	4	6	4	10
4	18	16	8	15	2	0	2	4	5	6	4	2	4	3	10
6	20	18	9	16	3	2	0	6	4	5	5	3	4	6	15
1	19	10	2	6	4	5	5	1	5	5	4	5	3	5	15
5	18	18	6	6	2	4	4	5	0	4	4	4	5	8	18
2	25	16	2	14	2	6	5	2	3	0	4	5	0	3	15
4	23	12	8	15	4	4	5	4	4	4	0	3	4	6	15
5	20	12	10	14	4	2	3	5	4	5	3	0	5	7	14
2	24	15	6	13	2	4	4	2	5	1	4	5	0	4	15
4	23	14	5	15	4	3	6	4	8	3	6	7	4	0	17
16	30	30	18	30	10	10	15	16	18	15	15	4	15	17	0

```
n=?;
!其中：n表示计划游玩的景点数目;
enddata
min=@sum(jingdian(j):@sum(jingdian(i):r(i,j)*(cc(i,j)+0.5*(c(i)+c(j)))));
min=@sum(jingdian(j):@sum(jingdian(i):100*w(j)*r(i,j)*(cc(i,j)+0.5*90*(c(i)+c(j)))));
min=@sum(jingdian(j):@sum(jingdian(i):r(i,j)*(cc(i,j)+0.5*(c(i)+c(j)))));
@for(jingdian(i):r(i,i)=0);
@for(jingdian(i)|i#ge#2:@for(jingdian(j)|j#ge#2:r(i,j)+r(j,i)<1))
```

```
;
    a=@sum(jingdian(j):@sum(jingdian(i):r(i,j)*(tt(i,j)+0.5*(t(i)+t(j)
))));
    @sum(jingdian(j):@sum(jingdian(i):r(i,j)*(tt(i,j)+0.5*(t(i)+t(j)))
))<120;
    @for(jingdian(i):@sum(jingdian(j):r(i,j))=@sum(jingdian(j):r(j,i))
);
    @for(jingdian(i)|i#eq#1:@sum(jingdian(j):r(i,j))=1);
    @for(jingdian(i)|i#ne#1:@sum(jingdian(j):r(i,j))<1);
    @for(links:@bin(r));
    @sum(jingdian(j):@sum(jingdian(i):r(i,j)))=n;
    @for(jingdian(i):@for(jingdian(j)|j#gt#1#and#j#ne#i:l(j)>=l(i)+r(
i,j)-(n-2)*(1-r(i,j))+(n-3)*r(j,i)));
    @for(jingdian(i)|i#gt#1:l(i)<n-1-(n-2)*r(1,i);l(i)>1+(n-2)*r(i,1))
;
    min=@sum(jingdian(j):@sum(jingdian(i):w(j)*r(i,j)*(cc(i,j)+0.95*c
(j)*(1-rrv(j)*(1-z)))))+@sum(jingdian(j):@sum(jingdian(i):w2(j)*r2(i,
j)*(cc(i,j)+0.95*c(j)*(1-rrv(j)*(1-z)))));!
    feiyong=@sum(jingdian(j):@sum(jingdian(i):r(i,j)*(cc(i,j)+0.95*c(
j)*(1-rrv(j)*(1-z)))));
    feiyong2=@sum(jingdian(j):@sum(jingdian(i):r2(i,j)*(cc(i,j)+0.95*
c(j)*(1-rrv(j)*(1-z)))));
    @sum(jingdian(j):@sum(jingdian(i):w(j)*r(i,j)*(cc(i,j)+0.95*c(j)*
(1-rrv(j)*(1-z)))))+@sum(jingdian(j):@sum(jingdian(i):w2(j)*r2(i,j)*(
cc(i,j)+0.95*c(j)*(1-rrv(j)*(1-z)))))>1493;
    @for(jingdian(i):r(i,i)=0);@for(jingdian(i):r2(i,i)=0);
    @for(jingdian(i)|i#ge#2:@for(jingdian(j)|j#ge#2:r(i,j)+r(j,i)<1))
;
    @for(jingdian(i)|i#ge#2:@for(jingdian(j)|j#ge#2:r2(i,j)+r2(j,i)<1)
);
    @sum(jingdian(j):@sum(jingdian(i):r(i,j)*(tt(i,j)+t(j))))<120;
    @sum(jingdian(j):@sum(jingdian(i):r2(i,j)*(tt(i,j)+t(j))))<120;
    @for(jingdian(i):@sum(jingdian(j):r(i,j))=@sum(jingdian(j):r(j,i))
);
    @for(jingdian(i):@sum(jingdian(j):r2(i,j))=@sum(jingdian(j):r2(j,
i));
    @for(jingdian(i)|i#eq#1:@sum(jingdian(j):r(i,j))=1);
    @for(jingdian(i)|i#eq#1:@sum(jingdian(j):r2(i,j))=1);
    @for(jingdian(i)|i#ne#1:@sum(jingdian(j):r(i,j))<1);
    @for(jingdian(i)|i#ne#1:@sum(jingdian(j):r2(i,j))<1);
    @for(links:@bin(r));
    @for(links:@bin(r2));
    @for(jingdian:@bin(rrv));
    @for(links:@bin(rrr));
```

```
@sum(jingdian(j):@sum(jingdian(i):r(i,j)))=n;
@sum(jingdian(j):@sum(jingdian(i):r2(i,j)))=n2;
!@sum(jingdian(j):@sum(jingdian(i):r(i,j)))>n-0.5;
!@sum(jingdian(j):@sum(jingdian(i):r(i,j)))<n+0.5;
!@sum(jingdian(j):@sum(jingdian(i):r2(i,j)))<n2+0.5;
!@sum(jingdian(j):@sum(jingdian(i):r2(i,j)))>n2-0.5;
@for(jingdian(i):@for(jingdian(j)|j#gt#1#and#j#ne#i:l(j)>=l(i)+r(
i,j)-(n-2)*(1-r(i,j))+(n-3)*r(j,i)));
@for(jingdian(i):@for(jingdian(j)|j#gt#1#and#j#ne#i:l2(j)>=l2(i)+
r2(i,j)-(n2-2)*(1-r2(i,j))+(n2-3)*r2(j,i)));
@for(jingdian(i)|i#gt#1:l(i)<n-1-(n-2)*r(1,i);l(i)>1+(n-2)*r(i,1))
;
@for(jingdian(i)|i#gt#1:l2(i)<n2-1-(n2-2)*r2(1,i);l2(i)>1+(n2-2)*
r2(i,1));
@for(jingdian(i)|1#eq#i:v(i)=1;b(i)=0);
!@for(jingdian(k)|1#lt#k#and#k#le#n:@for(jingdian(i):@for(jingdia
n(j):x(k,i,j)=@if(r(i,j)#eq#1#and#v(k-1)#eq#i,j,0)));!v(k)=@sum(jingd
ian(j):@sum(jingdian(i):x(k,i,j))));
@for(jingdian(k)|1#lt#k#and#k#le#n:@for(jingdian(i):@for(jingdian
(j):x(k,i,j)=@if(0.5#le#r(i,j)#and#r(i,j)#le#1.5#and#(i-0.5)#le#v(k-1)
#and#v(k-1)#le#(i+0.5),j,0)));v(k)=@sum(jingdian(j):@sum(jingdian(i):
x(k,i,j))));
@for(jingdian(i)|1#eq#i:v2(i)=1;b2(i)=0);
!@for(jingdian(k)|1#lt#k#and#k#le#n2:@for(jingdian(i):@for(jingdi
an(j):x2(k,i,j)=@if(r(i,j)#eq#1#and#v2(k-1)#eq#i,j,0)));!v2(k)=@sum(j
ingdian(j):@sum(jingdian(i):x2(k,i,j))));
@for(jingdian(k)|1#lt#k#and#k#le#n2:@for(jingdian(i):@for(jingdia
n(j):x2(k,i,j)=@if(0.5#le#r2(i,j)#and#r2(i,j)#le#1.5#and#(i-0.5)#le#v
2(k-1)#and#v2(k-1)#le#(i+0.5),j,0)));v2(k)=@sum(jingdian(j):@sum(jing
dian(i):x2(k,i,j))));
@for(jingdian(i)|2#le#i#and#i#le#(n):@for(jingdian(k):@for(jingdi
an(j):bb(k,i,j)=@if(v(i)#eq#j#and#v(i-1)#eq#k,t(k)+tt(k,j),0)));b(i)=
@sum(jingdian(j):@sum(jingdian(k):bb(k,i,j))));
@for(jingdian(k)|k#le#n:tv(k)=@sum(jingdian(i)|i#le#(k):b(i))/12)
;
@for(jingdian(i)|2#le#i#and#i#le#(n2):@for(jingdian(k):@for(jingd
ian(j):bb2(k,i,j)=@if(v2(i)#eq#j#and#v2(i-1)#eq#k,t(k)+tt(k,j),0)));b
2(i)=@sum(jingdian(j):@sum(jingdian(k):bb2(k,i,j))));
@for(jingdian(k)|k#ne#1#and#k#le#n2:tv2(k)=@sum(jingdian(i)|i#le#
(k):b2(i))/12+4);
@for(jingdian(k)|k#eq#1#or#k#gt#n2:tv2(k)=0);
@for(jingdian(k)|k#le#n2:@for(jingdian(j)|j#le#n:rrr(j,k)=@if(v(j)
#eq#v2(k)#and#(tv2(k)-tv(j))#lt#1#and#(tv(j)-tv2(k))#lt#1,1,0)));
@for(links(j,k)|(j#gt#n#and#k#le#n2)#or#(j#le#n#and#k#gt#n)#or#(j
```

```
#gt#n#and#k#gt#n):rrr(j,k)=0);
    @for(jingdian(j)|j#ge#2#and#j#le#n2:rrv(j)=@sum(jingdian(k):rrr(j,
k)));
    @for(jingdian(k)|k#eq#1#or#k#gt#n2:rrv(k)=0);
    End
```