Optimization Research on School Bus Resource Allocation Problem and Empty Return Problem

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Abstract: In recent years, many universities across the country have expanded rapidly and established many new campuses. The use of school bus transportation between campuses has become a major trend. The aim of this paper is to optimize the space-time allocation scheme of school buses by establishing a mathematical model to reduce the number of empty returns of school buses between campuses, thus reducing the waste of administrative resources of universities and ensuring the normal development of teaching work. This paper uses a 0 and 1 assignment model, i.e. buses that have never been sent out are assigned a value of 0; buses that are sent to and temporarily stay at the old campus are assigned a value of 1, and buses that are sent to and temporarily stay at the new campus are assigned a value of -1. Using the enumeration iteration method, a specific one-latitude time axis is established, i.e. the first time point is assigned a value of 0, and so on, each time point is i (the value of i is 0-20). By constantly changing the initial setting value and optimizing the basic algorithm, the data is analyzed to obtain the minimum number of empty return vehicles under different conditions and the allocation ratio of school buses between the old and new campuses, thus greatly improving the efficiency of school bus transportation between different campuses. Using the 0 1 allocation model established in this paper, the probability of empty school bus returns can be effectively reduced, which is of practical significance to major universities with multiple campuses.

1. Introduction

A school has staff who travel by bus from the old campus to the new campus every day to work and most will return after work. The Logistics Group arranges for vehicles to run between the old and new campuses on a daily basis.[1] However, at certain times of the day, the number of staff traveling from the old campus to the new campus is uneven, for example, in the morning it is mainly staff from the old campus who travel to the new campus, and at lunchtime and in the afternoon, it is mainly staff returning from the old campus to the new campus. [1] Due to the limited number of vehicles, it is sometimes necessary to send empty vehicles back from another campus (called empty returns) in order to meet the demand for vehicles at the current campus. It is a matter of great concern to the Logistics Group to keep the number of empty vehicles to a minimum.

The school shuttle bus runs on the following schedule.

I. Monday to Friday

1. Old Campus to New Campus

7:00, 8:00, 9:20, 10:00, 11:00, 12:00, 12:50, 14:00, 14:50, 16:00, 17:00, 17:50, 21:00, 22:30.

2. New Campus to Old Campus

9:00, 10:30, 11:00, 12:30, 4:00, 15:00, 16:00, 17:10, 18:00, 19:00, 21:00, 22:30

II. Saturday and Sunday

1. Old Campus to New Campus

8:00, 9:20, 12:50, 14:00, 18:00, 20:00.

2. New Campus to Old Campus

9:00, 11:00, 12:30, 17:00, 18:00, 21:00.

The vehicle running time at both campuses is approximately one hour. For simplicity, it is assumed that each vehicle takes one hour to travel from one campus to the other. Due to the imbalance in demand for vehicles at different times between the two campuses, when the number of vehicles required at one campus is high and the available vehicles cannot meet the demand, it is necessary to dispatch empty vehicles back from the other campus.[2] Empty buses can depart at a certain point in the existing schedule or one hour earlier if required.

The school has a total of 20 vehicles, each with a capacity of 47 passengers. This paper solves the following four problems by developing a specific mathematical model.

Question 1: If the number of vehicles needed to travel from the old campus to the new campus on a given day (Monday to Friday) is 7,6,4,3,1,1,4,3,1,2,1,2,1,1 (corresponding to the number of vehicles needed for 14 departure times). The number of vehicles required from the new campus to the old campus is 2,3,2,6, 2,1,7,6, 4,2,1,1, and if so, how can the vehicles be arranged so that there are no empty vehicles? What if the number of vehicles needed from the old campus to the new campus is 9,8,4,3,1,1,4,3,1,2,1,2,1,1 and the number of vehicles needed from the new campus to the old campus is 3,4,2,6, 2,1,7,8, 4,2,1,1? (Ask for the initial number of vehicles on both campuses, the number of vehicles on both campuses after they stop running for the day, and the total number of empty returns).

Question 2: If the continuous daily operation is maintained, the number of vehicles required for each shift at the old campus remains 9,8,4,3,1,1,4,3,1,2,1,2,1,1 per day; the number of vehicles required for each shift at the new campus remains 3,4,2,6, 2,1,7,8, 4,2,1,1, and how can this be arranged to minimize the total number of empty returns for the week (Monday to Friday)?

Give the initial number of vehicles on both campuses on Monday, the number of vehicles on both campuses after they stop running on Friday, and the total number of empty returns.[3,4]

Question 3: If the number of vehicles required for each shift on Saturday is 5,4,6,4,3,2 for the old campus and 3,5,7,6,2,1 for the new campus, and the number of vehicles required for each shift on Sunday is 5,4,4,6,3,7 for the old campus and 2,6,5,3,3,1 for the new campus, how can this be arranged to minimize the number of empty returns considering that there are 7 days between Monday and Sunday?

Give the number of vehicles on both campuses at the beginning of Monday, the number of vehicles on both campuses after Sunday stops running, and the total number of empty vehicles.[5]

Question 4: In practical vehicle scheduling, it is desirable to have a continuous weekly run. If the number of vehicles on both campuses after the Sunday stop is the same as the initial number of vehicles on both campuses on Monday, given the requirements of question 3, how can the minimum number of empty vehicles be arranged? (The total number of empty returns should be given as either the initial number of vehicles on the two campuses on Monday or the number of vehicles on the two campuses after the Sunday stoppage).

This paper establishes a 0-1 integer programming model and an exhaustive iterative model for the problem of the empty return of college school buses and then transforms them into timeline assignment solutions, which is scientific.[5] However, because some practical problems deviate from the idealized assumptions made, the obtained results will have some deviations from the actual problems, which need to be compared with the actual problems and need to be further modified, such as the genetic algorithm and its improved algorithm for further research with approximation.[6]

2. Basic Assumptions

1. Assuming that the traffic conditions between the two campuses are ideal, the time it takes for a school bus to travel between the old and new campuses is always one hour.[7]

2. Assume that the time taken by teachers and students to get on and off the bus on the two campuses is zero.

3. Assuming that the school bus can ignore the weather conditions, it must be able to leave on time according to the school bus timetable.

4. Assuming that the number of school buses in a certain campus is insufficient at a certain time, the empty-returning vehicles of another campus must depart at the nearest time node one hour or more before the time.

5. It is assumed that the number of empty-return vehicles takes the minimum value of the required number of empty-return vehicles this time.

6. Assuming that both campuses require empty return vehicles at the same time will not occur.

7. The basic symbols are shown in Table 1.

Table 1: Meaning of the different symbols.

Symbol	Symbol Description
Mi	It is the sum of the number of vehicles arriving at the i-th time point in the old campus and the number of empty-return vehicles at this time (the number of empty-return vehicles at this time is the number of flight attendant vehicles that Xi found for the new campus before)
Ni	It is the sum of the number of vehicles arriving at the new campus at the i-th time point and the number of empty-return vehicles at this time (the number of empty-return vehicles at this time is the number of empty-return vehicles that Yi found for the new campus before)
Xi	is the number of vehicles in the old school at the i-th time point
Yi	number of vehicles in the new campus at the ith time point
Ai	It is the sum of the number of vehicles issued by the old school at the i-th time and the number of empty return vehicles at this time (the number of empty return vehicles at this time is the number of flight attendant vehicles adjusted by the old school when Yi is not enough)
Bi	It is the sum of the number of vehicles issued by the new campus at the i-th time and the number of empty-return vehicles at this time (the number of empty-return vehicles at this time is the number of empty-return vehicles adjusted by the new campus when Xi is not enough)
Ci	The number of empty return vehicles arriving at time i
Di	Number of empty return cars leaving at time i
Pi	The number of vehicles arriving at time i
Qi	The number of cars leaving the car at time i
T	Total number of empty return vehicles
i	time number

3. Problem Analysis

3.1. Problem 1 Analysis

In question 1, there are two main problems waiting for us to solve. One is the initial allocation of school buses between the two campuses, and the other is the problem of finding the number of empty return vehicles. In this question, the timeline is limited to a single day from Monday to Friday. [7] We can directly list the dynamic changes of vehicles between the two campuses or set 0, 1, and -1 variables, use the improved 0.1 model to express the state of the school bus, and then obtain the number of empty return vehicles. and the allocation of vehicles.

Considering that there may be a departure time point between the departure time and the arrival time, we can modify the state number of the school bus in the state of 1 or -1 to make it different from ±1 (eg: ±2 or ±3), when the time axis Going to the next point, these abnormal state numbers can be checked and transformed to approach 1 or -1. [8] The positive or negative of the abnormal number is determined by the state number at the time of arrival, and the absolute value is determined by the number of time points between the departure point and the arrival time (or the time after the arrival time and the closest time to the arrival time).

For the optimal allocation scheme, 21 allocation schemes can be enumerated to obtain the scheme with the smallest number of flight attendants, and then the optimal solution can be obtained.

3.2. Problem 2 Analysis

Question 2 further expands the time axis on the basis of question 1, using the data of the second question in question 1, for a total of five days.[8] On the basis of the first question, we need to additionally consider the impact of the number of school buses owned by the two campuses on the scheduling of the next day after the school bus completes the one-day flow. After an actual operation, we found that when using the second set of conditions of the first question, no matter how the initial allocation scheme changes,[9] the final state of school bus allocation in the old and new campuses is always the same. The final number of empty return vehicles has a linear relationship with the number of vehicles initially allocated by the old campus. Using these two special conditions, we can use enumeration to find the optimal allocation.

3.3. Problem 3 Analysis

The idea of this question is similar to that of Question 2, the main difference is the departure time of the school bus and the limited range of the time axis. According to the analysis in Question 2, the number of school buses on the old and new campuses is fixed on Friday night, and the minimum number of empty return vehicles from Monday to Friday has been obtained in the previous question. Therefore, we only need to limit the time axis to two days on Saturday, Sunday, and two days. According to the method of the previous question, we can obtain the initial allocation plan of the minimum number of empty return vehicles and the corresponding number of empty return vehicles, and then obtain the allocation plan between the two campuses on Friday evening. When the distribution of school buses is changed, the number of empty school buses that must be mobilized for the situation in this scheme,[9] and the two are added to the minimum number of empty return vehicles from Monday to Friday to obtain the minimum number of empty return vehicles for a week.

3.4. Problem 4 Analysis

From question 2, the distribution status of school buses on the two campuses is fixed on Friday night, and the final school bus distribution on Sunday is the same as the school bus distribution on Monday. Therefore, we can add the following four parts: [9] First, the minimum number of empty return vehicles on weekdays (obtained); the second is the number of empty return vehicles required to adjust the state from the end of Friday to the state of early Saturday and early Saturday; the third is the number of empty return vehicles on Saturday and Sunday; [9,10] the fourth is the empty return used to adjust the state from the end of Sunday evening to the state of early Monday number of vehicles. In fact, we can enumerate the sum of the last three parts to find the optimal solution, and then add it to the first part to find the solution required in the question.

4. Model Establishment and Solution

4.1. Problem 1 Establishment and Solution of the model

In order to simulate the dynamic change of the number of school buses on the time axis, we first set up a time axis, marked all the departure times of the old and new campuses on the time axis, and marked the new and old campuses at these times in turn when the new and old schools should depart, as shown in the Figure 1 below:

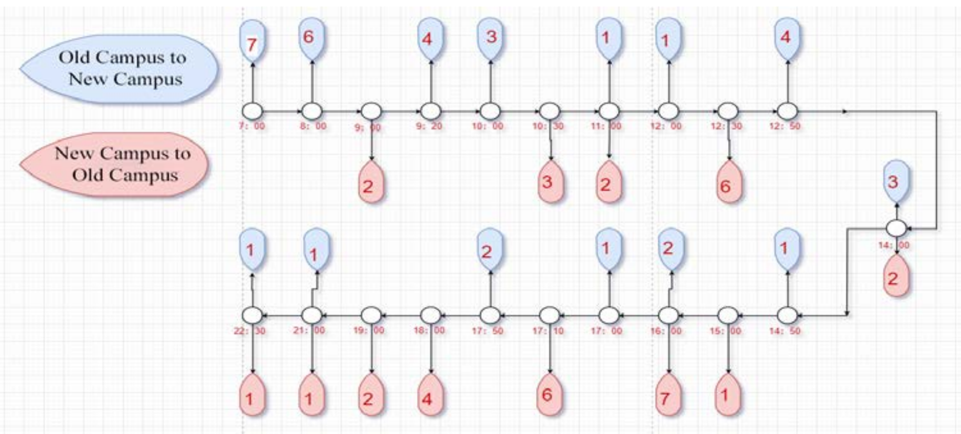

Figure 1: Number of departures at different times for the old and new campuses.

We can assign values to each school bus. For a school bus that has never been dispatched, it is assigned a value of 0; a school bus dispatched to and temporarily staying at the old campus is assigned a value of 1, and a school bus dispatched to and temporarily staying at the new campus is assigned a value of -1. Assume that the initial allocation of school buses in the old and new campuses is unknown, and assign 0 to all twenty school buses. For the new and old campuses at a certain time, if the number of -1 or 1 is greater than the departure demand of the new campus and the old campus, then subtract the demand from -1 or 1; if it is not enough, assign a value of 0 from the Pick up the corresponding number of school buses from the school bus to complete the difference, assign them as -1 or 1, and then reset the number of -1 or 1 to zero.

Changing 1 and -1 does not immediately become -1 and 1 is added to the next time point. In fact, since it takes an hour for a school bus to arrive at another campus, the next moment on the timeline is not necessarily the moment when the school bus arrives. [10] We can take the time on the time axis that is closest to the departure time after the departure time, more than or equal to one hour away from the departure time, as the settlement point. Obviously, the settlement points corresponding to each departure time are corresponding. If there are x points between the departure time and the settlement time, the state value may be multiplied by -(i+1).

Every time a moment passes, check all the state quantities that are not ±1 and subtract one if it is positive, and add one if it is negative. In this way, when the settlement time is reached, the state quantities of these "issued" school buses will become the inverse numbers of the previous "issued" state quantities.

In fact, the process of "borrowing 0" between the old campus and the new campus is the process of allocating the initial number of school buses between the two campuses.[10] By counting the flow of school buses assigned a value of 0, we can obtain the initial number of school buses allocated to each of the two campuses.

Under this set of data, the number of vehicles in the old and new campuses at each departure time is shown in Table 2.

Table 2: Number of vehicles per moment corresponding to the old and new campuses.

Timing	Timetable	Number of unallocated vehicles	Number of vehicles on the old campus	Number of vehicles on the new campus
0	7:00	13	0	0
1	8:00	7	0	7
2	9:00	7	0	11
3	9:20	3	0	11
4	10:00	2	3	11
5	10:30	2	0	12
6	11:00	1	0	14
7	12:00	1	4	14
8	12:30	1	4	8
9	12:50	1	0	8
10	14:00	1	3	11
11	14:50	1	2	11
12	15:00	1	4	13
13	16:00	1	3	7
14	17:00	1	9	9
15	17:10	1	9	3
16	17:50	1	2	3
17	18:00	1	7	0
18	19:00	1	17	0
19	21:00	0	18	0
20	22:30	0	18	0

The vehicles dispatched at a certain time in this table are not subtracted immediately at that time but will be subtracted at a certain time period after this time.

Since there is one school bus on the way to the old and new campuses at this time, we can finally conclude that there are 19 cars on the old campus and 1 car on the new campus. The unallocated number is exactly zero, that is, 20 cars are exactly allocated.[11] Therefore, according to the first group of departure plans, there is no empty return.

However, the case of the first group of departure scenarios is special. Since there were no empty-return vehicles, the departure went exactly as planned, which is not universal. When we tried to use this method to calculate the second departure scheme in this paper, empty returning vehicles appeared.[11] Therefore, we need to establish a more complete mathematical model to solve the problem more universally.

Using the same method, we establish a one-dimensional time coordinate system as shown in Figure 2.

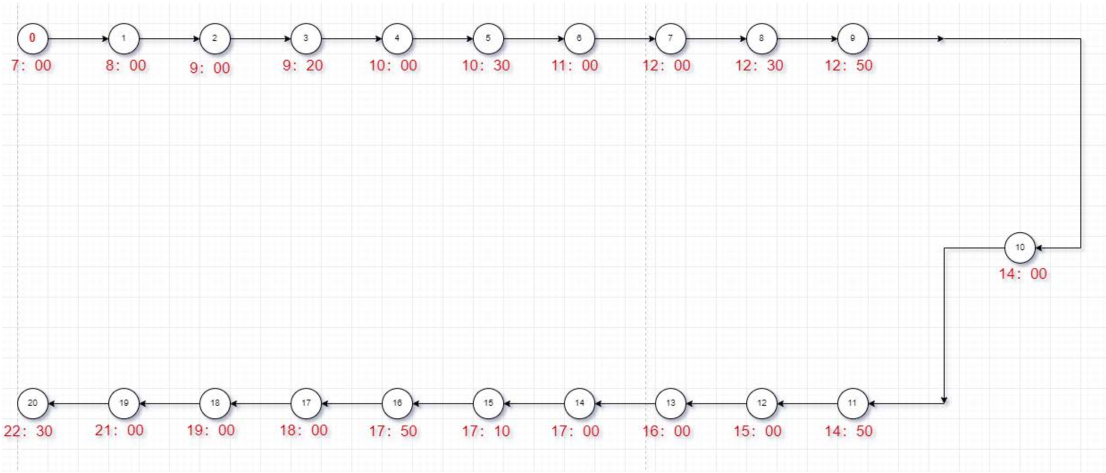

Figure 2: Schematic diagram of the 1D time axis.

According to the order of time, we record the first time point as code 0, and so on as 0~20. i is 1~20.

Definition:

" X_i " is the number of vehicles in the old campus at the i-th time point;

" Y_i " is the number of vehicles in the new campus at the ith time point ;

" M_i " is the sum of the number of vehicles arriving at the i-th time point in the old campus and the number of empty-return vehicles at this time (the number of empty-return vehicles at this time is the number of empty-return vehicles that Xi found for the new campus before);

" N_i " is the sum of the number of vehicles arriving at the new campus at the i-th time point and the number of empty-return vehicles at this time (the number of empty-return vehicles at this time is the number of empty-return vehicles that Yi had previously adjusted to the new campus);

" A_i " is the sum of the number of vehicles sent out by the old school at the i-th time and the number of empty-return vehicles at this time (the number of empty-return vehicles at this time is the number of empty-return vehicles adjusted by the old school when Yi is not enough later);

" B_i " is the sum of the number of vehicles issued by the new campus at the i-th time and the number of empty-return vehicles at this time (the number of empty-return vehicles at this time is the number of empty-return vehicles adjusted by the new campus when Xi is not enough);

The main formula is equation (1) and (2):

$$X\mathbf{i} = X\mathbf{i} - 1 + M\mathbf{i} + Ai - Bi - Ni \quad (1)$$

$$Yi = Yi - 1 + Mi + Ai - Bi - Ni \quad (2)$$

Idea: Do not allocate 20 school buses first (similar to the first method, in a free state), and add the situation that the old school and the new school do not need enough vehicles when they depart, and the school buses in the free state can be directly classified as the school bus of this school. For school buses, if there are not enough school buses in the free state, first divide the school buses in the free state, and then shun the buses in advance at the opposite campus.

The program implementation is shown in the code of the first question in the appendix.

1. For the departure from the old campus to the new campus, it is 7,6,4,3,1,1,4,3,1,2,1,2,1,1;

The departure time from the new campus to the old campus is 2, 3, 2, 6, 2, 1, 7, 6, 4, 2, 1.

The number of empty return vehicles is 0;

The initial distribution of vehicles between the old campus and the new campus is 19:1;

The data for each node is consistent with Figure 2. (After inspection, the results obtained by the program are consistent with this result.) [Prove that the program is correct]

2. For the departure from the old campus to the new campus, it is 7,6,4,3,1,1,4,3,1,2,1,2,1,1;

The departure time from the new campus to the old campus is 2, 3, 2, 6, 2, 1, 7, 6, 4, 2, 1.

The number of empty return vehicles is 5;

The initial distribution of vehicles between the old campus and the new campus is 20:0;

4.2. Establishment and Solution of the Second Problem Model

$$X\mathrm{i} = Xi - 1 + Pi + Ci - Di - Qi \tag{3}$$

$$Yi = Yi - 1 + Pi + Ci - Di - Qi \tag{4}$$

$$T = \sum_{i=0}^{20} Ci \tag{5}$$

$$T = \sum_{i=0}^{20} Di \tag{6}$$

We obtained the number of empty return vehicles per day for each allocation situation by changing the vehicle allocation situation of the old campus and the new campus (because the old campus sent 9 school buses for the first time, so the old campus cannot be less than 9), as shown in the following Table 3.

Table 3: Number of empty returns during the week with different initial vehicle ratios for the old and new campuses.

During the week		
Ratio of initial number of vehicles on old campus to new campus	spare	Ratio of the number of vehicles on the night at the old campus to the new campus
9:11	16	19:01
10:10	15	19:01
11:09	14	19:01
12:08	13	19:01
13:07	12	19:01
14:06	11	19:01
15:05	10	19:01
16:04	9	19:01
17:03	8	19:01
18:02	7	19:01
19:01	6	19:01
20:00	5	19:01

Analysis: Regardless of the distribution of vehicles in the old campus and the new campus, the ratio of the number of vehicles in the old campus and the new campus that night is a fixed value of 19:1. Therefore, if the minimum number of empty return vehicles is required from Monday to Friday, the initial allocation on Monday is 20:0.[11] At the beginning of Tuesday at 19:1, the number of empty-return vehicles is 6; at 20:0 on Tuesday, the number of empty-return vehicles is the sum of the number of empty-return vehicles adjusted from Monday to Tuesday and the number of empty-return vehicles on Tuesday, which is still 6; However, when the number of vehicles in the old campus is less than 19 on Tuesday, the number of empty-return vehicles in the two days increases with the decrease in the number of vehicles in the old campus, and the number of empty-return vehicles on Tuesday increases with the decrease in the number of vehicles in the old campus, so the total number of empty-return vehicles increases. The number of vehicles will increase, so it does not meet the meaning of the title.

Same thing from Wednesday to Friday.

Therefore, the minimum number of empty return vehicles is calculated as 5+6+6+6+6=29

The initial school bus allocation between the old campus and the new campus on Monday is 20:0

After the shutdown on Friday, the distribution of school buses between the old campus and the new campus is 19:1

The arrangement of a school bus: The initial allocation between the old campus and the new campus is 20:0 on Monday, and the initial allocation between the old campus and the new campus is 19:1 or 20:0 from Tuesday to Friday.

4.3. Establishment and Solution of the Third Problem Model

For the third question, by observing the question, the preliminary judgment is to use the same method and code as the first and second questions,[12] but to establish two new time axes by changing (see Figure 3), and in the new time axis is assigned a new number of new departures corresponding to a new time (see Figure 3), we still use core formulas (3), (4), (5), (6).

To implement this problem, we changed the brand, and new timeline to the problem one code (see the third question code in the appendix), and by running the program we found that the total number of school buses in the old and new campuses on Saturday and Sunday night was 15 instead of 20, by checking the code and analyzing the number of final 0-state buses, we found that the final number of 0-state school buses on Saturday and Sunday (see zeros in the appendix) is not 0, so here we borrow 0-state school buses as an intermediate quantity. Obviously, It is inappropriate, we can directly assign the initial values of 1 and -1 to 20 school buses (see appendix old and new) to find the case with the smallest number of empty return vehicles, but due to Saturday and Sunday at 8:00 am and At nine o'clock, 5 cars from the old campus will be sent to the new campus, so we assign the range of 5 to 15 cars in the morning of the old campus, and then substitute the initial value into the code of the second question above (see the code of the second question in the appendix),[13] you can obtain the number of empty return vehicles on Saturday and Sunday and the final school bus allocation in the old and new campuses that night, and then get (Table 5).

After that, we only need to find the minimum number of empty return vehicles from Monday to Friday and the initial distribution value on Monday morning.[13] Here we can directly refer to the answer to the second question before, and it is not difficult to find from the previous calculation results that from Monday to week 5 Regardless of the vehicle ratio of the new and old campuses at the beginning of Monday morning, the old campuses are: new campuses = 9:11, 10:10 and each group number until 20 : 0, the final old campus on Monday night The number of vehicles: New campus = 19 :1 is constant because there will be no additional shunting from Monday to Thursday night. If the shunting is carried out from Monday to Thursday night, the final total empty return vehicles will be greater than or equal to Monday. If the vehicle is not dispatched on Thursday (see question 2 for the specific reason), the number of empty-return vehicles in the four days from Tuesday to Friday is 6, which is a fixed value. Therefore, the minimum number of empty-return vehicles on Monday is Monday morning. The number of vehicles in the old campus: when the new campus = 20 :0, the number of vehicles returning to the sky is the smallest, which is 5 vehicles. The number of vehicles in the old campus: the new campus = 19 :1 is substituted into the starting ratio on Saturday morning, and the number of empty return vehicles on Saturday is 5, and the number of vehicles in the old campus on Saturday night: 14:6 for the new school bus (see Table 4), and then substitute this 14:6 into Sunday's table, the number of empty return vehicles on Sunday is 0, and the final number of vehicles in the old campus on Sunday night: new campus = 5:15. (See Table 5).[14] The total number of empty return vehicles is at least 5 + 6 * 4 + 5 = 34 vehicles.

The final answer to question 3 is: At the beginning of Monday, there are 20 school buses on the old campus and 0 school buses on the new campus. After the shutdown on Sunday, the old campus will be 5 vehicles and the new campus will be 15 vehicles. The total number of empty return vehicles in one week was 34. Vehicle arrangement: Initially on Monday, there will be 20 school buses on the old campus and 0 on the new campus. The initial vehicle allocation for the new and old campuses on Saturday is 14:6 or 15:5 or 16:4 or 17:3 or 18:2 or 19:1.

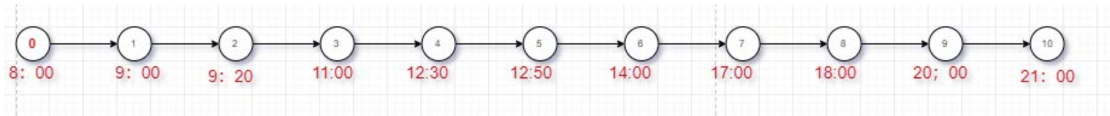

Figure 3: Diagram of the timeline corresponding to a specific time period.

Table 4: Number of empty returns for different initial vehicle ratios on the old and new campuses on Saturday.

Saturday		
Ratio of initial number of vehicles on old campus to new campus	spare	Ratio of the number of vehicles on the night at the old campus to the new campus
5:15	4	9:11
6:14	3	9:11
7:13	2	9:11
8:12	1	9:11
9:11	0	9:11
10:10	0	10:10
11:09	0	11:09
12:08	0	12:08
13:07	0	13:07
14:06	0	14:06
15:05	1	14:06
16:04	2	14:06
17:03	3	14:06
18:02	4	14:06
19:01	5	14:06
20:00	6	14:06

Table 5: Number of empty returns on Sunday for different initial vehicle ratios on the old and new campuses.

Sunday		
Ratio of initial number of vehicles on old campus to new campus	spare	Ratio of the number of vehicles on the night at the old campus to the new campus
5:15	5	1:19
6:14	4	1:19
7:13	3	1:19
8:12	2	1:19
9:11	1	1:19
10:10	0	1:19
11:09	0	2:18
12:08	0	3:17
13:07	0	4:16
14:06	0	5:15
15:05	0	6:14
16:04	0	7:13
17:03	1	7:13
18:02	2	7:13
19:01	3	7:13
20:00	4	7:13

4.4. Establishment and Solution of the Fourth Problem Model

According to Table 3, from Monday to Friday, no matter how school buses are allocated between the old campus and the new campus (the eligible allocation, that is, the number of school buses in the old campus is at least 9, and the maximum number is 20), the final distribution of school buses in the old campus and the new campus for 19 and 1. Pushed, the old school and new school bus allocations will be 19 and 1 on Friday night.

Given the question, it is required to obtain the minimum number of empty return vehicles within a week, so it is the same as in question 2, that is, the number of empty return vehicles from Tuesday to Friday is a certain value of 24. That is the value of E is in Table 6.

Because the vehicle condition is a certain value on Friday night, we set Saturday morning as the starting time. The distribution of vehicles may not be the same from Friday night to Saturday morning, so the number of empty return vehicles is required in this process, which is recorded as A. The number of empty return vehicles on Saturday is recorded as B. According to the third question, the number of empty return vehicles is the smallest on Saturday and Sunday.[14] The distribution of school buses on Saturday night is the same as that on Sunday morning, so there are no empty return vehicles from Saturday to Sunday. The number of empty return vehicles on Sunday is recorded as C. From Tables 3, 4, and 5, the sum of the number of empty return vehicles from Sunday to Monday and the number of empty return vehicles on Monday is a certain value, denoted as D, and the distribution of vehicles from the mid-term to the end of Sunday can be the same as any situation on Monday. The same, and does not affect the number of empty return vehicles.[14]

To sum up, when the number of vehicles in the two campuses after the operation is stopped on Sunday is the same as the initial number of vehicles in the two campuses on Monday, the number of empty return vehicles in a week is A+B+C+D+E, denoted as F, and the data is brought into the table 6 as follows:

Table 6: Number of empty return vehicles per day of the week.

Vehicle ratios from Saturday	A	B	C	D	E	F
20:00	1	6	0	20	24	51
19:01	0	5	0	20	24	49
18:02	1	4	0	20	24	49
17:03	2	3	0	20	24	49
16:04	3	2	0	20	24	49
15:05	4	1	0	20	24	49
14:06	5	0	0	20	24	49
13:07	6	0	0	21	24	51
12:08	7	0	0	22	24	53
11:09	8	0	0	23	24	55
10:10	9	0	0	24	24	57
9:11	10	0	1	24	24	59
8:12	11	1	1	24	24	61
7:13	12	2	1	24	24	63
6:14	13	3	1	24	24	65
5:15	14	4	1	24	24	67

Note: Starting on Friday night (the ratio is always 19:1 on Friday night), A, the number of empty returns needed on Saturday morning; B, the number of empty returns on Saturday; C, the number of empty returns on Sunday; D, the number of empty returns needed on Monday morning + the number of empty returns on Monday; E, the number of empty returns on Tuesday to Thursday; F, the number of empty returns needed for the week

Analyze the graph:

When the vehicle ratio starts on Saturday at 19:1; 18:2; 17:3; 16:4; 15:5; 14:6, the number of empty return vehicles F can achieve a minimum value of 49, and because of the vehicle distribution at the end of Sunday, the situation can be the same as the arbitrary distribution situation at the beginning of Monday, so the initial vehicle distribution situation on Monday can be obtained, that is, the following figure.

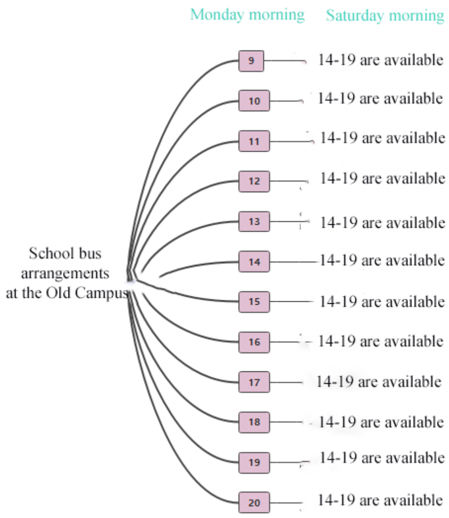

Figure 4: Monday's initial vehicle allocation.

That is, the initial distribution of vehicles on the old campus and the new campus on Monday is as follows:

9:11;
10:10;
11:9;
12:8;
13:7;
14:6;
15:5;
16:4;
17:3;
18:2;
19:1;
20:0; hour,

Both can set the number of empty return vehicles to a minimum of 49. How the specific vehicles are distributed is shown in figure 4.

5. Model Promotion and Evaluation

5.1. Advantages

(1) The model has strong operability, data can be replaced many times, and the framework of the program is more flexible.

(2) The model is thoughtful, and the handling of the empty return situation is more rigorous.

(3) The model cleverly uses the program to simulate the timeline, which greatly improves the fidelity of the model.

5.2. Disadvantages

(1) The enumeration algorithm is used, which is slow when running large amounts of data.

(2) Extreme conditions such as bad weather and traffic jams are not considered.

(3) The model is too idealized and does not take into account the time teachers and students

spend on boarding.

5.3. Model Improvement and Promotion

This model assumes more ideal conditions when simulating inter-school traffic, which not only reduces the practicability of the model but also makes the model great potential for improvement.[15,16] Based on this model, combined with weather conditions and traffic conditions, the school bus scheduling problem can be simulated in different situations. Combined with the actual situation and massive real-life statistical data, the actual utility of this model will be perfect.

6. Conclusion

This paper establishes a 0 1 assignment model for solving the school bus empty return problem, by defining whether the school bus departs and where it is located, and by establishing a time axis for each specific time point through the enumeration iteration method, according to which the model can solve the problem of wasted resources caused by school buses returning to different campuses, optimize school bus allocation and improve transportation efficiency, which has guiding significance for major universities.

The model established in this paper has a guiding effect on the solution of programming problems. The model in this paper is established to solve the problem of empty returns in school bus transportation. Balance the moment relationship between them by optimizing resource allocation for leverage. Putting the time impact factor into the planning model can take into account the overall optimal solution.

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