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Research Article

Crew Scheduling of Transport Bus Services-A Case Study

Trivedi H.S. †*

†Production Engg. Department, Shantilal Shah Engg. College, Sidsar, Bhavnagar, India

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Abstract

In this paper I have considered a case-study dealing with the scheduling of buses and its crews at Rajdhani Travels, Bhavnagar. The systems of scheduling various transport is a well-known problem nowadays. It consists of designing the duties to the resources in such a way that the maximum time is utilized should be in optimum manner. Herein, I have firstly done the scheduling of buses of Rajdhani Travels, Bhavnagar by using hungerian method of assignment problem solution and mathematical modeling. Then after, I have gone for Crew Scheduling Problem (CSP) which is a well-known problem in the field of Operations Research. It consists of designing duties using pre-defined tasks with fixed starting and ending times and locations. Each duty must satisfy a set of work laws and agreements. The objective is to minimize a combination of fixed costs (the number of duties) and variable costs (e.g. penalties for less desired constructions). Although usually the crew scheduling problem is solved after the vehicle schedules have been designed, it has recently also become possible to design integrated vehicle and crew schedules for small to medium-scale problems. Herein, I have firstly done the vehicle scheduling and then crew scheduling by logically assigning the duties such a way that it has minimum waiting time and optimum utilization.

Keywords: *Crew Scheduling, Travel operators, Operations Research, Assignment, Optimization of cost*

Introduction

The project is mainly based on scheduling of a travel agency. In this Paper I have undergone the study of the basic understanding of Scheduling, various scheduling techniques, its application in the real life examples and its limitations.

Then after taken up the case problem of Rajdhani Travels, which is a travels agency at Bhavnagar and it's routing of various buses at Ahmedabad, Baroda, Surat and Mumbai.

The main objectives of my study at the Rajdhani Travels Bhavnagar are:

- To study the existing scheduling system of the Rajdhani Travels.
- To study the strengths and weaknesses of the existing system.
- To minimize the weaknesses or try to eliminate them.
- To suggest them a new schedule and develop a new system.
- To provide the optimum schedule such that there is minimum waiting or idle time in the system and the resources (buses and drivers and cleaners) allocated in an optimum manner.

*Corresponding author **Trivedi H.S.** is working as Associate Professor

The Scope of the study

The study is conducted in the Bhavnagar for Rajdhani Travels.

- The study has been taken place considering only the routes from Bhavnagar to Ahmedabad and Ahmedabad to Bhavnagar.
- Today, Rajdhani Travels is having a wide network all over Gujarat connecting the major cities there. It is offering about seven services to Mumbai.
- It is having about 26 buses connecting all the major cities of Gujarat and Mumbai.
- But, as my scope of study is limited to the route of Bhavnagar and Ahmedabad I have undergone a indepth network study and scheduling of the buses in that route only.
- There are 11 buses offering services to Bhavnagar and Ahmedabad and the number of services offered a day is fifteen.
- It is one of the recognized travel agency at Bhavnagar, but as any system always has further chances to be more efficient, I have undergone a detailed study there.
- There are about 20 drivers and 20 cleaners working in this route.
- Out of which 15 are engaged in daily service and 5 are extras i.e. they are engaged only in the cases of emergency.

Proposed Schedule for Rajdhani Travels

The firm is running 15 trips a day from Bhavnagar to Ahmedabad and from Ahmedabad to Bhavnagar. In these 15 trips the firm is utilizing 11 buses and 20 drivers.

This showed that the resources were not utilized in a proper manner so in order to provide an optimal schedule I have undergone a case study at the Rajdhani Travels, Bhavnagar.

Here, along with the scheduling of the buses, the crew scheduling also need to be done. So, the convenient technique after studying the whole case seemed to be the Assignment Model of optimum allocation.

Hence, I have selected the Mathematical model of assignment problem to schedule the buses and drivers of the Rajdhani Travels, Bhavnagar.

Basic understanding of the application of the Assignment Technique:

Here are (i) 15-jobs (from Bhavnagar to Ahmedabad) for a the travel agency and has (j) 15-jobs to process the jobs (from Ahmedabad to Bhavnagar). A job i (i=1,2,...15) when processed by machine j (j=1,2,...15) is assumed to take the time cij. The assignment is to be made in such a way that each job can associate with one and only one machine. Determine an assignment of jobs from Bhavnagar to Ahmedabad and from Ahmedabad to Bhavnagar so as to minimize the overall time.

Mathematical Formulation

$$\sum_{i=1}^{n} x_{ij} = 1, and \sum_{j=1}^{n} x_{ij} = 1$$

We can define xij = 0, if the ith job not assigned to jth machine.
= 1 , if the ith job is assigned to jth machine

We can assign one trip of Bhavnagar to one trip of Ahmedabad,

The total assignment time is given by (including the set-up time)

$$z = \sum_{j=1}^{n} \sum_{i=1}^{n} c_{ij} x_{ij}$$

Service from Bhavnagar to Ahmedabad				
	Bhavnagar		Ahmedabad	
Service	Departure	arrival	Departure	arrival
1	6	11	6	11
2	6.3	11.3	7	12
3	7	12	7.3	12.3
4	8	13	8	13
5	9	14	9	14
6	11	16	11.3	16.3
7	13	18	13	18
8	14	19	14	19
9	15	20	15	20
10	16	21	16.3	21.3
11	17	22	17	22
12	18	23	18	23
13	19	24	19	24
14	20	1	20	1
15	24	5	23	4

(in considering the lead time in the metrix scale is 15 minutes = 1unit)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	76	80	82	84	88	2	8	12	16	22	24	28	32	36	48
2	74	78	80	82	86	0	6	10	14	20	22	26	30	34	46
3	72	76	78	80	84	94	4	8	12	18	20	24	28	32	44
4	68	72	74	76	80	90	0	4	8	14	16	20	24	28	40
5	64	68	70	72	76	86	92	0	4	10	12	16	20	24	36
6	56	60	62	64	68	78	84	88	92	2	4	8	12	16	28
7	48	52	54	56	60	70	76	80	84	90	92	0	4	8	20
8	44	48	50	52	56	66	72	76	80	86	88	92	0	4	16
9	40	44	46	48	52	62	68	72	76	82	84	88	92	0	12
10	36	40	42	44	48	58	64	68	72	78	80	84	88	92	8
11	32	36	38	40	44	54	58	64	68	74	76	80	84	88	4
12	28	32	34	36	40	50	54	60	64	70	72	76	80	84	0
13	24	28	30	32	36	46	50	56	60	66	68	72	76	80	92
14	20	24	26	28	32	42	46	52	56	62	64	68	72	76	88
15	4	8	10	12	16	26	32	36	40	46	48	52	56	60	72

Hence the time matrix of the given trip from Bhavnagar to Ahmedabad is as shown above

Step 1

After determining the effectiveness matrix. Subtract the minimum element of each row of the given cost matrix from all of the elements of the row. Examine if there is at least one zero in each row and in each column. If it is so, stop here, otherwise subtract the minimum element of each column from all the elements of the column. The resulting matrix is the starting effectiveness matrix.

Row Minima

Step 2

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	74	74	74	74	74	**0**	6	10	10	20	20	26	30	34	46
2	74	74	74	74	74	0	6	10	10	20	20	26	30	34	46
3	68	68	68	68	68	90	**0**	4	4	14	14	20	24	28	40
4	68	68	68	68	68	90	0	4	4	14	14	20	24	28	40
5	64	64	64	64	64	80	92	**0**	0	10	10	16	20	24	36
6	54	54	54	54	54	76	82	86	86	**0**	0	6	10	14	26
7	48	48	48	48	48	70	76	80	80	90	90	**0**	4	8	20
8	44	44	44	44	44	66	72	76	76	86	86	92	**0**	4	16
9	40	40	40	40	40	62	68	72	72	82	82	88	92	**0**	12
10	28	28	28	28	28	50	56	60	60	70	70	76	80	84	**0**
11	28	28	28	28	28	50	54	60	60	70	70	76	80	84	0
12	28	28	28	28	28	50	54	60	60	70	70	76	80	84	0
13	**0**	0	0	0	0	22	26	32	32	42	42	48	52	56	68
14	0	**0**	0	0	0	22	26	32	32	42	42	48	52	56	68
15	0	0	**0**	0	0	22	26	32	32	42	42	48	52	56	68

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	70	70	70	70	70	**0**	6	6	6	16	16	22	26	30	46
2	70	70	70	70	70	0	6	6	6	16	16	22	26	30	46
3	64	64	64	64	64	90	**0**	0	0	10	10	16	20	24	
4	64	64	64	64	64	90	0	**0**	0	10	10	16	20	24	40
5	64	64	64	64	64	90	0	0	**0**	10	10	16	20	24	40
6	54	54	54	54	54	80	88	86	86	**0**	0	6	10	14	30
7	48	48	48	48	48	74	80	80	80	90	90	**0**	4	8	24
8	44	44	44	44	44	70	76	76	76	86	86	92	**0**	4	20
9	40	40	40	40	40	66	72	72	72	82	82	88	92	**0**	16
10	24	24	24	24	24	50	56	56	56	66	66	72	76	80	**0**
11	24	24	24	24	24	50	54	56	56	66	66	72	76	80	0
12	24	24	24	24	24	50	54	56	56	66	66	72	76	80	0
13	**0**	0	0	0	0	26	30	32	32	42	42	48	52	56	72
14	0	**0**	0	0	0	26	30	32	32	42	42	48	52	56	72
15	0	0	**0**	0	0	26	30	32	32	42	42	48	52	56	72

Column Minima

Step 3

As per table above

Step 4 Assign the zeroes

(a). Examine the rows of the current effective matrix successively until a row with exactly one unmarked zero is found. Mark this zero, indicating that an assignment will be made there. Mark all other zeroes lying in the column of above encircled zero. The cells marked will not be considered for any future assignment. Continue in this manner until all the rows have taken care of. (b). Similarly for columns.

Step 5 Check for Optimality. Repeat step 2 successively till one of the following occurs.

(a). There is no row and no column without assignment. In such a case, the current assignment is optimal. (b). There may be some row or column without an assignment. In this case the current solution is not optimal. Proceed to next step.

Step 6 Draw minimum number of lines crossing all zeroes as follows. If the number of lines is equal to the order of the matrix, then the current solution is optimal, otherwise it is not optimal. Go to the next step

Step 7 Examine the elements that do not have a line through them. Select the smallest of these elements and subtract the same from all the elements that do not have a line through them, and add this element to every element that lies in the intersection of the two lines.

Step 8 Repeat this until an optimal assignment is reached.

When the cost matrix of an assignment problem is not a square matrix, i.e; number of sources is not equal to the number of destinations, the assignment problem is called an unbalanced assignment problem. In such problems, dummy rows or columns are added in the matrix so as to complete it to form a square matrix.

Optimal Table

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	54	54	54	54	54	**0**	0	0	0	0	0	6	10	14	46
2	54	54	54	54	54	0	**0**	0	0	0	0	6	10	14	46
3	54	54	54	54	54	0	0	**0**	0	0	0	6	10	14	46
4	54	54	54	54	54	0	0	0	**0**	0	0	6	10	14	46
5	54	54	54	54	54	0	0	0	0	**0**	0	6	10	14	46
6	54	54	54	54	54	0	0	0	0	0	**0**	6	10	14	46
7	48	48	48	48	48	90	90	90	90	90	90	**0**	4	8	40
8	44	44	44	44	44	86	86	86	86	86	86	72	**0**	4	36
9	40	40	40	40	40	82	82	82	82	82	82		92	**0**	32
10	0	0	0	0	0	42	42	42	42	42	42	48	52	56	**0**
11	**0**	0	0	0	0	42	40	42	42	42	42	48	52	56	0
12	0	**0**	0	0	0	42	40	42	42	42	42	48	52	56	0
13	0	0	**0**	0	0	42	40	42	42	42	42	48	52	56	0
14	0	0	0	**0**	0	42	40	42	42	42	42	48	52	56	0
15	0	0	0	0	**0**	42	40	42	42	42	42	48	52	56	0

Hence, the allocation of the bus trips from Bhavnagar to Ahmedabad is as shown below:

Service from Bhavnagar to Ahmedabad

Service	Waiting time
1- F	2
2- G	6
3- H	8
4- I	8
5- J	10
6- K	4
7- L	0
8- M	0
9- N	0
10- O	8
11- A	32
12- B	32
13- C	30
14-D	28
15- E	16
	184
	46 Hrs.

Similarly for allocation from Ahmedabad to Bhavangar is shown below:

Service	Waiting time
A- 06	0
B- 07	4
C- 08	6
D- 09	8
E- 10	8
F- 11	2
G- 12	0
H- 13	0
I- 14	0
J- 15	10
K- 01	32
L- 02	30
M- 03	28
N- 04	28
O- 05	20
	176
	44 Hrs.

Hence, the proposed schedule is as below:

Bhavnagar to Ahmedabad

Service-I

Start time	End time	Bus no.	Driver
6:00	11.00	1	A
6.30	11.30	2	B
7.00	12.00	3	C
8.00	13.00	4	D
9.00	14.00	5	E

Ahmedabad to Bhavnagar

Service-ii Driver

Start time	End time	Bus no.	Driver
11.30	16.30	1	A
13.00	18.00	2	B
14.00	19.00	3	C
15.00	20.00	4	D
16.30	21.30	5	E

Bhavnagar to Ahmedabad

Start time	End time	Bus no.	Driver
17.00	22.00	1	F
18.00	23.00	2	G
19.00	24.00	3	H
20.00	01.00	4	I
24.00	05.00	5	J

Ahmedabad to Bhvnagar

Start time	End time	Bus no.	Driver
6:00	11.00	6	F
6.30	11.30	7	G
7.00	12.00	8	H
8.00	13.00	9	I
9.00	14.00	10	J

Bhavnagar to Ahmedabad

Start time	End time	Bus no.	Driver
11.30	16.30	6	K
13.00	18.00	7	L
14.00	19.00	8	M
15.00	20.00	9	N
16.30	21.30	10	O

Ahmedabad to Bhavnagar

Start time	End time	Bus no.	Driver
17.00	22.00	6	K
18.00	23.00	7	L
19.00	24.00	8	M
20.00	01.00	9	N
24.00	05.00	10	O

Conclusion

As a result of modeling and simulation using Optimization methods, it is found that the travel operator can provide the same frequency between two stations with less number of buses, less lay over time and optimized man power resources.

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