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The Optimal Dividing of Available Human Resources On Existing Machinery

Alexandru Victor Amariei, Daniel Mihai Amariei

In the present paper is followed an optimal dividing of five operators on the same number of machines, using the Hungarian algorithm through Network Modeling module, in the WinQSB software.

Keywords: *hungarian algorithm, optimal allocation, execution time, assignment, iteration, objective function*

1. Theoretical notions

Allocation represents the optimal dividing or assignment of a particular entity to a certain location [5].

Firstly, in the present paper, will be divided five operators for the same number of available machines, supposing that an operator has the ability to take more than one position. In this case, the assignment takes in consideration the minimal total execution time.

2. Case study

Five operators are being tested so they can participate to an optimal dividing on five machines. The time that each operator obtained after the processing on the machines is measured in minutes and presented in the table 1.

Table 1.

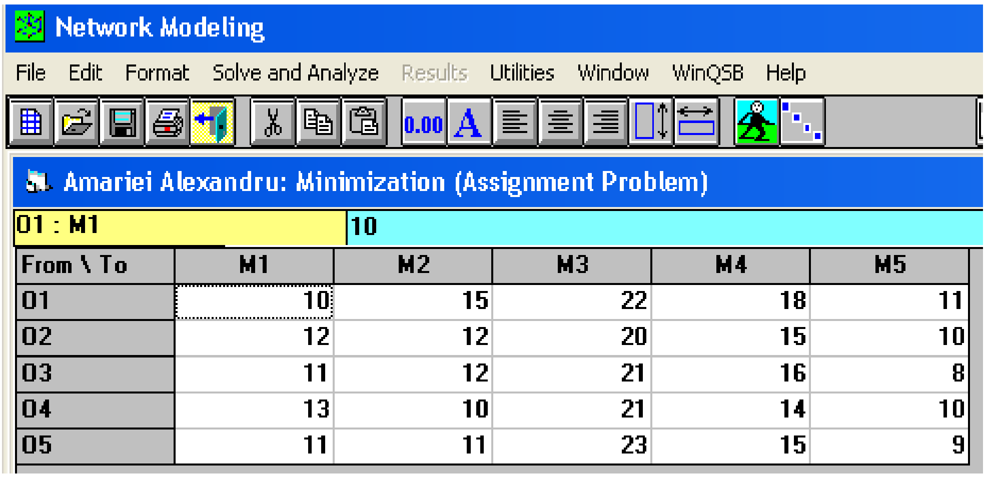
Machines / Operators	M_1	M_2	M_3	M_4	M_5
O_1	10	15	22	18	11
O_2	12	12	20	15	10
O_3	11	12	21	16	8
O_4	13	10	21	14	10
O_5	11	11	23	15	9

1) Make usage of the Hungarian algorithm, an optimal dividing of available human resource in a way in wich, all in all, the whole execution time on the machines to be minimal.

2) Make an optimal dividing of three operators, if the other two get sick.

3. The problem solution

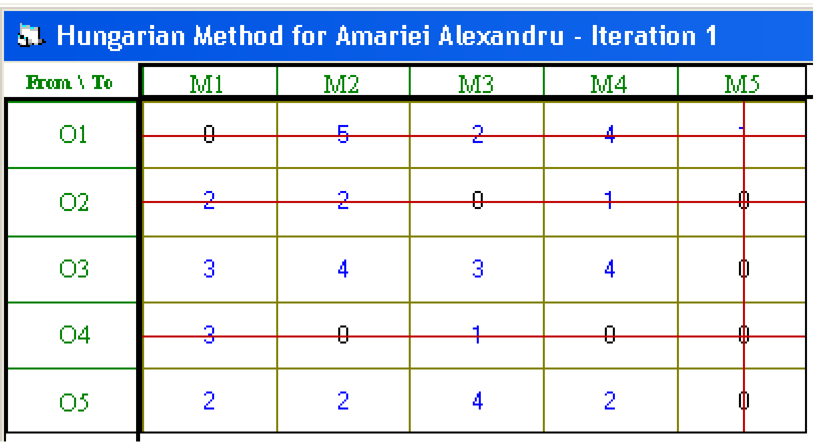
1) Introduce the problem data according to the figure 1.



From \ To	M1	M2	M3	M4	M5
01	10	15	22	18	11
02	12	12	20	15	10
03	11	12	21	16	8
04	13	10	21	14	10
05	11	11	23	15	9

Figure 1. Input data for the problem

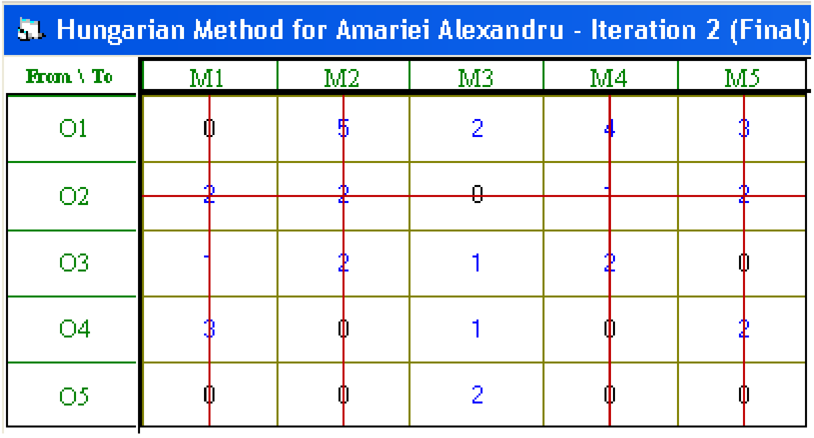
It is decreasing the minimal value of each line, then of each column and it is being obtained the data from figure 2.



From \ To	M1	M2	M3	M4	M5
O1	0	5	2	4	1
O2	2	2	0	1	0
O3	3	4	3	4	0
O4	3	0	1	0	0
O5	2	2	4	2	0

Figure 2. Iteration 1

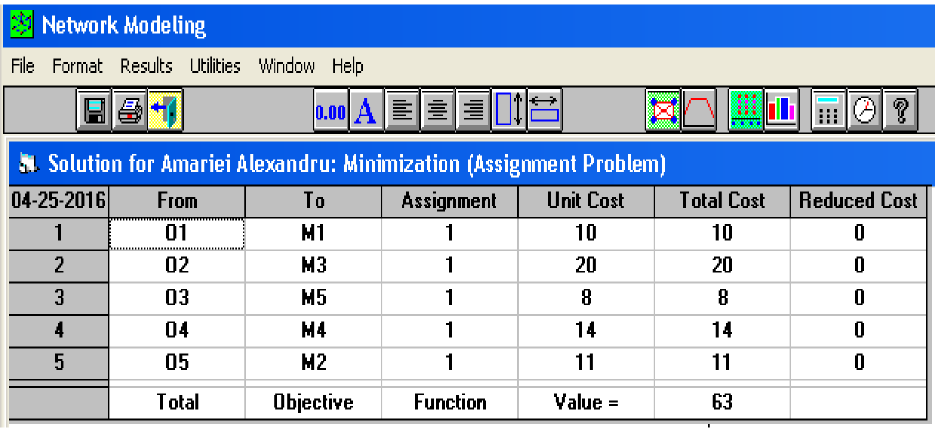
It is used the Hungarian algorithm until on each line and each column exists an "0" classified, so the coupling is maximum.



From \ To	M1	M2	M3	M4	M5
O1	0	5	2	4	3
O2	2	2	0	1	2
O3	1	2	1	2	0
O4	3	0	1	0	2
O5	0	0	2	0	0

Figure 3. Iteration 2 (finale)

The optimum obtained solution it is presented in figure 4.



04-25-2016	From	To	Assignment	Unit Cost	Total Cost	Reduced Cost
1	O1	M1	1	10	10	0
2	O2	M3	1	20	20	0
3	O3	M5	1	8	8	0
4	O4	M4	1	14	14	0
5	O5	M2	1	11	11	0
	Total	Objective	Function	Value =	63	

Figure 4. Problem data solution

It can be observed that the operator O1 it is allocated to machine M1, O2 on M3, O3 on M5, O4 on M4 and O5 on M2, so the total time of execution is 63 minutes.

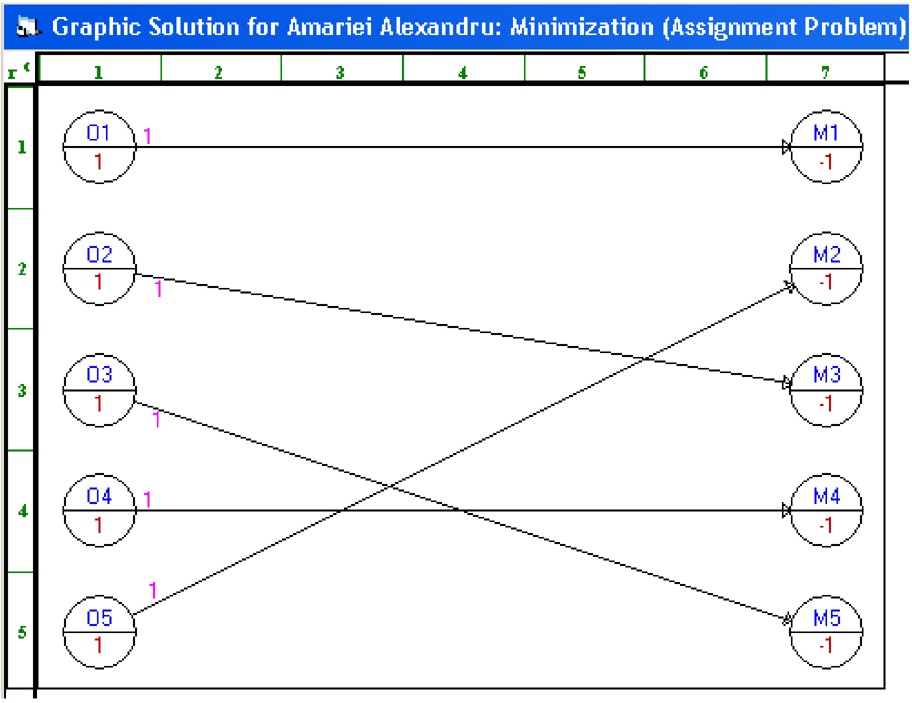


Figure 5. The problem solution in graphic form

2) In the case that two operators are missing, respectively O1 and O4, it has to realise an optimal assignation of the three operator remained. The problem becomes unbalanced, and to balance it, we introduce two fictive operators – OF1 and OF4.

Machines Operators	M_1	M_2	M_3	M_4	M_5
OF_1	0	0	0	0	0
O_2	12	12	20	15	10
O_3	11	12	21	16	8
OF_4	0	0	0	0	0
O_5	11	11	23	15	9

Hungarian Method for Amariei Alexandru - Iteration 1

From \ To	M1	M2	M3	M4	M5
OF1	0	0	0	0	0
O2	2	2	10	5	0
O3	3	4	13	8	0
OF4	0	0	0	0	0
O5	2	2	14	6	0

Figure 6. Iteration 1

Hungarian Method for Amariei Alexandru - Iteration 2 (Final)

From \ To	M1	M2	M3	M4	M5
OF1	0	0	0	0	2
O2	0	0	8	3	0
O3	1	2	11	6	0
OF4	0	0	0	0	2
O5	0	0	12	4	0

Figure 7. Iteration 2 (final)

The obtained solution it is presented in figure 8. It can be observed that the allocation plan has changed, such as the fictive operators OF1 and OF4 are allocated on the M3 and M4 machines, and the operators O2, O3 and O5 on the machines M1, M5 and M2.

Solution for Amariei Alexandru: Minimization (Assignment Problem)

04-25-2016	From	To	Assignment	Unit Cost	Total Cost	Reduced Cost
1	OF1	M3	1	0	0	0
2	O2	M1	1	12	12	0
3	O3	M5	1	8	8	0
4	OF4	M4	1	0	0	0
5	O5	M2	1	11	11	0
	Total	Objective	Function	Value =	31	

Figure 8. The problem solution in matrix form

It can be observed that the two fictive operators are allocated to the machines M3 and M4 and that's why it is necessarily to share these machines at two of three existing operators, according to figure 9.

Amariei Alexandru: Minimization (Assi

O5 : M4 | 15

From \ To	M4	M3
O2	15	20
O3	16	21
O5	15	23

Figure 9. Input data

After using the Hungarian algorithm, it is obtained the final solution after one iteration (figure 10).

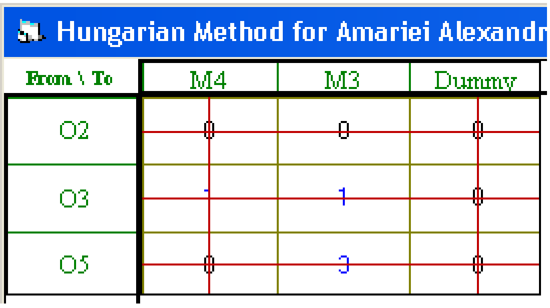


Figure 10. The final iteration

Solution for Amariei Alexandru: Minimization (Assignment Problem)

04-25-2016	From	To	Assignment	Unit Cost	Total Cost	Reduced Cost
1	O2	M3	1	20	20	0
2	O3	Unused_Supply	1	0	0	0
3	O5	M4	1	15	15	0
	Total	Objective	Function	Value =	35	

Figure 11. The final solution in matrix form

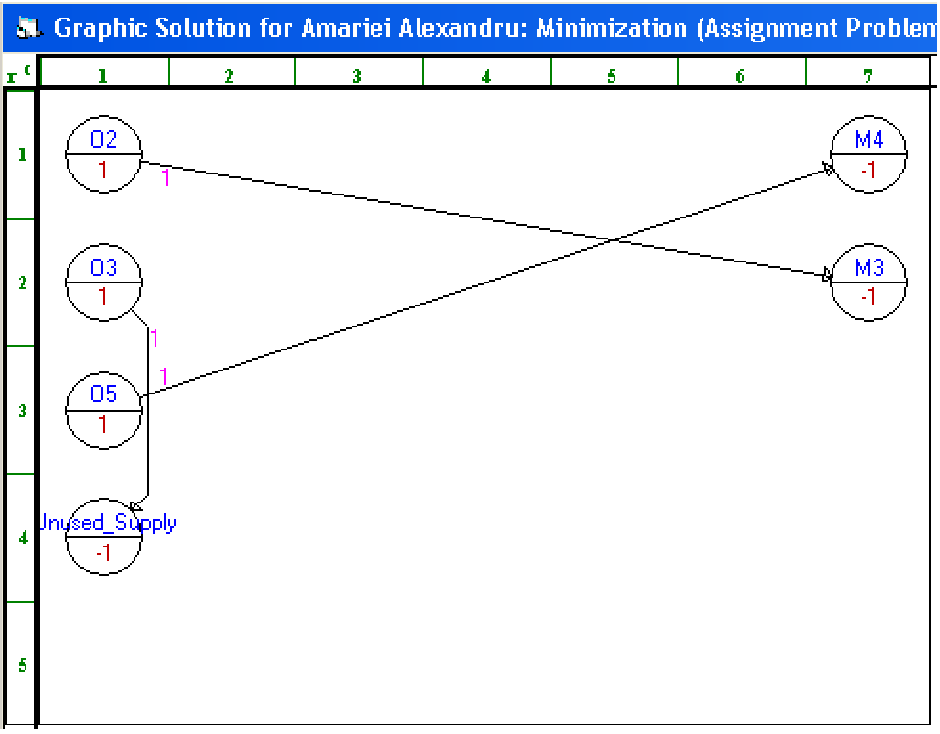


Figure 12. The final solution in graphic form

4. Conclusions

The optimal allocation for the five operators on the number of machines is:

- operator O1 is allocated on the machine M1;
- operator O2 on the machine M3;
- operator O3 on the machine M5;
- operator O4 on the machine M4;
- operator O5 on the machine M2,

and the total execution time is 63 minutes.

In the second case, but taking in consideration the solution for the first case, the optimal solution for the problem is:

- operator O2 will work on the machines M1 and M3;
- operator O3 will be allocated on the machine M5;
- operator O5 will work on the machines M2 and M4.

The objecting function is: [min]f = 12+20+8+11+15=66 min.

It can be seen an increase for the objective function value, meaning the total execution time with 3 minutes, after the absence of two operators and the replacement of the two of three existing operators.

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Addresses:

- Eng. Drd. Alexandru Victor Amariei, University "Politehnica" Timișoara, Strada Remus, nr.14, 300191, Timișoara, dj.ruvy@yahoo.com
- Prof. Drd. Daniel Mihai Amariei, University "Politehnica" Timișoara, Strada Remus, nr.14, 300191, Timișoara, amarieidaniel@yahoo.com