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Optimizing Distribution Problems using WinQSB Software

In the present paper we are presenting a problem of distribution using the Network Modeling Module of the WinQSB software, were we have 5 athletes which we must assign the optimal sample, function of the obtained time, so as to obtain the maximum output of the athletes. Also we analyzed the case of an accident of 2 athletes, the coupling of 3 athletes with 5 various athletic events causing the maximum coupling, done using the Hungarian algorithm.

***Keywords**: Hungarian algorithm, distribution, athletes, athletic events, optimum solutions, optimal solution.*

1. Introduction.

The assignment consists in the optimum distribution or allotment of a certain entity to a certain location [1].

There are $n \in \mathrm{N}^*$ necessities and for each there are at least one and maximum n possibilities of achievement. It is required to find n possibilities to distribute the n necessities corresponding to a maximum efficiency.

If we need to distribute n applicants onto n vacant positions, in the hypothesis an applicant has the competency to fill more than one position, the assignment may take into account the global satisfaction of preferences or the obtaining of a maximum global efficiency. If n persons must divide n indivisible asset of quasi-equal values, one will aim at performing an equitable partition [3].

2. Case Study.

The competition's program where 5 athletes must attend is very loaded, so every athletes needs to participate at only one single event. For this, the coach wishes to determine an optimal repartition of the athlete's events.

The obtained times (seconds) of each athlete corresponding to each event are presented in the table from Figure 1.

From \ To	100 m	200 m	400 m	110 m Hurdles	400 m Hurdles
Athlete 1	12.03	24.14	54.35	14.01	60.46
Athlete 2	11.5	22.04	54.5	14	59.51
Athlete 3	11.02	22.15	51.3	13.9	55.7
Athlete 4	11.52	23.01	52.2	14.02	56
Athlete 5	11.08	22.1	51.2	13.8	55.4

Figure 1. Problem data in matrix form

Using the Hungarian algorithm, we tried to get on each row and each column at least one zero [2], [5]. To achieve this, we highlight from the elements of each line respectively column, the minimum element accordingly.

Thus, after deducting the minimal value from all the elements of the respective line and repeat the same process on columns we obtain the matrix in Figure 2.

Hungarian Method for Anale 2015 - Iteration 1

From \ To	100 m	200 m	400 m	110 m Hurdle	400 m Hurdle
Athlete 1	0	1,57	2,2	0	4,11
Athlete 2	0	0	2,88	0,52	3,69
Athlete 3	0	0,59	0,16	0,9	0,36
Athlete 4	0	0,95	0,56	0,52	0,16
Athlete 5	0	0,48	0	0,74	0

Figure 2. First Iteration

It follows after the zeros positioning. We choose the line with fewer zeros and assign one zero, all the others located on the zero line and column are strikeout. The process is repeated until all zeros are assigned or strikeout. In our case we have to have five zeros assigned.

Table 1.

Events / Athletes	100 m	200 m	400 m	110 m Hurdles	400 m Hurdles
Athlete 1	ø	1.57	2.2	■	4.11
Athlete 2	ø	■	2.88	0.52	3.69
Athlete 3	■	0.59	0.16	0.9	0.36
Athlete 4	ø	0.95	0.56	0.52	0.16
Athlete 5	ø	0.48	■	0.74	ø

In Table 1 we have only 4 zeros assigned, the number of zeros assigned is less than the matrix order, resulting that we did not reached the optimal solution.

Line 4 and column 5 contain no zero framed; therefore we have to proceed to mark rows and columns.

Table 2.

Events / Athletes	100 m	200 m	400 m	110 m Hurdles	400 m Hurdles	Marked lines
Athlete 1	ø	1.57	2.2	◙	4.11	
Athlete 2	ø	◙	2.88	0.52	3.69	
Athlete 3	◙	0.59	0.16	0.9	0.36	*
Athlete 4	ø	0.95	0.56	0.52	0.16	*
Athlete 5	ø	0.48	◙	0.74	ø	
Marked columns	*					

It follows the zeroes displacement, subtracting the minimum of the matrix free element, for our case 0,16. This is added to the double strikeout elements, leaving unchanged the simply strikeout elements, getting the matrix from Figure 3.

Hungarian Method for Anale 2015 - Iteration 2 (Final)

From \ To	100 m	200 m	400 m	110 m Hurdle	400 m Hurdle
Athlete 1	0,16	1,57	2,2	0	4,11
Athlete 2	0,16	0	2,88	0,52	3,69
Athlete 3	0	0,43	0	0,74	0,2
Athlete 4	0	0,79	0,4	0,36	0
Athlete 5	0,16	0,48	0	0,74	0

Figure 3. Iteration 2

The problem's optimal solution is presented in matrix form in Figure 4 and graphically in Figure 5.

06-17-2015	From	To	Assignment	Unit Cost	Total Cost	Reduced Cost
1	Athlete 1	110 m Hurdles	1	14,01	14,01	0
2	Athlete 2	200 m	1	22,04	22,04	0
3	Athlete 3	100 m	1	11,02	11,02	0
4	Athlete 4	400 m Hurdles	1	56	56	0,00
5	Athlete 5	400 m	1	51,20	51,20	0
	Total	Objective	Function	Value =	154,27	

Figure 4. The solution of the problem in matrix form

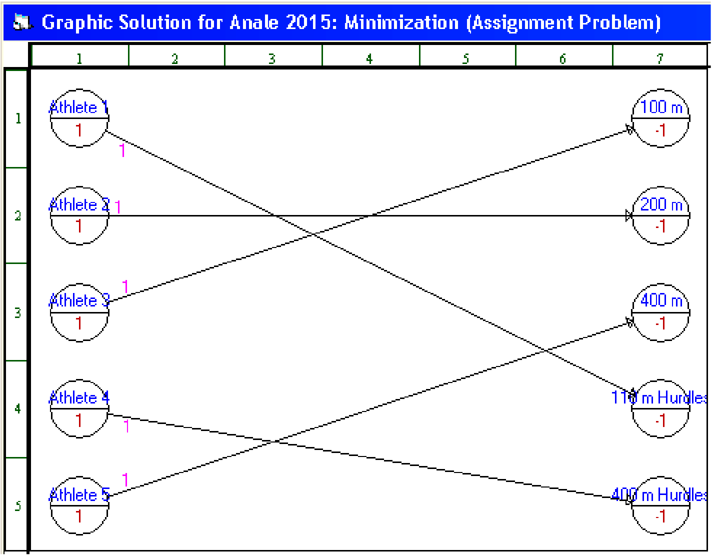

Figure 5. The solution of the problem in graphic form

If we change the problem data, eliminating two of the athletes because of accidents, namely athletes 1 and 4, we get the following matrix (Figure 6):

From \ To	100 m	200 m	400 m	110 m Hurdles	400 m Hurdles
Athlete 1	0	0	0	0	0
Athlete 2	11.5	22.04	54.5	14	59.51
Athlete 3	11.02	22.15	51.3	13.9	55.7
Athlete 4	0	0	0	0	0
Athlete 5	11.08	22.1	51.2	13.8	55.4

Figure 6. The modified problems data

The best solution offered by WinQSB software is given in figure 7.

06-17-2015	From	To	Assignment	Unit Cost	Total Cost	Reduced Cost
1	Athlete 1	400 m	1	0	0	0
2	Athlete 2	200 m	1	22,04	22,04	0
3	Athlete 3	100 m	1	11,02	11,02	0
4	Athlete 4	400 m Hurdles	1	0	0	0
5	Athlete 5	110 m Hurdles	1	13,80	13,80	9,536743E-07
	Total	Objective	Function	Value =	46,86	

Figure 7. The results of the modified problem

Two of the three athletes available (athlete 2, 3 and 5), must participate in two events.

It may be observed that the athlete 1, one of the two injured athletes, must compete in 400 meter dash event, time in which the other injured athlete would be assigned for the 400 m hurdles. But in these events must attend available athletes. The new data according to Figure 8 and we obtain, after applying the Hungarian algorithm, the solution highlighted in Figure 10.

From \ To	400 m	400 m Hurdles
Athlete 3	54.5	59.51
Athlete 2	51.3	55.7
Athlete 5	51.2	55.4

Figure 8. Problem data

Hungarian Method for Anale 2015 - Iteration 2 (Final)

From \ To	400 m	400 m Hurdles	Dummy
Athlete 3	3,2	4,01	0
Athlete 2	0	0,2	0
Athlete 5	0	0	0,1

Figure 9. Final iteration

06-17-2015	From	To	Assignment	Unit Cost	Total Cost	Reduced Cost
1	Athlete 3	Unused_Supply	1	0	0	0
2	Athlete 2	400 m	1	51,30	51,30	0
3	Athlete 5	400 m Hurdles	1	55,40	55,40	0
	Total	Objective	Function	Value =	106,70	

Figure 10. The final solution

Also in the previously solution determined, the final solution to the problem is:
- The 2 athlete will compete in the 200 m dash;
- The 3 athlete will compete in the 100 m dash and 400 m dash;
- The 5 athlete will participate in 110 m hurdles and 400 m hurdles.

3. Conclusion

The optimal solution for the distribution of the 5 athletes on the 5 samples was as follows:
- First athlete competing at 110 m hurdles;
- The athlete 2 - 200 m flat;
- The athlete 3 - 100 m flat;

- The athlete 4 - 400 m hurdles;
- The athlete 5 - 400 m flat.

After injury of the athletes 1 and 4, the optimum solution was determined as follows:

- The athlete 2 will compete in the 200 m flat;
- The athlete 3 will compete in the 100 m flat and 400 m flat;
- The athlete 5 will participate in the 110 m hurdles and 400 m hurdles.

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