The optimal allocation of the company's human resources through the use of allocation models: Case of the Trans_Logistics transport company unit of Tiaret

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Abstract

This research paper is located in the field of operations research, more precisely in linear programming which is part of this discipline. It concerns the use of allocation models for the optimal allocation of human resources.

The main objective of this research paper is to deal with a very important topic, namely the problem of allocation of human resources, because the optimal allocation and rational utilization of these resources become one of the concerns of companies and is essential to the satisfaction of their objectives.

Through this research document we deal with a problem of allocation of human resources of the transport company Trans_Logistics unit of Tiaret, the objective is the minimization of the overall distance traveled by the different drivers when carrying out the different transport operations.

The study resulted in proposing an assignment model, its resolution made it possible to reach and obtain the optimal assignment which allows the transport company Trans_Logistics unit of Tiaret to assign these different drivers to the different transport operations, which made it possible to achieve them at the lowest possible cost.

Key words: *Assignment, Human resources, Road transport, Optimization*
Jel Codes Classification : *C60, C61, C69*

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التعيين الأمثل للموارد البشرية للمؤسسة باستخدام نماذج التخصيص
حالة مؤسسة النقل Trans_Logistics وحدة تيارت

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ملخص

يندرج هذا المقال ضمن ميدان بحوث العمليات، و بالأخص ضمن البرمجة الخطية التي تعتبر جزء من هذا الميدان، حيث يتعلق باستخدام نماذج التعيين من اجل التخصيص الامثل للموارد البشرية.

الهدف الاساسي لهذا المقال هو معالجة موضوع تخصيص الموارد البشرية لمؤسسة النقل، ذلك ان التخصيص الامثل لهذه الموارد اصبح يشكل احد انشغالات و اهتمامات المؤسسات، حيث اثبت انه جد ضروري لهذه المؤسسات بغية تحقيق اهدافها.

عبر هذا المقال تم معالجة مشكل تخصيص الموارد البشرية لمؤسسة النقل Trans_Logistics وحدة تيارت، حيث كان الهدف هو تدنئة و تقليص التكاليف الممثلة في المسافة الكلية و الاجمالية التي يقطعها مختلف سائقي المؤسسة اثناء انجاز مختلف عمليات النقل.

الدراسة انتهت باقتراح نموذج تخصيص، حيث أن حل هذا الاخير اتاح لنا الوصول و الحصول على التخصيص الأمثل الذي يسمح لـ لمؤسسة النقل تعيين و توزيع مختلف السائقين على مختلف عمليات النقل، الامر الذي مكن الشركة من انجاز عمليات النقل هذه بأقل تكلفة ممكنة.

الكلمات المفاتيح: التخصيص، الموارد البشرية، النقل البري، الأمثلية
التصنيف JEL : C60, C61, C69

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Introduction:

The human resources factor has become one of the key and indispensable elements for the competitiveness and improvement of company performance, whether of an economic nature or of a service nature, and this is due to the very important role and contribution effective of this factor. So there is no longer any question of neglecting the presence of this factor within the company. Indeed, people have become an essential component which profoundly influences and has a very profound impact on the profitability of the company.

Aware of this fact, several researchers have taken an interest in work relating to the management of human resources and more precisely and in particular the problem of allocation of these resources.

From what has been presented above, this research paper inspires its problem, which can be formulated and translated into the following main question.

What is the role of the use of allocation models in solving the problems of distribution and allocation of human resources within the company?

The answer to this question is the main objective of this research paper. The latter is subdivided into five parts or sections. Through the first, we approached the definition and presentation of assignment problems. In the second section of this work we presented the modeling and mathematical formulation of assignment problems. In the third section we presented the different algorithms and methods for solving assignment models. Through the fourth section we applied everything that was discussed in the first two sections, to the problem of assignment and distribution of the different drivers of the transport company Trans_Logistics unit of Tiaret, on these different daily transport operations, this which leads us to draw some remarks and conclusions through the fifth and last section of this research paper.

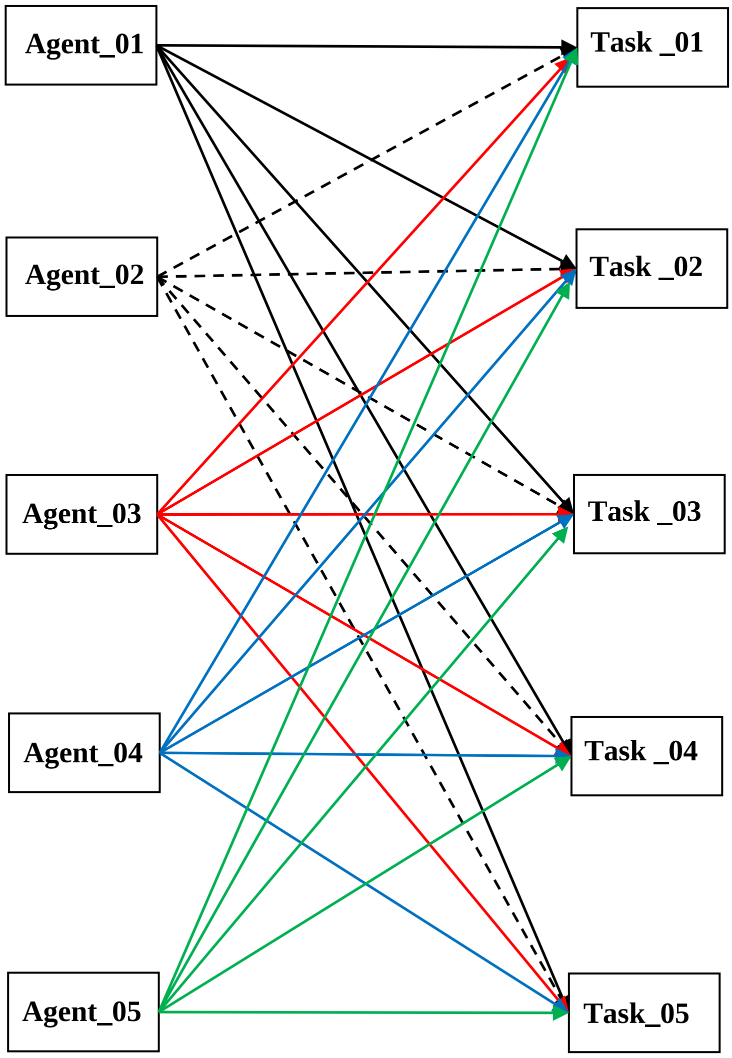
I- Definition of the assignment problem:

The assignment problem is a classic problem that frequently arises in operations research. The main objective of the assignment problem is to determine a maximum coupling in a valued bipartite graph. (ROY, 2000, p. 185) So the assignment problem consists of realizing and establishing a bijection and links of the elements i of a set I on those j of a set J, of the same cardinality, in such a way that a certain cost function, depending on the choice of pairs (i,j), is minimal and respecting the link uniqueness constraints for each element. (Faure, 1996, p. 123)

We consider n tasks and n agents, for any pair (i, j), the assignment of the task i to the agent j leads to a realization cost noted D_{ij} . Knowing that each agent can perform at most one task and each task must be carried out and carried out once and only once. So the assignment problem consists of assigning n agents to n tasks (n tasks to n agents), so as to minimize the total costs of completion and implementation while respecting the assignment constraints, namely: the availability constraints of the agents and the constraints of carrying out the tasks. (TOMBOLA, 2011, p. 102)

The assignment problem can be represented in the form of a bipartite graph as follows:

Figure n°1: Representation of the assignment problem in the form of a graph



Source: established by researchers

II- Modeling the assignment problem:

Modeling or mathematical formulation of the assignment problem is defined as the construction of a mathematical model from experimental data. It makes it possible to interpret the different parameters of a given problem and translate them into a mathematical language that can be manipulated and to which we can apply quantitative resolution tools and methods. (MAQUIN, 2003, p. 121) Through this section, we will model the assignment problem using the most appropriate model to which we will subsequently apply the different known solution methods.

To any (i, j) agent/task pair (task/agent), we associate a noted X_{ij} binary decision variable called assignment variable, this variable takes the value 1 if the task i is assigned to the agent j and equal to 0 otherwise i.e. d. This is the task i is not assigned to the agent j. The overall costs resulting from carrying out the different tasks are then expressed by the algebraic expression: $Z = \sum_{i=1}^{n} \sum_{j=1}^{m} C_{ij} \times X_{ij}$. Knowing that the number of tasks carried out by the agent j is given by the expression: $\sum_{i=1}^{n} X_{ij}$, for each $j = 1,\dots, n$ . . The number of agents performing the task i is given by the expression: $\sum_{j=1}^{n} X_{ij}$, for each $i = 1,\dots, n$. (CARLIER, 2008, p. 92) So the assignment model can be modeled in the following form:

$$\text{Minimization } Z = \sum_{i=1}^{n} \sum_{j=1}^{m} C_{ij} \times X_{ij}$$

Under the constraints:

$$\sum_{j=1}^{n} X_{ij} = 1 \ \forall \ i = 1,\dots,n$$

$$\sum_{i=1}^{n} X_{ij} = 1 \ \forall \ j = 1,\dots,n$$

$$X_{ij} \in \{0 \ , \ 1\} \ \forall \ i = 1,\dots,n \ , \ \forall \ j = 1,\dots,n$$

III- Methods for solving the assignment problem:

Solving an assignment problem means reaching the optimal solution (assignment), to do this there are simple and effective methods and algorithms, among these methods we cite: (Hachicha, 2015, p. 85)

1. List of possible assignments
2. The Hungarian method
3. Algorithm of assignment units
4. The simplex method

III-1- List of possible assignments:

According to this method, the optimal allocation is achieved by following the following steps:

1. List all possible assignments: The number of possible assignments is equal to $n!$
2. Calculate the cost (or revenue) corresponding to each assignment obtained in step 1 above.
3. Determine the optimal assignment, it is the one that corresponds to the assignment:
   - Having the lowest cost in the case where the objective function is of Minimization type.
   - Having a highest profile in the case where the objective function is of the Maximization type.

The main disadvantage of this method is that we cannot or it is very difficult to list all the possible assignments when the value of which represents the number of spots or the number of agents is high.

III-2- The Hungarian method:

The Hungarian algorithm or Hungarian method sometimes also called the Kuhn-Munkres algorithm is a combinatorial optimization algorithm, which solves the assignment problem in polynomial time. It was proposed in 1955 by the American mathematician Harold Kuhn, who named it the "Hungarian method" because it built on earlier work by two Hungarian mathematicians: Dénes Kőnig and Jenő Egerváry. James Munkres revised the algorithm in 1957 and proved that it ran in polynomial time. (Picouleau, Faure, & Lemaire, 2014, p. 125)

To achieve the optimal assignment (solution) according to this method we must follow the following steps: (Kuhn, 2010, p. 101)

1. Formulation of the cost table (matrix) based on the problem data.

2. Reduction of the cost table (matrix).

- Remove the smallest element in each line.
- Remove the smallest element in each column.
- Every row and column now has at least one zero value.

3. **Assignment of the unique zero to each row/column (Making an assignment in the cost matrix):**
   - For each row and/or column, enclose the value zero to denote an assignment.
   - For each boxed zero value that becomes assigned, cross out all other zeros in the same row and/or column.
   - Repeat 1 and 2 until all zeros in rows/columns are assigned
4. **Optimality test:**
   - If the number of allocation cells is equal to the number of rows/columns, this is an optimal solution, the total cost associated with this solution is obtained by summing the values of the original costs in the occupied cells.
   - If no optimal solution is found, go to step 5.
5. **Creating additional zeros:**
   Cross out the horizontal and vertical lines to cover all zeros of the cost obtained from step 3 using the following procedure:
   - Check (X) the lines that do not have framed zeros.
   - Check (X) the columns with a crossed zero on a line already marked.
   - Check (X) rows with a framed zero in a marked column.
   - Cross out each marked column and each unmarked row.

   If the number of striped rows is equal to the format of the matrix, the current solution is the optimal solution, otherwise go to step 6.
6. **Improvement of the new cost table (matrix):**
   - Choose the smallest element from the rest of the unstriped cells.
   - Subtract this smallest element from each element of the unstriped cells.
   - Add it to each element of the twice-striped cells.

   Elements in cells crossed out only once remain unchanged.

IV- The experimental study:

The experimental part of the present study was carried out with the services of the human resources department of the transport company called Trans_Logistique unit of Tiaret. Our main mission through this study is to determine a transport program which allows this company to carry out the various transport tasks at the lowest possible cost (distance). In other words, designate for each driver the transport task that must be carried out at the lowest cost.

IV-1- Presentation of the problem of the company Trans_Logistics unit of Tiaret:

Through this section we will present the problem of the transport company Trans_Logistics unit of Tiaret. The latter carries out a set of transport tasks every day, each task is made up of the following four operations:

Through this section we will present the problem of the transport company Trans_Logistique unit of Tiaret. The latter carries out a set of transport tasks every day, each task is made up of the following four operations:

1. First operation: Each driver i with i=1,…,5 noted Driver_i, brings back his transport truck from his home or his place of residence noted Sit_Res_i which represents the starting point of each transport task, to one loading sites noted Load_Sit_j with j=1,…,5.

2. Second operation: Loading of the transport truck at the loading site Load_Sit_j with j=1,…,5
3. Third operation: After loading the truck i at the loading site j, Each driver i drives the transport truck from the loading site Load_Sit_j to one of the unloading sites noted Unload_Site_k with k=1,…,5
4. Fourth operation: After unloading, Each driver i returns to his place of residence Resi_Sit_i

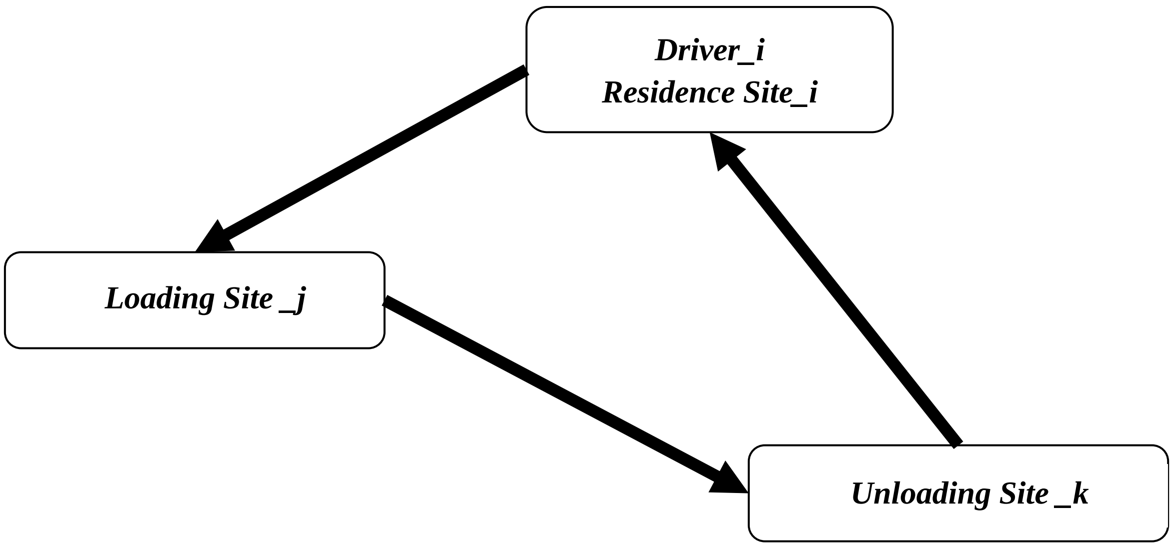
The study firm's problem can be reformulated and summarized in the following way:

The company named the transport company Trans_Logistic unit of Tiaret has a set of transport trucks, each truck has its own driver, this company must carry out a set of transport tasks every day. Every day in the morning, driver number i noted Driver_i drives his truck from his place of residence (home) j noted Resi_Sit_i to a loading site j noted Load_Sit_j among the loading sites. At this loading site Load_Sit_j, he loads his truck and then, he drives it to one of the unloading sites k noted Unload_Sit_k, after unloading the truck, the driver i noted Driver_i returns with his truck to his place of residence (home) i noted Resi_Sit_i to repeat the same journey the next day.

In the language of assignment problems, the problem of the transport company Trans_Logistic unit of Tiaret is to determine the optimal assignment which must assign the different drivers to the different transport tasks for a minimum overall distance. In other words, determine an optimal transport program which makes it possible to assign and designate the appropriate driver for each transport task, that is to say the driver who carries it out at the lowest cost (distance traveled).

So the route traveled by each driver can be represented as follows:

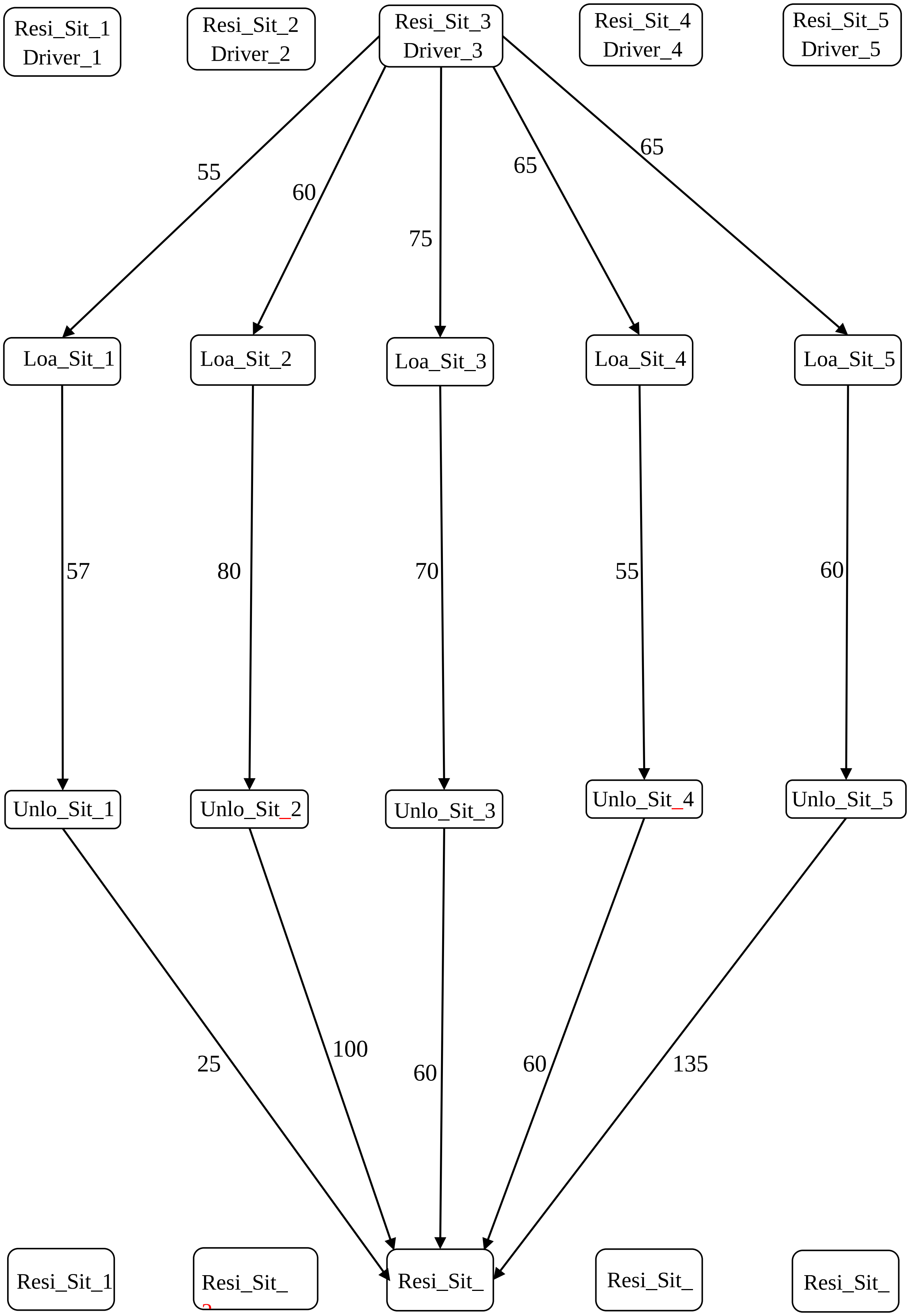
Figure n°2: Route traveled by each driver



Source: established by researchers

Following the presentation of the company's problem cited above, we can summarize it using the following figure:

Figure n°3: summary diagram of the problem of the company Trans_Logistics



Source: established by researchers

Let the following data be given:

1- Aij: Represents the distance separating the different places of residence of the drivers ***Resi_Sit_i*** and the different loading points ***Load_Sit_j***

Table n°1: Distance between *Resi_Sit_i* and *Load_Sit_j* in km

A_{ij} =

	Load_Sit_1	Load_Sit_2	Load_Sit_3	Load_Sit_4	Load_Sit_5
Resi_Sit _1	40	20	120	20	15
Resi_Sit _2	105	40	75	85	60
Resi_Sit _3	55	60	75	65	65
Resi_Sit _4	35	100	65	85	100
Resi_Sit _5	105	135	05	145	145

Source: established by researchers based on data from the Trans_Logistics company

2- Bik : Represents the distance separating the different loading points *Load_Sit_j* and the different unloading points *Unload_Sit_k*

Table n°2: Distance between *Load_Sit_j* and *Unload_Sit_k* in km

B_{ik} =

	Unload_Sit_1	Unload_Sit_2	Unload_Sit_3	Unload_Sit_4	Unload_Sit_5
Load_Sit_1	57	/	/	/	/
Load_Sit_2	/	80	/	/	/
Load_Sit_3	/	/	70	/	/
Load_Sit_4	/	/	/	55	/
Load_Sit_5	/	/	/	/	60

Source: established by researchers based on data from the Trans_Logistics company

3- Cki : represents the distance separating the different unloading points *Unload_Sit_k* and the different places of residence of the drivers *Resi_Sit_i*.

Table n°3: Distance between *Unload_Sit_k* and *Resi_Sit _i* in km

C_{ki} =

	Resi_Sit_1	Resi_Sit_2	Resi_Sit_3	Resi_Sit_4	Resi_Sit_5
Unload_Sit_1	60	145	25	85	85
Unload_Sit_2	05	110	100	20	110
Unload_Sit_3	55	100	60	40	60
Unload_Sit_4	100	75	60	55	10
Unload_Sit_5	95	15	135	10	35

Source: established by researchers based on data from the Trans_Logistics company

Following the presentation of the problem of the Trans_Logistics company (TLC) cited above, our main mission through this research document consists in presenting an optimal solution (allocation) which allows the Trans_Logistics company (TLC) to carry out the different transport tasks so as to designate for each transport task among the five operations, one driver (truck) of the five drivers, so as to minimize as much as possible the total and overall distance traveled by the five trucks (drivers) and respect the assignment constraints, namely: the constraints availability of drivers and the constraints of carrying out transport operations.

IV-2- Solving the problem of the company Trans_Logistics:

The problem of the Trans_Logistics company unit of Tiaret is to carry out the five transport operations so as to designate for each transport operation among the five operations, a driver (truck) so as to minimize as much as possible the total and overall distance traveled by the five trucks (drivers).

From the data cited above we can deduce and construct a new table (matrix) of the total distances traveled for each driver (truck), these total distances form the data of this new table, these data are obtained by adding the different distances shown in the tables above, as follows:

Table n°4: The distance traveled by each driver in km

$D_{ij} =$

	Load_Sit _1	Load_Sit _2	Load_Sit_3	Load_Sit_4	Load_Sit_5
Resi_Sit _1 Driver _1	40+57+60	20+80+05	120+70+55	20+55+100	15+60+95
Resi_Sit _2 Driver _2	105+57+145	40+80+110	75+70+100	85+55+75	60+60+15
Resi_Sit _3 Driver _3	55+57+25	60+80+100	75+70+60	65+55+60	65+60+135
Resi_Sit _4 Driver _4	35+57+85	100+80+20	65+70+40	85+55+55	100+60+10
Resi_Sit _5 Driver _5	105+57+85	135+80+110	05+70+60	145+55+10	145+60+35

Source: established by the researchers from the data in the tables above

After calculating the results of the different addition operations, we obtain the new table of the total distance traveled by each driver when he carries out each transport operation among the five planned operations.

Table n°5: The distance traveled by each driver in km

$D_{ij} =$

	Load_Sit_1	Load_Sit_2	Load_Sit_3	Load_Sit_4	Load_Sit_5
Resi_Sit_1 Driver _1	157	105	245	175	170
Resi_Sit _2 Driver _2	307	230	245	215	135
Resi_Sit _3 Driver _3	137	240	205	180	260
Resi_Sit _4 Driver _4	177	200	175	195	170
Resi_Sit _5 Driver _5	247	325	135	210	240

Source: established by the researchers from the data in the tables above

IV-2-a. Mathematical formulation of the problem of the Trans_Logistics company:

We can therefore model the problem of assigning the Trans_Logistics company unit of Tiaret in the form of a standard linear program. In order to model the business problem of our study we must follow the following steps:

1- Definition of decision variables:

Decision variables are defined as follows:

$$X_{ij} = \begin{cases} 1, & if\ \_the\ \_driver\ \_i\ is\ assigneand\ \_made\ \_the\ \_route \quad : \text{Sit\_Cha\_j} \rightarrow \text{Sit\_Déch\_k} \\ 0, & other\ . \end{cases}$$

2- Determining the economic function:

The objective is to minimize the objective function, where

$$
\begin{aligned}
Min\ \ Z = {} & 157\,X_{11} + 105\,X_{12} + 245\,X_{13} + 175\,X_{14} + 170\,X_{15} + \\
& 307\,X_{21} + 230\,X_{22} + 245\,X_{23} + 215\,X_{24} + 135\,X_{25} + \\
& 137\,X_{31} + 240\,X_{32} + 205\,X_{33} + 180\,X_{34} + 260\,X_{35} + \\
& 177\,X_{41} + 200\,X_{42} + 175\,X_{43} + 195\,X_{44} + 170\,X_{45} + \\
& 274\,X_{51} + 325\,X_{52} + 135\,X_{53} + 210\,X_{54} + 240\,X_{55} +
\end{aligned}
$$

3- Determination of constraints:

Constraints form three groups

- $$
\begin{aligned}
X_{11} + X_{12} + X_{13} + X_{14} + X_{15} = 1 \\
X_{21} + X_{22} + X_{23} + X_{24} + X_{25} = 1 \\
X_{31} + X_{32} + X_{33} + X_{34} + X_{35} = 1 \\
X_{41} + X_{42} + X_{43} + X_{44} + X_{45} = 1 \\
X_{51} + X_{52} + X_{53} + X_{54} + X_{55} = 1
\end{aligned}
$$

- $$
\begin{aligned}
X_{11} + X_{21} + X_{31} + X_{41} + X_{51} = 1 \\
X_{12} + X_{22} + X_{32} + X_{42} + X_{52} = 1 \\
X_{13} + X_{23} + X_{33} + X_{43} + X_{53} = 1 \\
X_{14} + X_{24} + X_{34} + X_{44} + X_{54} = 1 \\
X_{15} + X_{25} + X_{35} + X_{45} + X_{55} = 1
\end{aligned}
$$

- $X_{ij} \in \{0\ ,\ 1\}\ ,\ \ i = 1,\ldots,5\ \ ,\ \ j = 1,\ldots,5$

IV-2-b- Resolution method:

Among the methods for solving assignment models we cite the following methods:

1. First method: List of possible assignments
2. Second method: the Hungarian method.

- Enumeration of possible assignments:

Following this method the number of possible assignments equal to assignments, it seems difficult to cite them, which is why we only use the Hungarian method to reach the optimal solution (assignment).

- The Hungarian method:

As mentioned above in paragraph II.2 to obtain the optimal allocation following this method, the following steps must be followed:

1- Reduction-lines:

The line reduction operation consists of subtracting the minimum value of the line from each cost of a line. The resulting table is given below.

D_{ij} =

	Load_Sit_1	Load_Sit_2	Load_Sit_3	Load_Sit_4	Load_Sit_5
Resi_Sit_1 Driver _1	52	00	140	70	65
Resi_Sit_2 Driver _2	172	95	110	80	00
Resi_Sit_3 Driver _3	00	103	68	43	123
Resi_Sit_4 Driver _4	07	30	05	25	00
Resi_Sit_5 Driver _5	112	190	00	75	105

2- Reduction-columns:

The column reduction operation consists of subtracting from each cost of a column the minimum value of the column. The resulting table is given below

D_{ij} =

	Load_Sit_1	Load_Sit_2	Load_Sit_3	Load_Sit_4	Load_Sit_5
Resi_Sit_1 Driver _1	52	00	140	45	65
Resi_Sit _2 Driver _2	172	95	110	55	00
Resi_Sit _3 Driver _3	00	103	68	18	123
Resi_Sit _4 Driver _4	07	30	05	00	00
Resi_Sit _5 Driver _5	112	190	00	50	105

3- Assignment of the unique zero to each row/column:

D_{ij} =

	Load_Sit_1	Load_Sit_2	Load_Sit_3	Load_Sit_4	Load_Sit_5
Resi_Sit_1 Driver _1	52	**00**	140	45	65
Resi_Sit _2 Driver _2	172	95	110	55	**00**
Resi_Sit _3 Driver _3	**00**	103	68	18	123
Resi_Sit _4 Driver _4	07	30	05	**00**	00
Resi_Sit _5 Driver _5	112	190	**00**	50	105

According to the last table obtained, we notice that each driver has a well-determined assignment, so this last table represents the optimal assignment table.

4- The optimal allocation:

From the optimal table we can read and extract the optimal allocation of the Trans_Logistics company unit of Tiaret as follows:

- Driver_1 makes the journey Load_2 → Unload_2 with a distance equals: 105 Km
- Driver_2 makes the journey Load_5 → Unload_5 with a distance equals: 135 Km
- Driver_3 makes the journey Load_1 → Unload_1 with a distance equals: 137 Km
- Driver_4 makes the journey Load_4 → Unload_4 with a distance equals: 195 Km
- Driver_5 makes the journey Load_3 → Unload_3 with a distance equals: 135 Km

Using the data from table 04 above, the optimal distance (solution) equals: $105 + 135 + 137 + 195 + 135 = 707 \quad Km$.

V- Conclusion:

The management of road transport operations being a field relatively little studied in the past, it seemed necessary to approach this research document with a section or part describing and defining the problem of the Trans_Logistics company unit of Tiaret, the main subject of this research document, namely the planning and assignment and distribution of different drivers to different transport operations.

Through this research document which deals with one of the problems of assignment and distribution of different agents to different tasks, we have contributed to the resolution of the problem of assigning different drivers to different transport operations, of the Trans_Logistics company unit of Tiaret.

We believe we have contributed to advancing an important area of research, but we are also aware that this is only one step towards achieving a more global objective, namely the development of support tools. in decision-making for the management of transport operations.

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VII. Annexes :

Annexe I: Coding of places of residence

Places of residence	The code of the place of residence
Melakou	Resi_Sit _1
Sidi Hosni	Resi_Sit _2
Sougueur	Resi_Sit _3
Takhemart	Resi_Sit _4
Zemoura	Resi_Sit _5

Annexe II: Coding of loading points

Loading location	The loading location code
Frenda	Load_Sit_1
Ain-Merieme	Load_Sit_2
Ain-Kermes	Load_Sit_3
Tiaret	Load_Sit_4
Ain-Mesbah	Load_Sit_5