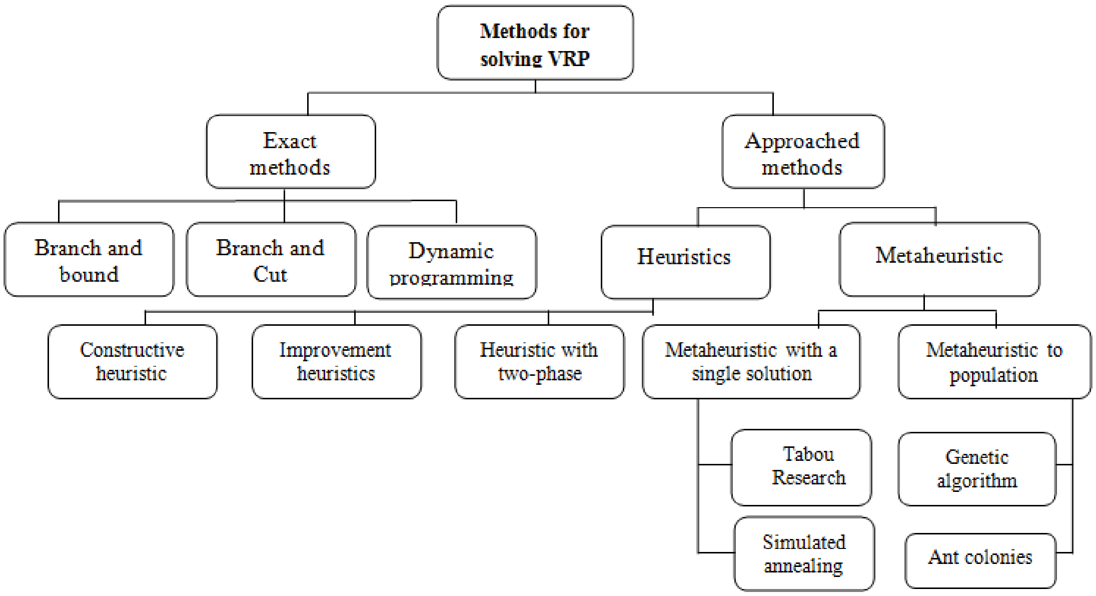

Figure 2. The methods of solving VRP

5. Methodology of resolution

5.1 The delivery network of Fez-Meknes-Oujda region: Current situation

The mail network of the region Fes - Meknes - Oujda account 104 agencies classified by category and distributed on all the regional territory. It covers the region of the north center, of Meknes and the oriental region by the existence of ten regional axes in narrow relation with flat national shape mail. The figure below represents the network of the region Fez - Meknes - Oujda:

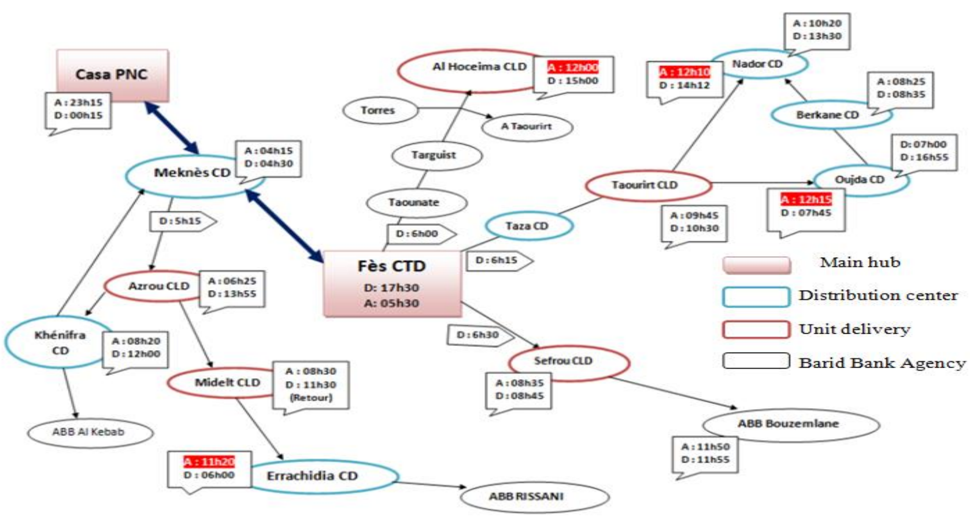

Figure 3. Structure of the delivery network of FMO region[1]

Despite major recent efforts on postal presence, much remains to be done in adapting the network to customer needs. This is evident in the rate of implementation of "time End to End J+1" that represents only 25% while the target is about 80%[2]. Several factors are at the root of this problem, namely:

---

[1]Service order of the Fez-Meknes-Oujda regional transport routes, Operations Department, DR AP Fez-Meknes-Oujda, Postal Activities Center, 2013.
[2] Objective of the Contract Program 2012.

- Delay of arrival of the mails at the center Errachidia CD (Arrival at 11h20 so distribution at J +2);
- Delay of arrival of the mails in Al Hoceima center CLD (Arrival at 12h00);
- Delay of arrival of the mails at the center Oujda CD (Arrival at 12h15) and center Nador CD (Arrival at 12h10);
- Lack of coordination in the routing circuits;
- Inadequate means of transport safe and regular;
- Long stay sort of mails;
- Non-compliance with judgments for the delivery and management of mails;

These problems are opposed to improving the quality of service at the FMO region. Therefore deduced problem is what shook the tactical organization of routing circuits to deliver all nodes at minimum costs and respecting the commitments of quality and timeliness.

5.2 Approximate to a Vehicle Routing Problem with Time Windows

The problem is a generalization of the vehicle routing problem with time windows. The target network consists of about 8 distribution centers, 5 units with a hub for processing and distribution to Fez closely with Casa national platform of mail. The hub Fez is the point of arrival and departure of vehicles. It has a fleet of heterogeneous vehicles which ensures the delivery of mails in each distribution center. And a team of drivers / conveyors handle this transportation network.

5.3 Choice of the method of resolution

To choose the method adequate for solving our problem, we used the criteria grid as a simple tool to aid decision making(Zhi et al., 2009). We chose four types of criteria: the size of the problem, the optimality of the obtained solution, the ease of implementation of the algorithm of resolution and efficiency of the method(Kahraman, 2008). To fill every compartment, we assign to each criterion a value of 1 to 5 according to its importance (Daamen & Phillipson, 2015). The following table shows the grid of criteria for the choice of solving approaches:

Choice / **Criteria**		**Problem size**	**Guaranteed optimality**	**Efficiency**	**Ease of implementation**	Total
Exact Method	Branch and Bound	2	4	3	2	11
	Branch and Cut	2	5	3	2	12
	Dynamic programming	1	5	3	1	10
Heuristics Method	Constructive H	4	1	2	4	11
	H. with two phase	3	2	3	2	10
	Improvement H	4	3	4	4	15
Metaheuristic Method	Single solution	4	3	4	1	12
	M. to population	5	3	5	1	14

Figure 4. Criteria grid

Based on this analysis, the exact methods have allowed finding optimal solutions for problems of reasonable size and generally having difficulties to face large applications (Baldacci et al., 2012). In contrast, the approximate method (heuristic & Metaheuristic) does not guarantee to find an exact solution, but only an approximation. We will retain in terms of quality of solutions, Metaheuristic are generally better than the heuristics; and in terms of ease of implementation the comparison is reversed(Mehrjerdi, 2012). Similarly, if we compare the construction heuristic to improvement heuristic, the first are much faster than the second but produce solutions of lower quality because they are less sophisticated.
As a result of this comparison we decided to use to solve our problem the improvement approaches.

5.4 The improvement heuristics

Improvement heuristics for the VRP operate on each vehicle route taken separately or on several routes at a time. In the first case, any improvement heuristic for the TSP can be applied. In the second case, procedures that exploit the multi-route structure of the VRP can be developed (Stålhane et al., 2012).
This method starts in part of an initial solution which is successively replaced by a continuation of solutions of decreasing costs. The process stops when we cannot improve any more the common solution. The main advantage

of this method lives in its big simplicity and its speed. Among the operators of exchanges most usually used we have (Mahmudy, 2016) :

- String Cross (SC): Two strings (or chains) of vertices are exchanged by crossing two edges of two different routes.
- String Exchange (SE): Two strings of at most k vertices are exchanged between two routes.
- String Relocation (SR): A string of at most k vertices is moved from one route to another, typically with k= 1or 2 (Stålhane et al., 2012).
- String Mix(SM): The best move between SE and SR is selected (Fleszar, 2013).

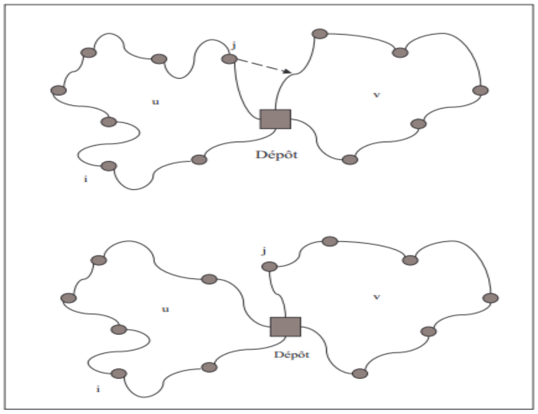

Figure 5. Example of process improvement

6. Trying to solve the VRPTW using the improvement heuristics

6.1 Preliminary Steps

Before presenting the scenarios change, it is useful to recall the method that was used to calculate the transport cost of each axis, as well as planning tour routing.

- **Calculate the cost of Transport**

Any routing operation generates during the course costs that accumulate, it is transportation costs that can be analyzed and divided into two types (Pettersson & Segerstedt, 2013) :

- **The fixed costs**: these are the ones that the company has to bear any level of business; they represent vehicle insurance, rental prices, and wages for drivers, administrative expenses.... etc.
- **The variable costs**: were those which vary depending on the use of the vehicle, namely: fuel consumption, tire wear, spare parts, tolls, maintenance and repair.

Cost of transport = Unit cost of Transport * Distance in kilometers

To calculate the unit cost of each vehicle k, for the data available, we have taken into account the consumption of fuel, salaries of driving, tolls, maintenance cost of vehicles and the rental cost.

6.2 In search of optimal planning - Set of scenarios

Starting from an initial situation of the network routing, we identify the optimal organization through a set of scenario has on the basis of available data, to simulate configurations in which the cost of transport is a very important criterion from an economic point of view, while the compliance of time windows, within each distribution site, is a crucial point for quality of service.

a) Scenario 1:

This configuration is to improve the scheduling of national axis Fez - Casa in particular. Specifically, we removed the distribution center Meknes CD back to reduce the time of arrival of the vehicle at the center Fez CTD. That gives birth to two new regional axes: Fez - Khenifra - Midelt. Service orders will be the same as in the initial situation of the network routing for axes Fez-Taourirt, Fez-Boulmane, Taourirt-Oujda, Nador and Oujda-Nador-Taourirt-Bni Anzer. All delivery vehicles leave and return to the treatment center Fez CTD except for Fez axis - Khenifra, the return will stop at Meknes CD. The following diagram illustrates this new organization:

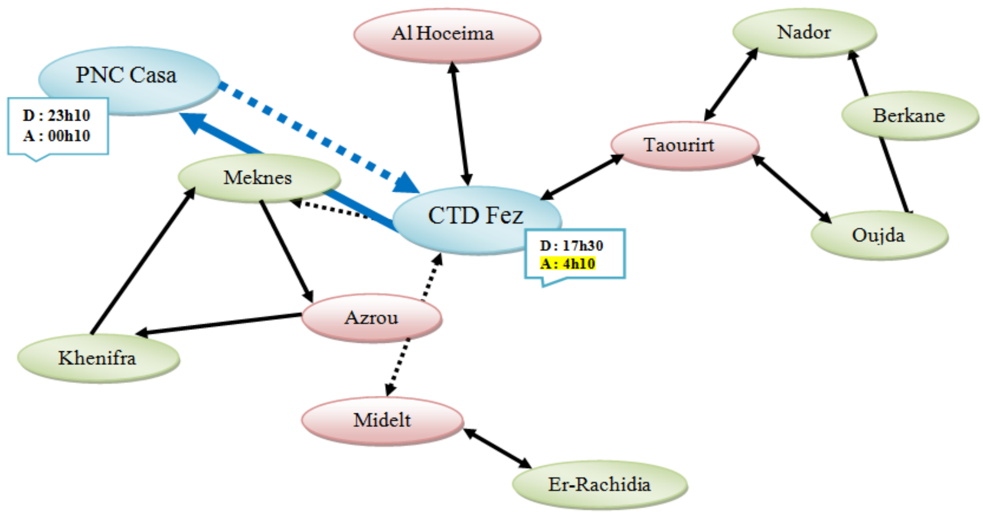

Figure 6. Schematic description of Scenario 1

- Order Service of regional axes:

Axe	Former departure	New departure	Former arrival	New Arrival	Back to the center
Fez – Al Hoceima	6h00	4h40	12h00	10:30	19h20
Fez – Midelt	4h30	4h35	8h30	8h10	15h10
Errachidia - Midelt	6h00	5h40	8h30	8h10	10h30
Fez – Meknes – Khenifra	5h15	5h00	8h20	9h40	15h45
Fez – Taourirt	6h15	5h00	9h40	7h45	13h20
Fez – Boulmane	6h30	5h30	11h50	10h50	15h00
Oujda – Taourirt	7h45	5h45	9h45	7h45	10h15
Taourirt – Nador – Bni Anzer	10h30	8h30	12h10	10h10	17h00
Oujda – Nador	7h00	10h30	10h20	13h50	20h25

Table 1. Scenario 1 - Chronology of regional axes

b) Scenario 2:

To address the problem of delay between the arrival time of the vehicle bringing the news of the distribution cell Al Hoceima and the departure time of the vehicle of the national focus, we proposed a second scenario always with the aim of improving the quality of service within the network region of the FMO. It's to create a direct contact between the national platform of mail and regional platform Fez CTD, this through the elimination of Meknes center in both directions. Dispatches reaching the Al Hoceima cell and its regions will also be sent with shipments from other regions on the same day of arrival at Fez regional center since the departure time of the vehicle of the national focus at 19h30. Configuring routing axes of the second scenario is shown in the following figure:

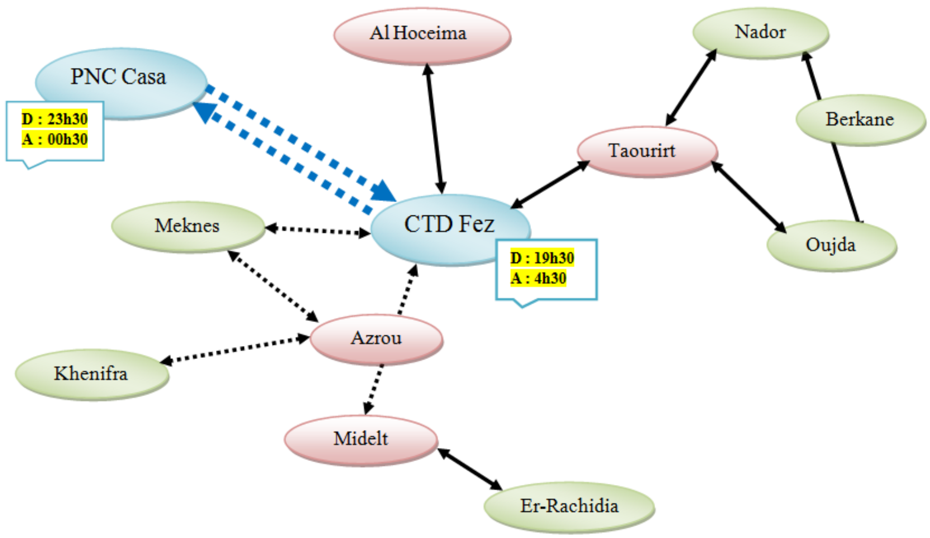

Figure 7. Schematic representative scenario 2

- Service Order of regional axes:

Axe	Former departure	New departure	Former arrival	New Arrival	Back to the center
Fez – Al Hoceima	6h00	4h45	12h00	10:35	19h25
Fez – Midelt	4h30	4h35	8h30	8h10	15h10
Errachidia - Midelt	6h00	5h40	8h30	8h10	10h30
Fez – Meknes – Khenifra	5h15	5h00	8h20	9h40	17h00
Fez – Taourirt	6h15	5h15	9h40	8h00	13h35
Fez – Boulmane	6h30	5h30	11h50	10h50	15h00
Oujda – Taourirt	7h45	6h00	9h45	8h00	10h30
Taourirt – Nador – Bni Anzer	10h30	8h45	12h10	10h25	17h15
Oujda – Nador	7h00	10h45	10h20	14h05	20h40

Table 2. Scenario 2 - Chronology of regional axes

6.3 Analysis results

This table summarizes the results obtained in the two scenarios presented earlier:

Axe	Scenario 1	Scenario 2
	Cost of transport (Dh/day)	Cost of transport (Dh/day)
Fez – Casa PNC	3190	3184
Fez – Al Hoceima	1437	1437
Fez – Midelt	1071	1071
Errachidia - Midelt	693	693
Fez – Meknes – Khenifra	785	903
Fez – Taourirt	2052	2052
Fez – Boulmane	1329	1329
Oujda – Taourirt	762	762
Taourirt – Nador – Bni Anzer	791	791
Oujda – Nador	961	961
Total	**13 071**	**13184**
Initial Cost of transport = 13690 Dh /day	**Reduction of 5%**	**Reduction of 4%**

Table 3. Cost of transport in scenarios 1 and 2

From the results, we see that the first scenario, even if it achieves the minimum cost, not clenched probably not viewed favorably, as the news reached Al Hoceima cell arrive late with respect to time of departure of the vehicle ensuring the delivery of national focus. For cons, the second scenario modeled the operation of the network in order to satisfy all the constraints of time and availability, so all items will be shipped the same day of their arrival at the Fez treatment center. Therefore, it is of interest to choose the second scenario.

7. Conclusion

This article has highlighted the different elements of routing problem in the FMO region. It fits within the vehicle routing problems with time windows. So in this work, we have presented a state-of-the-art about vehicle routing problems (VRP). We then presented the possible methods of resolution proposed in the literature. We have studied the case of the Moroccan post office for postal delivery in the Fes-Meknes-Oujda region. We have tried to improve the postal routing network by using the improvement heuristic based on a set of scenarios in order to arrive at a tactical planning of routing network and efficient management of vehicle fleet while respecting in the same time quality, time and cost constraints.

The main contribution of this work is to provide workable solutions to a real case of distribution. Among other things, network optimization product to potential savings in time and distance while promoting efficient use of transport vehicles.

REFERENCES

Baldacci, R., Mingozzi, A., & Roberti, R. (2012). Recent exact algorithms for solving the vehicle routing problem under capacity and time window constraints. *European Journal of Operational Research*, *218*(1), 1–6. https://doi.org/10.1016/j.ejor.2011.07.037

Braekers, K., Ramaekers, K., & Van Nieuwenhuyse, I. (2016). The vehicle routing problem: State of the art classification and review. *Computers and Industrial Engineering*. https://doi.org/10.1016/j.cie.2015.12.007

Daamen, R., & Phillipson, F. (2015). Comparison of heuristic methods for the design of edge disjoint circuits. *Computer Communications*, *61*, 90–102. https://doi.org/10.1016/j.comcom.2015.01.001

Fleszar, K. (2013). Three insertion heuristics and a justification improvement heuristic for two-dimensional bin packing with guillotine cuts. *Computers and Operations Research*, *40*(1), 463–474. https://doi.org/10.1016/j.cor.2012.07.016

Kahraman, C. (2008). Multi-Criteria Decision Making. *Fuzzy Multi-Criteria Decision Making*, 1–18. https://doi.org/10.1016/j.prevetmed.2010.06.010

Kim, G., Ong, Y. S., Heng, C. K., Tan, P. S., & Zhang, N. A. (2015). City Vehicle Routing Problem (City VRP): A Review. *IEEE Transactions on Intelligent Transportation Systems*, *16*(4), 1654–1666. https://doi.org/10.1109/TITS.2015.2395536

Lambert, V., Laporte, G., Louveaux, F., & Sebag, A. (2015). VRP. *ACM SIGGRAPH 2015 Computer Animation Festival*, *20*(7), 156. https://doi.org/10.1145/2745234.2746797

Liu, R., Xie, X., Augusto, V., & Rodriguez, C. (2013). Heuristic algorithms for a vehicle routing problem with simultaneous delivery and pickup and time windows in home health care. *European Journal of Operational Research*, *230*(3), 475–486. https://doi.org/10.1016/j.ejor.2013.04.044

Mahmudy, W. F. (2016). Improved Simulated Annealing for Optimization of Vehicle Routing Problem With Time Windows (VRPTW). *Kursor*, *7*(3), 109–116. https://doi.org/10.21107/KURSOR.V7I3.1092

Matai, R., Singh, S., & Lal, M. (2010). Traveling Salesman Problem: an Overview of Applications, Formulations, and Solution Approaches. In *Traveling Salesman Problem, Theory and Applications*. https://doi.org/10.5772/12909

Mehrjerdi, Y. Z. (2012). Vehicle Routing Problem: Meta-heuristic Approaches. *International Journal of Applied Operational Research Journal*, *2*(3), 55–68.

Pettersson, A. I., & Segerstedt, A. (2013). Measuring supply chain cost. In *International Journal of Production Economics* (Vol. 143, pp. 357–363). https://doi.org/10.1016/j.ijpe.2012.03.012

Soonpracha, K., Mungwattana, A., Janssens, G. K., & Manisri, T. (2014). Heterogeneous VRP review and conceptual framework. *Proceedings of the International MultiConference of Engineers and Computer Scientist*, *II*. Retrieved from https://uhdspace.uhasselt.be/dspace/handle/1942/17715

Stålhane, M., Rakke, J. G., Moe, C. R., Andersson, H., Christiansen, M., & Fagerholt, K. (2012). A construction and improvement heuristic for a liquefied natural gas inventory routing problem. *Computers & Industrial Engineering*, *62*(1), 245–255. https://doi.org/10.1016/j.cie.2011.09.011

Zhi, J., Liu, J. Y., Yu, J., Jing, L., & Du, H. L. (2009). VRP problem with time windows in the logistics and distribution solved by immune ant colony algorithm. In *Proceedings of the 1st International Workshop on Education Technology and Computer Science*, *ETCS 2009* (Vol. 2, pp. 692–696). https://doi.org/10.1109/ETCS.2009.414

Zhi, L. M., Zhi, J., Zhi, D., Yu, J., & Song, L. P. (2009). VRP problem with time windows in the logistics and distribution solved by immune genetic algorithm. In *2009 International Workshop on Intelligent Systems and Applications*, *ISA 2009*. https://doi.org/10.1109/IWISA.2009.5073234