1) Introduction

The Home Care Service (HCS) is mainly dedicated to dependent people such as citizens who have difficulty leaving their homes by offering them social, medico-social, and medical services such as cleaning, cooking, shopping, hygiene assistance, nursing, etc. These types of services are provided by different public and private home care structures. In the literature, many issues relative to Home Care Service HCS are considered such as the geographical partitioning of a territory into districts (Benzarti et al., 2013), the assignment of human resources to districts (Hertz and Lahrichi, 2006), and the daily resources routing and scheduling that consists of assigning resources to clients and designing the optimal sequence of visits (Gayraud et al., 2013; Frifita et al., 2017).

We focus in this paper on the routing and scheduling problem that is modeled as a VRPTW with Synchronized visits in (Bredstrôm and Rônnqvist, 2008). The authors dealt with the problem for one center and provided a MIP and a benchmark that has been considered by several researchers (Afifi et al, 2016; Frifita et al., 2017). We extended the MIP of Bredstrôm and Rônnqvist (2008) to deal with a new variant that we called VRPTW-TD-2MS (VRPTW with multiple structures, multiple specialties and temporal dependencies). We generated new instances based on a real case from France and the rules used to generate the benchmark in Bredstrôm and Rônnqvist (2008).

2) The solving techniques

To solve the VRPTW-S problem, we proposed a set of meta-heuristics: a GA, a Hybrid GA coupling GA with a Pipe VND, three nested VND, two mixed VND, and a Generalized VNS algorithm. The VND algorithm incorporates two local search techniques (Local Search Insertion and Local Search Swap) based on four neighborhood structures including insertion move and swap move, between different routes and inside the same route. The Pipe VND serves as a local search technique and the N-VND and M-VND algorithms serve as independent meta-heuristics. To get the Hybrid GA, we incorporated the P-VND algorithm as a local search strategy just after the mutation in the AG general scheme. We limit the application of P-VND to descendent children with good quality solution less or equal to a threshold. This contributes to accelerate the convergence of our algorithm by reducing time spent in exploring non fructuous search space. To get the GVNS, the P-VND is introduced as a local search in the VNS descent phase.

The studied problem is NP Hard, and for many instances in the benchmark, the optimum is not obtained. The relaxation of some constraints could be useful to get interesting results in low computation time. Thus, we relaxed hard constraints, in particular time window, horizon and synchronization, and added a degree of violation of these constraints to the objective function, with low penalties for time window and horizon violations and high penalty for synchronization. This idea is applied on all the provided algorithms.

To solve this new problem we proposed a mathematical model and three metaheuristics: VNS, a Generalized VNS and GVNS with EC. The mathematical model is a generalization of the MIP provided in Bredstrom and Ronnqvist (2008) to additional constraints and multi-structures. The GVNS-EC is a hybridization of VNS with several local search techniques: two inside the VNS and one just after the VNS.

3) Computational results:

We first tested our algorithms on the benchmark instances of Bredstrom and Ronnqvist (2008) about the VRPTW-S. Then, new instances have been generated to deal with VRPTW-TD-2MS. We based on the benchmark of Bredstrôm and Rônnqvist, (2008).

For VRPTTW-S: Our algorithms are compared to the SA-ILS of Afifi et al. (2016) in terms of solution quality and CPU-time (see fig 1)

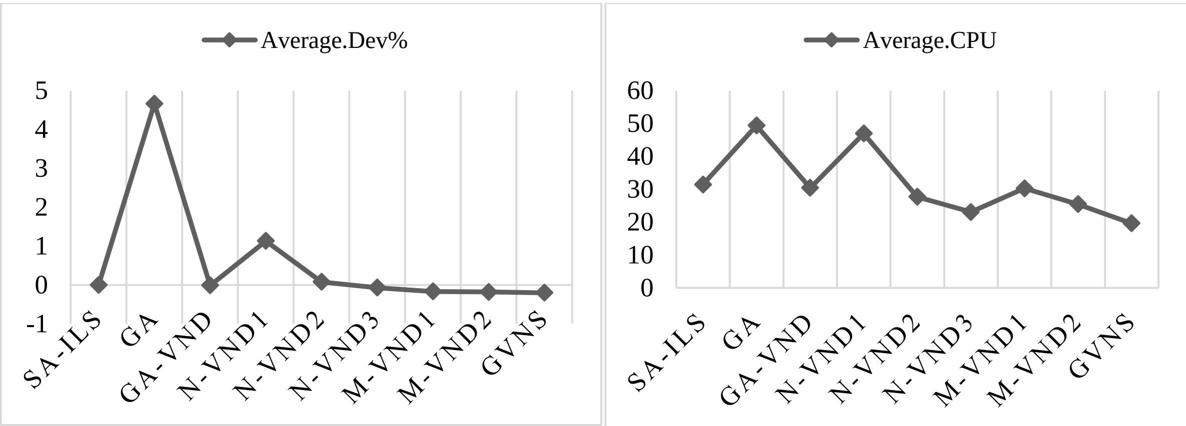

Fig.1: Average Dev% and average CPU for the VRPTW- S

To recognize if the difference in the performance between the meta-heuristics is significant, we applied statistical analysis such as ANOVA and Tukey test. The results show that at least one meta-heuristic is different from at least one other meta-heuristic.

The algorithms GVNS, M-VND2, M-VND1, NVND3 and GA-VND outperform the SA-ILS, and the N-VND2 is competitive in both effectiveness and efficiency.

For the VRPTW-TD-2MS: the three meta-heuristics are compared to the MIP that have been solved with Cplex solver considering a limit of CPU equal to 1h. For most of the test instances, Cplex finds a feasible or optimal solution within one hour, but we get Out of Memory for several big instances.

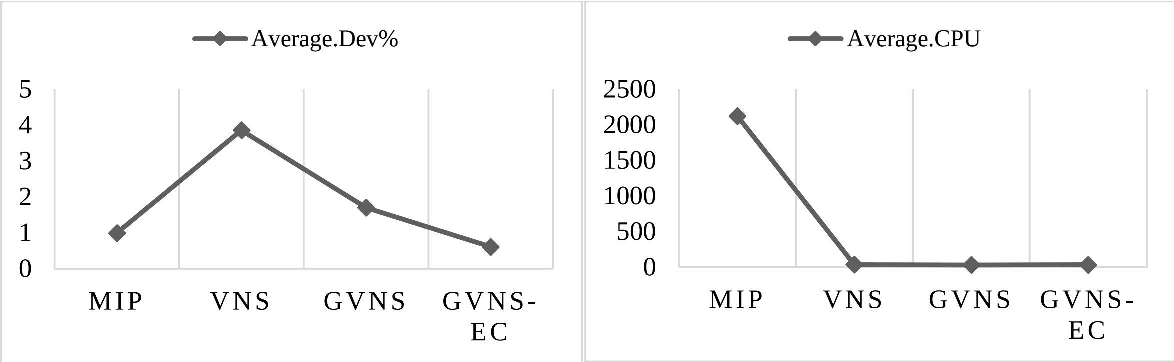

Fig.2: Average Dev% and average CPU for the VRPTW-TD-2MS

The GVNS-EC algorithm outperforms the MIP and the other algorithms in terms of objective value and CPU time.

4) Conclusion

We considered the problem of Home care routing and scheduling and treated two variants: VRPTW-S while considering one Home care structure, and VRPTW-TD-2MS while considering multi-structures and additional realistic constraints. We provided several efficient meta-heuristics to deal with VRPTW-S, and provided a MIP and several meta-heuristics to deal with VRPTW-TD-2MS. We showed the efficiency and effectiveness of our algorithms. As perspective, we plan to integrate other realistic constraints, e.g., regulations, electric vehicles etc., and develop multi-objective studies by including preference and fairness as objective functions.

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