



HAL
open science

NGAP: a novel hybrid metaheuristic algorithm for round-trip carsharing fleet planning

Boonyarit Changaival, Grégoire Danoy, Dzmitry Kliazovich, Frédéric Guinand, Matthias Brust, Jędrzej Musiał, Kittichai Lavangnananda, Pascal Bouvry

► To cite this version:

Boonyarit Changaival, Grégoire Danoy, Dzmitry Kliazovich, Frédéric Guinand, Matthias Brust, et al.. NGAP: a novel hybrid metaheuristic algorithm for round-trip carsharing fleet planning. GECCO '20: Genetic and Evolutionary Computation Conference, Jul 2020, Cancún (on line), Mexico. pp.259-260, 10.1145/3377929.3389941 . hal-03352610

HAL Id: hal-03352610

<https://hal.archives-ouvertes.fr/hal-03352610>

Submitted on 23 Sep 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

NGAP: a novel hybrid metaheuristic algorithm for round-trip carsharing fleet planning

Boonyarit Changaival, Grégoire Danoy, Dzmitry Kliazovich, Frédéric Guinand, Matthias Brust, Jędrzej Musiał, Kittichai Lavangnananda, Pascal Bouvry

► To cite this version:

Boonyarit Changaival, Grégoire Danoy, Dzmitry Kliazovich, Frédéric Guinand, Matthias Brust, et al.. NGAP: a novel hybrid metaheuristic algorithm for round-trip carsharing fleet planning. GECCO '20: Genetic and Evolutionary Computation Conference, Jul 2020, Cancún, Mexico. pp.259-260, 10.1145/3377929.3389941 . hal-03352610

HAL Id: hal-03352610

<https://hal.archives-ouvertes.fr/hal-03352610>

Submitted on 23 Sep 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

NGAP: A Novel Hybrid Metaheuristic Algorithm for Round-trip Carsharing Fleet Planning

Boonyarit Changaival
SnT, University of Luxembourg
Luxembourg
boonyarit.changaival@uni.lu

Grégoire Danoy
SnT, FSTM/DCS University of
Luxembourg
Luxembourg
gregoire.danoy@uni.lu

Dzmitry Kliazovich
Oply S.A.
Luxembourg
kliazovich@ieeee.org

Frédéric Guinand
Le Havre University of Normandy
France
frederic.guinand@univ-lehavre.fr

Matthias R. Brust
SnT, University of Luxembourg
Luxembourg
matthias.brust@uni.lu

Jedrzej Musial
Poznan University of Technology
Poland
jedrzej.musial@cs.put.poznan.pl

Kittichai Lavangnananda
King Mongkut's University of
Technology Thonburi, Thailand
kitt@sit.kmutt.ac.th

Pascal Bouvry
SnT, FSTM/DCS, University of
Luxembourg
Luxembourg
pascal.bouvry@uni.lu

ABSTRACT

The growing awareness of the environmental movement greatly influences the transportation scene of this century leading to several transportation alternatives. One among them is carsharing service which has been gaining traction and support in major cities around the globe. It is also undeniable that the location planning of the fleet vehicles can contribute to its success. The fleet vehicles must be easily accessed and in the proximity of various transportation hubs and facilities. In this paper, we study the Vehicle Placement Problem (VPP) for round-trip carsharing and propose a novel hybrid algorithm, NGAP, which is a combination of NSGA-III and Pareto Local Search (PLS) to enhance the quality of the results over NSGA-III. The proposed algorithm is tested on 10 synthetic and four real-world instances. NGAP is shown to be significantly more efficient than NSGA-III on almost all instances in terms of Inverted Generational Distance (IGD), and Hypervolume.

CCS CONCEPTS

• **Applied computing** → **Transportation**; • **Computing methodologies** → **Optimization algorithms**;

KEYWORDS

Carsharing, Hybridization, Multi-objective Optimization, Vehicle Placement

ACM Reference Format:

Boonyarit Changaival, Grégoire Danoy, Dzmitry Kliazovich, Frédéric Guinand, Matthias R. Brust, Jedrzej Musial, Kittichai Lavangnananda, and Pascal Bouvry. 2020. NGAP: A Novel Hybrid Metaheuristic Algorithm for Round-trip Carsharing Fleet Planning. In *Genetic and Evolutionary Computation Conference Companion (GECCO '20 Companion)*, July 8–12, 2020, Cancún, Mexico. ACM, New York, NY, USA, 2 pages. <https://doi.org/10.1145/3377929.3389941>

1 INTRODUCTION

Efficient fleet planning management is crucial for carsharing services. However, such planning is currently done manually which is laborious and often leads to inefficient solutions. The Vehicle Placement Problem (VPP), first introduced in [1], considers three common objectives usually are, 1. maximization of user coverage (i.e., to identify the highly populated areas), 2. minimization of number of vehicles used and 3. maximization of public transportation coverage (i.e. satisfying users requirements). In this paper, a novel hybrid metaheuristic algorithm based on NSGA-III and Pareto Local Search (PLS), abbreviated as NGAP, and a novel local search operator Extensible Neighborhood Search (ENS) are proposed. Hybridization is a method to combine two or more algorithms and make them collaborate with each other [6] and there has been attempts to continuously improve the hybridization of algorithms [3, 4] over the past decade. Nevertheless, three facets still presents major obstacles. These are, determination of suitable priorities for objectives, implementation of a suitable local search operator and determination of the size of search neighborhood.

2 VEHICLE PLACEMENT PROBLEM (VPP)

A vehicle is placed on a location on a street node $S = \{s_1, s_2, \dots, s_j\}$. The maximum walking distance from a building to a station is d . Users start the trip from their residences. The number of users p_j is

associated with the building b_j . Public transportation t_k has an importance factor of w_k . The coverage of each location s_i for buildings $B = \{b_1, b_2, \dots, b_j\}$ and public transportation $T = \{t_1, t_2, \dots, t_k\}$ is defined in matrices E and G .

$$\begin{aligned} & \text{Maximize} && \sum_{j=1}^m (e_j \times p_j) \\ & \text{Minimize} && \sum_{i=1}^n s'_i \\ & \text{Maximize} && \sum_{k=1}^q (g_k \times w_k) \\ & \text{Subject To} && e_j = E_{ij} \times s'_i \quad (1) \\ & && g_k = G_{i,j} \times s'_i \quad (2) \\ & && x \leq \sum_{i=1}^n s'_i \leq y \quad (3) \\ & && s'_i, e_j, g_k \in \{0, 1\} \quad (4) \\ & && n, x, y, m, q \in \mathbb{Z}^+ \quad (5) \\ & && d \in \mathbb{Z}^{\geq 0} \quad (6) \end{aligned}$$

Constraint 1 indicates that a building b_j can be covered by multiple vehicle locations and ensures that a building b_j is considered only once during the calculation. Constraint 2 is similar to constraint 1, but for public transport. Constraint 3 signifies the lowest and highest number of selected vehicle location allowed. Finally, constraints 4 – 6 define the domains of the variables and parameters.

3 METHODOLOGY

NGAP is the combination of NSGA-III [2] based algorithm with Pareto Local Search (PLS) [5] which is classified as low-level teamwork hybrid (LTH) as defined in [6]. PLS is activated at every predetermined generation or time to deploy a problem-specific local search operator, Extensible Neighborhood Search (ENS).

ENS utilizes the concept of neighborhood in graph theory. There are three main processes in ENS which are *Add* (to maximize coverage), *Remove* (to minimize vehicle number) and *Improve* (to maximize coverage). These processes use Pareto-dominance to add higher coverage locations, remove redundant low coverage locations, and relocate to higher coverage location respectively. There are two parameters, *MaxHop* and *MinHop*. In add, the considered neighbors are the subtraction of neighborhood from *MaxHop* and *MinHop*, while the other processes' consider only neighborhood from *MinHop*. These processes are executed sequentially on all locations on all solutions. The local search operator is terminated once the solution cannot be improved further, or reach a predetermined number of iterations.

4 EXPERIMENTAL RESULTS

We compare NGAP and NSGA-III on 10 synthetic and four real-world instances, but for ease of understanding, only the city Hamburg is shown here. In terms of the Inverted Generational Distance (IGD) metric (lower value of IGD indicates better convergence), NGAP dominates the original NSGA-III in 13 test instances. An example of Hamburg instance is shown in Fig. 1. With respect to

the Spread indicator, both algorithms yield comparable spread in all experimental instances. This is to be expected since the objective of local search is not to increase the diversity to the population but to improve the coverage and minimize the vehicle number (reflect the convergence). The same trend as in IGD also appears in when comparing the Hypervolume (the higher value of Hypervolume indicates better convergence and diversity) as shown in Fig. 1. The proposed NGAP is superior to the original NSGA-III in all experimental instances.

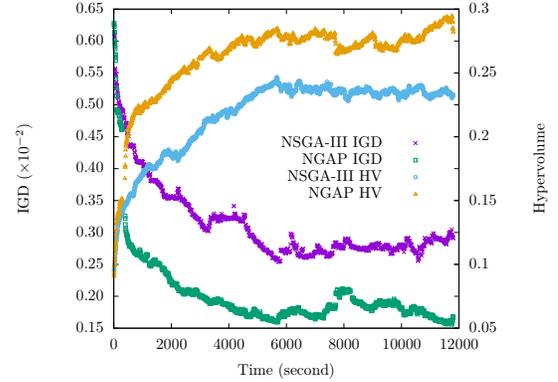


Figure 1: Generational plot of IGD and Hypervolume of each algorithm on Hamburg instance.

5 CONCLUSION

In the paper, a novel hybrid metaheuristic algorithm, NGAP, which is based on NSGA-III and Pareto local Search (PLS) is proposed. It is able to provide effective solutions to the Vehicle Placement Problem (VPP). NGAP also utilizes a novel local search operator called Extensible Neighborhood Search (ENS). Comparisons between the proposed algorithm and NSGA-III were performed on 10 synthetic and four real-world cities where the well known metrics, IGD, Spread and Hypervolume were used. The results reveal that NGAP is superior to NSGA-III in Vehicle Placement Problem. The work reaffirms the effort of hybridization of MOEAs and merits further studies in this field.

REFERENCES

- [1] Boonyarit Changaival, Grégoire Danoy, Dzmitry Kliazovich, Frédéric Guinand, Matthias R Brust, Jędrzej Musiał, Kittichai Lavangnananda, and Pascal Bouvry. 2019. Toward real-world vehicle placement optimization in round-trip carsharing. In *Proceedings of the Genetic and Evolutionary Computation Conference*. 1138–1146.
- [2] Kalyanmoy Deb and Himanshu Jain. 2014. An evolutionary many-objective optimization algorithm using reference-point-based nondominated sorting approach, part I: Solving problems with box constraints. *IEEE Trans. Evolutionary Computation* 18, 4 (2014), 577–601.
- [3] Hisao Ishibuchi and Tadahiko Murata. 1998. A multi-objective genetic local search algorithm and its application to flowshop scheduling. *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)* 28, 3 (1998), 392–403.
- [4] Andrzej Jaskiewicz. 2002. Genetic local search for multi-objective combinatorial optimization. *European journal of operational research* 137, 1 (2002), 50–71.
- [5] Luis Paquete, Marco Chiarandini, and Thomas Stützle. 2004. Pareto local optimum sets in the biobjective traveling salesman problem: An experimental study. In *Metaheuristics for multiobjective optimisation*. Springer, 177–199.
- [6] El-Ghazali Talbi. 2009. *Metaheuristics: from design to implementation*. Vol. 74. John Wiley & Sons.