6TH INTERNATIONAL CONFERENCE ON

VARIABLE NEIGHBORHOOD SEARCH

VNS 2018

6th International Conference on Variable Neighborhood Search

Sithonia, Halkidiki, Greece

October 4-7, 2018

http://vns2018.uom.gr

Organizers:

University of Macedonia Research Committee

CMOR Computational Methodologies & Operations Research

EWG EU/ME Metaheuristics

EU/ME

EURO

Sponsors:

GERAD

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Marathon Data Systems

TZIOLA PUBLICATIONS

6^{th} International Conference on Variable Neighborhood Search

Edited by:

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http://www.uom.gr

Thessaloniki, Greece, 2018

Contents

Preface

This book compiles the full program and the abstracts of the papers accepted for presentation at the 6th International Conference on Variable Neighborhood Search (ICVNS) that was held in Sithonia, Halkidiki, Greece (Porto Carras Meliton Hotel), during October 4-7, 2018.

The ICVNS is devoted to the Variable Neighborhood Search (VNS) metaheuristic which was proposed by Nenad Mladenović and Pierre Hansen in 1997. VNS is a metaheuristic based on systematic changes in the neighborhood structure within a search, for solving optimization problems and related tasks. Currently, VNS is consolidated as a general framework to solve hard optimization problems and has been successfully applied for solving many discrete and global optimization problems.

The main goal of the ICVNS 2018 is to provide a stimulating environment in which researchers coming from various scientific fields can share and discuss their knowledge, expertise and ideas related to the VNS Metaheuristic and its applications. The conference follows previous successful meetings that were held in Puerto de La Cruz, Tenerife, Spain (2005); Herceg Novi, Montenegro (2012); Djerba, Tunisia (2014); Malaga, Spain (2016); Ouro Preto, Brazil, (2017).

We would like to highlight that, the proceedings of this edition of the conference will be published in the Lecture Notes in Computer Science series, by Springer. Also, ICVNS 2018 will be supported by two special issues associated with it: Journal of Global Optimization (indexed in JCR) and Optimization Letters (indexed in JCR).

Finally, we would like to thank all the participants in the conference for their contributions and for their continuous effort to disseminate VNS.

Thessaloniki,
October, 2018

Angelo Sifaleras

Organizers & Sponsors

Organizers

In a rapidly changing world, the University of Macedonia (UOM) ought to be in the foreground of innovation, extroversion and excellence relying on terms of social sensitivity and inclusion. Heading for its seventh decade of operation, the University of Macedonia is currently developing into an extrovert, innovative and bold academic institution placing teaching and research as its highest priorities rooted on solid and transparent qualification criteria. At the same time it is a well organized, functional, clean and student-friendly institution, defining its own identity, which is acknowledged by both the local and the wider Greek society.

EWG EUME, the EURO Working Group on Metaheuristics is a working group the main purpose of which is to provide a platform for communication among researchers in the field of metaheuristic optimization, practitioners interested in applying metaheuristic optimization techniques in practice, developers of optimization software, and the general public. EUME is the largest working group on metaheuristics worldwide, uniting over 1400 members from over 80 countries. EUME is officially sanctioned and financially supported by EURO, the Association of European Operational Research Societies.

The Computational Methodologies & Operations Research (CMOR Lab) supports educational and research activities of the Department of Applied Informatics in the following scientific fields: Optimization and Decision Making, High Performance Scientific Computations, Intelligent Agents, Cryptography, Machine Learning, Statistical Theory and Applications with Emphasis on Analysis of Large Data, Statistical Theory and Applications with emphasis on computational statistics, Algorithm Design and Analysis, Planning and Scheduling, and Artificial Intelligence.

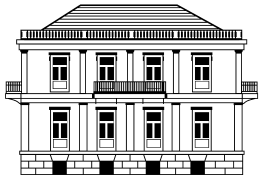
Sponsors

GERAD is a multi university research center founded in 1979. It involves some seventy experts from a mix of disciplines: quantitative methods for management, operations researchers, computer scientists, mathematicians and mathematical engineers, from HEC Montréal, Polytechnique Montréal, McGill University and Université du Québec à Montréal.

DIMOULAS Special Cables is the market leader in the supply of special cables to the Greek market. The company covers the demand for any type of cable from data cables for computer networks to power and instrumentation cables for the oil, gas, petrochemical and energy related industry.

Marathon Data Systems has been active in the Geographic Information Systems(GIS) market exclusively for over 20 years and was the pioneer in introducing the GIS to Greece and Cyprus. MDS is the official distributor of ESRI's products (ArcInfo - ArcView - ArcGIS Server GIS), both in Greece and internationally. ArcGIS is being currently used in the Public Sector, Local Authorities, Private and Academic sector with applications in several domains.

TZIOLA Publications have been active since 1978 and publish quality textbooks for Higher Education.



The Museum for the Macedonian Struggle is a historical museum. It presents the local history and cultural identity of Macedonia, keeping alive the memory of the struggles of Hellenism and highlighting the role of ordinary people who left indelible traces in a diverse cultural heritage. With the tours one discovers a lesser known but ideologically charged chapter of the Greek and Balkan history of the late 19th and early 20th centuries.

Committees

Conference Chairs

- Nenad Mladenović, Mathematical Institute, Serbian Academy of Sciences and Arts, Serbia (General chair).
- Pierre Hansen, GERAD and HEC Montreal, Canada (Honorary Chair).
- Angelo Sifaleras, University of Macedonia, Greece (Conference chair).

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- Chandra Irawan - Nottingham University Business School, China.
- Christos D. Tarantilis - Athens University of Economics, Greece.
- Daniel Aloise - GERAD, Montréal, Canada.
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- Dragoš Cvetković - Mathematical Institute SANU, Serbia.
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- Ioannis Refanidis - University of Macedonia, Greece.
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- Leo Liberti - LIX Ecole Polytechnique, Paris, France.
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- Thomas Stützle - Free University of Brussels, Belgium.
- Vera Kovačević-Vujčić - Faculty of Organizational Sciences, University of Belgrade, Serbia.
- Vitor Nazário Coelho - UFF, Brazil.
- Yannis Marinakis - Technical University of Crete, Chania, Greece.
- Yuri Kochetov - Novosibirsk, Russia.

Local Committee

- Nikolaos Tsaousis (Theocharidou Travel).
- Soula Theocharidou (Theocharidou Travel).

Publications

Proceedings

Revised selected, peer reviewed, papers will be published by Springer as a post-conference proceeding volume in its Lecture Notes in Computer Science series (2017, SJR: 0.295). Submissions should be uploaded using the Springer Online Conference Service (OCS): `https://ocs.springer.com/ocs/home/ICVNS2018`.

Special Issues

Two special issues, of the Journal of Global Optimization and the Optimization Letters, will be dedicated to significantly extended and improved versions of the papers presented at the ICVNS 2018 conference. All papers will be, peer reviewed, according to the journal standards.

Cfp: Special issue on "*Novel Variants & Emerging Applications of Variable Neighborhood Search*" of the **Journal of Global Optimization**

Variable Neighborhood Search (VNS) is a metaheuristic which has shown to be very successful for solving hard combinatorial and global optimization problems.

During the 6th International Conference on Variable Neighborhood Search (ICVNS 2018) which will be held in Halkidiki, Greece (Porto Carras Meliton Hotel) October 4-7, 2018, researchers from all around the world are going to present their most recent findings on VNS, either from a methodological viewpoint or as applications to real world problems.

A special issue of Journal of Global Optimization (I.F.: 1.733, SJR: 1.311) will be edited after the conference. Manuscripts should be prepared in LaTeX and submitted through the journal's editorial manager `http://jogo.edmgr.com`. Please use Springer's LaTeX macro package and choose the formatting option "smallextended".

The final submission should include the original source (including all style files and

figures) and a .pdf version of the compiled output. Submission system opens on October 8, 2018, and the paper submission deadline is December 31, 2018. Select "SI: VNS-2018" for the paper type when submitting your contribution. All papers will go through a regular peer review process.

Authors of papers that will presented at the forthcoming ICVNS 2018 are especially encouraged to submit their work to this special issue. However, the issue will be open to all researchers who can contribute to a better knowledge of VNS. Potential topics include, but are not limited to:

Theory and Methodology:

- Theoretical or empirical analysis of VNS
- New variants of deterministic and stochastic VNS
- Continuous global VNS
- Mat-heuristics and VNS
- Formulation space VNS
- Multi-objective VNS
- Parallel VNS
- VNS hybrids

Applications:

- Mixed integer programming
- Graphs, communication networks
- Clustering, data mining, location
- Inventory, routing, supply chains
- Packing and covering
- Discovery sciences
- Other real world problems

Guest Editors

Angelo Sifaleras, University of Macedonia, Greece, (sifalera@uom.gr)
Nenad Mladenović, Mathematical Institute, Serbian Academy of Sciences and Arts, (nenadmladenovic12@gmail.com)
Panos M. Pardalos, University of Florida, USA, (pardalos@ise.ufl.edu)

Cfp: Special issue on "*Progress on Variable Neighborhood Search and its Applications*" of the **Optimization Letters**

The Variable Neighborhood Search (VNS) metaheuristic is based on systematic changes in the neighborhood structure within a search, and has been successfully applied for solving various combinatorial, global optimization problems, and related tasks.

A special issue of Optimization Letters (I.F.: 1.310, SJR: 0.721) will be edited after the 6th International Conference on Variable Neighborhood Search (ICVNS 2018), which will be held in Halkidiki, Greece (Porto Carras Meliton Hotel) October 4-7, 2018. Although this special issue is linked to the forthcoming ICVNS 2018 conference, this Call for Papers is open to the entire community of academics and practitioners. This call is devoted to submissions on theoretical, methodological or applied aspects of VNS. The objective of this special issue is to present recent advances in the methodology and novel applications in practical optimization problems, informatics, engineering, and related areas.

Manuscripts should be prepared using Springer's LaTeX macro package and submitted through the journal's editorial manager `http://optl.edmgr.com`. Each paper will be peer-reviewed according to the editorial policy of Optimization Letters. Papers should be original, unpublished, and not currently under consideration for publication elsewhere.

Submission system opens on October 8, 2018, and the paper submission deadline is December 31, 2018. Select "S.I: VNS2018" for the paper type when submitting your contribution. All papers will go through a regular peer review process.

Guest Editors

Nenad Mladenović, Mathematical Institute, Serbian Academy of Sciences and Arts, (nenadmladenovic12@gmail.com)
Panos M. Pardalos, University of Florida, USA, (pardalos@ise.ufl.edu)
Angelo Sifaleras, University of Macedonia, Greece, (sifalera@uom.gr)

Useful Information

Conference Rooms

The conference sessions and invited talks will take place in the Porto Carras Meliton Hotel Ballrooms "THALIA" and "CHLOE" (`https://www.portocarras.com/resort/mice_and_events/conferences-venues-2`). Their capacities are as follows:

Room 1: THALIA

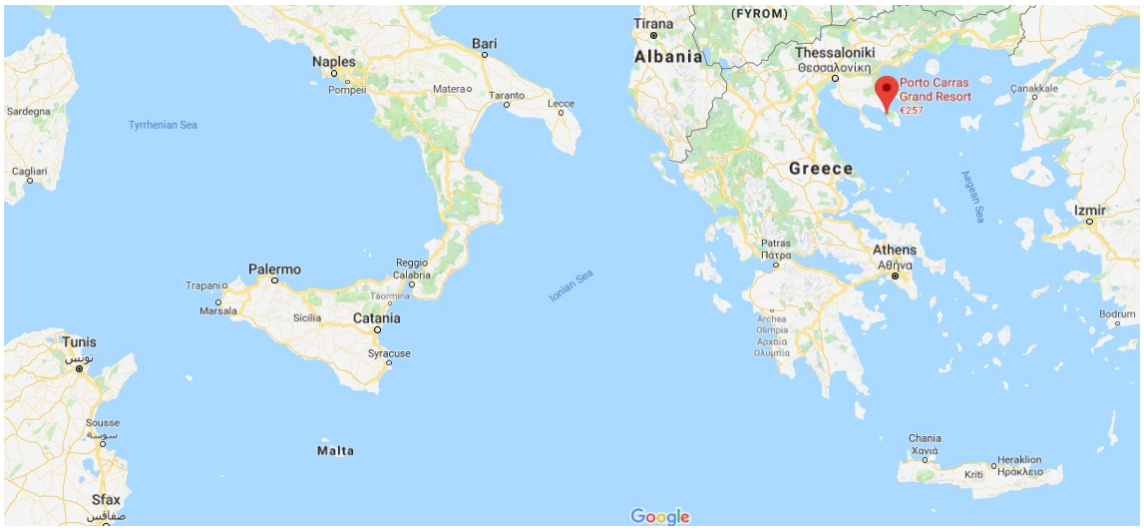
Theatre: 90
Classroom: 76
U-Shape: 45
Dining: 79
Area size(m^2): 117
Height(m): 3.5
Lightning: Day-Elec

Room 2: CHLOE

Theatre: 80
Classroom: 66
U-Shape: 45
Dining: 69
Area size(m^2): 104
Height(m): 3.5
Lightning: Day-Elec

Maps

Porto Carras Grand Resort is located only 120km away from the city of Thessaloniki (the second largest city in Greece) and 75 minutes drive from Thessaloniki's International Airport "Macedonia" (SKG).



Conference Schedule & Program

	Thursday 4th October 2018	Friday 5th October 2018		Saturday 6th October 2018		Sunday 7th October 2018
08.00 - 09.00		*Registration*				*Free time*
09.00 - 09.30		*Opening Session*		*Registration*		
09.30 - 10.30		**Plenary talk 1**		**Plenary talk 3**		
10.30 - 12.00		**Session 1**	**Session 2**	**Session 6**	**Session 7**	
12.00 - 12.30		*Coffee break*		*Coffee break*		
12.30 - 14.00		**Session 3**	**Session 4**	**Session 8**	**Session 9**	
14.00 - 15.30		*Lunch*		*Lunch*		
15.30 - 17.00		**Session 5**		**Session 10**		
17.00 - 17.30		*Coffee break*		*Coffee break*		
17.30 - 18.30		**Plenary talk 2**		*Closing Session*		
18.30 -20.00						
20.00 - 23.00	*Welcome Cocktail*	*Excursion to Neos Marmaras*		*Gala dinner*		

INTERNATIONAL CONFERENCE ON VARIABLE NEIGHBORHOOD SEARCH
VNS 2018

Conference Program

(Sithonia, Halkidiki, Greece, 4-7 October 2018)

Thursday, October 4, 2018	
20.00 - 23.00	**Welcome Cocktail**

Friday, October 5, 2018	
08.00 - 09.00	**Registration**
09.00 - 09.30	**Opening Session *(Room: THALIA)***
09.30 - 10.30	**Plenary Talk *(Room: THALIA), Chair: Athanasios Migdalas***
	On VNS for Hard Optimization Problems and the Power of Heuristics *Panos Pardalos*
10.30 - 12.00	**Session 1 *(Room: THALIA), Chair: Panos Pardalos***
	Multi Objective Optimization and VNS Strategies *Rolf Steinbuch*
	Detecting weak points in networks using Variable Neighborhood Search *Sergio Pérez-Peló, Jesús Sánchez-Oro Calvo, Abraham Duarte*
	On the k-medoids model for semi-supervised clustering *Rodrigo Randel, Daniel Aloise, Nenad Mladenović, Pierre Hansen*
	Variable Neighborhood Scatter Search for the Incremental Graph Drawing Problem *Anna Martínez-Gavara, Jesús Sánchez-Oro Calvo, Manuel Laguna, Rafael Marti, Abraham Duarte*
10.30 - 12.00	**Session 2 *(Room: CHLOE), Chair: Sergio Consoli***
	A Variable Neighborhood Search approach for solving the Multidimensional Multi-way Number Partitioning Problem *Alexandre Frias Faria, Sérgio Ricardo de Souza, Marcone Jamilson Freitas Souza, Carlos Alexandre Silva, Vitor Nazário Coelho*
	A Granular Skewed Variable Neighborhood Tabu Search for the Roaming Salesman Problem *Masoud Shahmanzari, Deniz Aksen*
	A multi-objective VNS for the Generalized Team Orienteering Problem *Adolfo J. Urrutia Zambrana, Gregorio Tirado Dominguez, Alfonso Mateos Caballero*
	Improved variable neighbourhood search heuristic for quartet clustering *Sergio Consoli, Jan Korst, Steffen Pauws, Gijs Geleijnse*
12.00 - 12.30	**Coffee break**
12.30 - 14.00	**Session 3 *(Room: THALIA), Chair: Eduardo G. Pardo***
	A Trilevel r-Interdiction Multi-Depot Vehicle Routing Problem with Customer Selection *Mir Ehsan Hesam Sadati, Deniz Aksen, Necati Aras*
	An Evolutionary Variable Neighborhood Descent for addressing an electric VRP variant *Dhekra Rezgui, Hend Bouziri, Wassila Aggoune-Mtalaa, Jouhaina Chaouachi Siala*
	On the optimization of multiple vehicles open routes *Ana D. López-Sánchez, Jesús Sánchez-Oro Calvo, J. Manuel Colmenar*
	New VNS variants for the Online Order Batching Problem *Sergio Gil-Borrás, Eduardo G. Pardo, Abraham Duarte, Antonio Alonso-Ayuso*
12.30 - 14.00	**Session 4 *(Room: CHLOE), Chair: Vitor Nazário Coelho***
	A Variable Neighborhood Descent heuristic for the multi-quay Berth Allocation and Crane Assignment Problem under availability constraints Issam Krimi, Afaf Aloullal, Rachid Benmansour, Abdessamad Ait El Cadi, Laurent Deshayes, David Duvivier
	Complexity and Heuristics for the Max Cut-Clique Problem *Mathias Bourel, Eduardo Canale, Franco Robledo, Pablo Romero, Luis Stábile*

INTERNATIONAL CONFERENCE ON VARIABLE NEIGHBORHOOD SEARCH
VNS 2018

Conference Program

(Sithonia, Halkidiki, Greece, 4-7 October 2018)

	Less is More: The Neighborhood Guided Evolution Strategies convergence on some classic neighborhood operators *Vitor Nazário Coelho, Igor Machado Coelho, Nenad Mladenovic, Helena Ramalhinho, Luiz Satoru, Frederico Guimarães, Marcone Souza*
	Studying the impact of perturbation methods on the efficiency of GVNS for the ATSP *Christos Papalitsas, Theodore Andronikos, Panagiotis Karakostas*
14.00 - 15.30	**Lunch**
15.30 - 17.00	**Session 5 *(Room: THALIA), Chair: J. Manuel Colmenar***
	A hybrid VNS-NSGAII for solving the dual resource constrained flexible job shop problem *Zoran Rakićević, Nina Turajlic, Dragana Makajic-Nikolic, Gordana Savic, Nenad Mladenović*
	A VNS approach to solve multi-level capacitated lotsizing problem with backlogging *Jerzy Duda, Adam Stawowy*
	Basic VNS algorithms for solving the pollution location inventory routing problem *Panagiotis Karakostas, Angelo Sifaleras, Michael Georgiadis*
	How to locate disperse obnoxious facility centers? *Jesús Sánchez-Oro Calvo, J. Manuel Colmenar, Enrique García-Galán, Ana D. López-Sánchez*
17.00 - 17.30	**Coffee break**
17.30 - 18.30	**Plenary Talk (*Room: THALIA*), *Chair: Nenad Mladenović***
	Clustering and Variable Neighborhood Search: A love story *Daniel Aloise*
20.00 - 23.00	**Excursion to Neos Marmaras**

Saturday, October 6, 2018	
09.00 - 09.30	**Registration**
09.30 - 10.30	**Plenary Talk *(Room: THALIA), Chair: Nenad Mladenović***
	Parallel VNS strategies *Abraham Duarte*
10.30 - 12.00	**Session 6 *(Room: THALIA), Chair: Abraham Duarte***
	A Variable Neighbourhood Search for the Packing of Rectangles into a Fixed Size Circular Container *Mouaouia Cherif Bouzid, Said Salhi*
	A Hybrid Firefly - VNS Algorithm for the Permutation Flowshop Scheduling Problem *Andromachi Taxidou, Ioannis Karafyllidis, Magdalene Marinaki, Yannis Marinakis, Athanasios Migdalas*
	Primal-dual VNS for large p-center problem *Jack Brimberg, Marija Ivanović, Nenad Mladenović, Dragan Urošević*
	Finding balanced bicliques in bipartite graphs using Variable Neighborhood Search *Jesús Sánchez-Oro Calvo, Juan David Quintana, Abraham Duarte*
10.30 - 12.00	**Session 7 *(Room: CHLOE), Chair: Zorica Stanimirović***
	An adaptive VNS and Skewed GVNS approaches for School Timetabling Problems *Ulisses Teixeira, Marcone Jamilson Freitas Souza, Sérgio Ricardo de Souza, Vitor Nazário Coelho*
	Profit maximization of Internet of things provider using variable neighbourhood search *Vesna Radonjić Đogatović, Marko Djogatović, Milorad Stanojević, Nenad Mladenović*
	General Variable Neighborhood Search for the Scheduling Heterogeneous Vehicles in Agriculture *Ana Anokić, Zorica Stanimirović, Djordje Stakić, Tatjana Davidović*
	VNS for optimizing the structure of a logical function in IBA framework *Pavle Milošević, Ana Poledica, Ivana Dragovic, Bratislav Petrović, Aleksandar Rakićević*

INTERNATIONAL CONFERENCE ON VARIABLE NEIGHBORHOOD SEARCH
VNS 2018

Conference Program

(Sithonia, Halkidiki, Greece, 4-7 October 2018)

12.00 - 12.30	**Coffee break**
12.30 - 14.00	**Session 8 *(Room: THALIA), Chair: Daniel Aloise***
	A VNS-based Algorithm with Adaptive Local Search for the MDVRP *Sinaide Nunes Bezerra, Marcone Jamilson Freitas Souza, Sérgio Ricardo de Souza, Vitor Nazário Coelho*
	Skewed Variable Neighborhood Search Method for the Weighted Generalized Regenerator Location Problem *Lazar Mrkela, Zorica Stanimirović*
	GVNS applied to the Weighted Fair Sequences Problem *Bruno J. S. Pessoa, Antônio V. C. S. Duarte, Lucidio A. F. Cabral, Daniel Aloise*
	Parallel variable neighborhood search for the capacitated vehicle routing problem *Panos Kalatzantonakis, Angelo Sifaleras, Nikolaos Samaras, Athanasios Migdalas*
12.30 - 14.00	**Session 9 *(Room: CHLOE), Chair: José Andrés Moreno Pérez***
	Variable Neighbourhood Search Based Data Association Filter for Multiple-target Tracking *Marko Djogatović, Vesna Radonjić Đogatović, Milorad Stanojević, Nenad Mladenović*
	Reference point based VNS for multiobjective capacitated vehicle routing *Laura Delgado Antequera, Jesús Sánchez-Oro Calvo, Rafael Marti, J. Manuel Colmenar*
	A Variable neighborhood search with integer programming for the zero-one Multiple-Choice Knapsack Problem with Setup *Yassine Adouani, Bassem Jarboui, Malek Masmoudi*
	A GRASP-VNS for solving a Vehicle Routing Problem for Waste Collection *José Andrés Moreno Pérez, Airam Expósito Márquez, Christopher Expósito Izquierdo, Julio Brito Santana, Dagoberto Castellanos Nieves*
14.00 - 15.30	**Lunch**
15.30 - 17.00	**Session 10 *(Room: THALIA), Chair: Rachid Benmansour***
	Solving the Vertex Bisection problem with a Basic Variable Neighborhood Search algorithm *Alberto Herrán, J. Manuel Colmenar, Abraham Duarte*
	Bi-objective VNS in 5G HetNets for Channel Allocation *Mara Bukvić, Mirjana Čangalović, Milan Stanojević, Bogdana Stanojević*
	VNS for tail index estimation *Jelena Jocković, Pavle Mladenović*
	Using a variable neighborhood search to solve the single processor scheduling problem with time restrictions *Rachid Benmansour, Oliver Braun, Said Hanafi, Nenad Mladenović*
17.00 - 17.30	**Coffee break**
17.30 - 18.30	**Closing Session (*Room: THALIA*)**
20.00 - 23.00	**Gala dinner**

Sunday, October 7, 2018	
	Free time

Social Program

The social program of the ICVNS 2018 conference includes the following networking activities in stimulating and relaxing environments in order that, the participants can discuss and exchange research ideas.

Welcome Cocktail
Date: Thursday 04 October
Time: 20:00-23:00
Place: Reflections lounge bar at the Porto Carras - Meliton Hotel
Description: The conference organizers have the pleasure to invite you for a Welcome Cocktail. The Welcome Cocktail includes light snacks and a beverage.

Excursion to Neos Marmaras
Date: Friday 05 October
Time: 20:00-23:00
Place: Fish Restaurant Okyalos, at Neos Marmaras
Description: Excursion to Neos Marmaras and dinner at the Fish Restaurant Okyalos `https://www.okyalos.gr/en`. The Fish Restaurant Okyalos is located in the heart of Neos Marmaras, at the peninsula of Sithonia, operating since 2002.

Gala Dinner
Date: Saturday 06 October
Time: 20:00-23:00
Place: Crystals Restaurant at the Porto Carras - Meliton Hotel
Description: The ICVNS 2018 conference dinner will include a five course dinner with beverages and entertainment.

All the above social events have no extra cost and are included in the registration fee for all participants and their accompanying persons.

Plenary Talks

Panos M. Pardalos

University of Florida, USA,
Center for Applied Optimization, Department of Industrial and Systems Engineering

Short Bio: Panos Pardalos is a Distinguished Professor and the Paul and Heidi Brown Preeminent Professor in the Department of Industrial and Systems Engineering at the University of Florida, and a world-renowned leader in Global Optimization, Mathematical Modeling, and Data Sciences. He is a Fellow of AAAS, AIMBE, and INFORMS and was awarded the 2013 Constantin Caratheodory Prize of the International Society of Global Optimization. In addition, Dr. Pardalos has been awarded the 2013 EURO Gold Medal prize bestowed by the Association for European Operational Research Societies. This medal is the preeminent European award given to Operations Research (OR) professionals for "scientific contributions that stand the test of time". Dr. Pardalos is also a Member of the New York Academy of Sciences, the Lithuanian Academy of Sciences, the Royal Academy of Spain, and the National Academy of Sciences of Ukraine. He is the Founding Editor of Optimization Letters, Energy Systems, and Co-Founder of the International Journal of Global Optimization, and Computational Management Science. He has published over 500 papers, editedauthored over 200 books and organized over 80 conferences. He has a google h-index of 94 and has graduated 61 PhD students so far.

On VNS for hard optimization problems and the power of heuristics

Large scale problems in the design and analysis of networks, energy systems, finance, biomedicine, and engineering are modeled as optimization and control problems. Both humans and nature are constantly optimizing to minimize costs or maximize profits, to maximize the flow in a network, or to minimize the probability of a blackout in the smart grid. The resulting optimization problems very often are nonconvex, hard to solve, or of very large scale.

Exact algorithms are of very limited use in these cases. Due to new algorithmic developments in heuristics, as well as the computational power of machines, optimization heuristics have been used to solve problems in a wide spectrum of

applications in science and engineering.

In this talk, we are going to address new developments with VNS and other heuristics, as well as discuss their power to solve hard problems and new developments for their evaluation.

Abraham Duarte

Department of Computer Sciences,
Universidad Rey Juan Carlos, Spain

Short Bio: Abraham Duarte is Full Professor in the Computer Science Department at the Rey Juan Carlos University (Madrid, Spain). He received his doctoral degree in Computer Sciences from the Rey Juan Carlos University. His research is devoted to the development of models and solution methods based on metaheuristics for combinatorial optimization problems. He has published 55 papers in SCI-JCR prestigious scientific journals such us European Journal of Operational Research, INFORMS Journal on Computing, Computational Optimization and Applications, or Computers & Operations Research. Dr. Duarte has also published 12 papers in non-indexed journals, 22 book chapters and more than 70 papers in conference proceedings. He has been the principal investigator on 5 competitive research projects with a total budget of 200000 euros (aprox.), he has been the advisor of 6 doctoral theses, and he is co-inventor of a US patent (US 20100138373 A1). Dr. Duarte is reviewer of the Journal of Heuristic, Journal of Mathematical Modeling and Algorithms, INFORMS Journal on Computing, Applied Soft Computing, European Journal of Operational Research and Soft Computing. He is also member of the program committee of the conferences MAEB, HIS, ISDA, SOCO or MHIPL.

Parallel VNS strategies

Variable neighborhood search (VNS) and all its variants have been successfully proved in hard combinatorial optimization problems. However, there are only few research papers concerning parallel VNS algorithms, compared with the amount of works devoted to sequential VNS design. In this talk, we will introduce different parallel designs for the VNS schema. We illustrate the performance of these general strategies by parallelizing some variants of VNS (Variable Formulation Search, Basic VNS, or General VNS). We will describe six different variants which differ in the VNS stages to be parallelized as well as in the communication mechanisms among processes. We group these variants into three different templates. The first one is oriented to parallelize the whole VNS method. The second one parallelizes the shake and the local search procedures. Finally, the third one explores in parallel the set of predefined neighborhoods.

We will illustrate the resulting designs on different combinatorial optimization problems. Specifically, the cutwidth minimization problem [1], the max-min order batching problem [2], the maximum leaf spanning tree problem [3], and the dynamic memory allocation problem [4]. Experimental results show that the parallel implementation of the VNS strategies outperforms previous methods in the state of the art for the corresponding optimization problem.

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Short Bio: Dr Daniel Aloise is an assistant professor at the Computer and Software Engineering Department at Polytechnique Montréal. He obtained his PhD in Applied Maths from Polytechnique Montréal in 2009 and he has been assistant professor at Universidade Federal do Rio Grande do Norte, Brazil, in 2009-2016. His research interests include data mining, optimization, mathematical programming and how these disciplines interact to tackle problems in the Big Data era. Daniel has published in leading operations research and data mining journals including Machine Learning, Pattern Recognition, European Journal of Operational Research, Mathematical Programming and Journal of Global Optimization.

Clustering and Variable Neighborhood Search: A love story

Clustering is a fundamental problem in data analysis. It consists in finding subsets of data objects, called clusters, which are similar between them and well separated from data objects in other clusters. The clustering problem is approached by different methods in the literature. In this talk, the clustering task is formulated as a combinatorial optimization problem whose computational complexity depends on some model characteristics desired by the data analyst. I will present how VNS has been successfully used in a wide range of clustering optimization models due to its simplicity and good observed performance.

Abstracts

Multi Objective Optimization and VNS Strategies

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Abstract. The well-defined optimization problem of finding the best values of a given function by varying its free parameters without violation of boundary conditions or other constraints is well known and analyzed. Many optimization strategies, which are appropriate for the different constellations, are available, among them VNS and its infinite number of variants. Unfortunately, problems that are more difficult may arise. Especially the Multi Objective Optimization (MOO), where we look at more than one unique objective necessitates a more elaborated way of approaching the questions posed. We introduce some of the basic ideas of MOO and discuss the handling of such problems especially by using VNS-like strategies. Having established the main implications of MOO, we proceed to expand the optimization strategies to MOO problems. There is an increased effort to deal not with isolated 1D-optima, but with hypersurfaces. This increases tremendously the required computing time and capacity for the handling of the problem. Typical examples explain the questions presented and present proposals to improve the solution approaches. These examples should help to understand the potential but as well the limitations of MOO. There are many difficulties to observe and there are not always simple ways to avoid them.

Keywords: Multi Objective Optimization, Bionic Optimization, Pareto front, metamodels.

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On the optimization of multiple vehicles open routes

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Abstract. This work tackles the Multi-Objective Open Vehicle Routing Problem (MO-OVRP). The MO-OVRP is a problem similar to the well-known Vehicle Routing Problem (VRP) but considering that a vehicle does not need to return to the depot once it has completed its route. Three different objectives are considered for optimization, in order to get closer to the real-life problem. In particular, the MO-OVRP consists of minimizing the number of routes considered, the sum of the distances traveled by all the vehicles, and the length of the longest route. The proposed algorithm follows the General Variable Neighborhood Search methodology, proposing different neighborhoods for each objective function considered. The experiments show the superiority of the proposal when compared with the multi-objective genetic algorithm NSGA-II.

Keywords: Open vehicle routing, General VNS, NSGA-II.
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A Granular Skewed Variable Neighborhood Tabu Search for the Roaming Salesman Problem

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Abstract. We present a Granular Skewed Variable Neighborhood Tabu Search (GSVNTS) for the Roaming Salesman Problem (RSP). RSP is a multi-period and selective version of the traveling salesman problem involving a set of cities with time-dependent rewards. Each city can be visited on any day and a subset of cities can be visited multiple times, though with diminishing rewards after the first visit. The goal is to determine an optimal campaign schedule consisting of either open or closed daily tours that maximize the total net benefit while respecting the maximum tour duration and the necessity to return to the campaign base frequently. We formulate RSP as a MILP problem. We also present a hybrid metaheuristic algorithm which can be classified as a Variable Neighborhood Search with Tabu Search conditions. The initial feasible solution is constructed via a novel matheuristic approach. This solution is improved using the proposed local search procedure. We consider a set of 95 cities in Turkey and a campaign period of 40 days as our largest problem instance. Computational results on actual distance and travel time data show that the developed algorithm GSVNTS can find near-optimal solutions in reasonable CPU times.

Keywords: Variable Neighborhood Search, Granular Neighborhoods, Roaming Salesman Problem, Metaheuristic, Matheuristic, Mixed-Integer Linear Programming.

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A Variable Neighbourhood Search for the Packing of Rectangles into a Fixed Size Circular Container

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Abstract. Recently, the packing of rectangular objects into a circular container of a fixed diameter has been tackled using a FFS approach. In this talk, we present a VNS algorithm to tackle the same problem where we define appropriate neighbourhood structures with a suitable and powerful local search engine. Experiments are conducted on benchmark instances to demonstrate the performance of our approach.

Keywords: Variable neighbourhood search; rectangle packing.
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Variable Neighborhood Scatter Search for the Incremental Graph Drawing Problem

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Abstract. Drawings of graphs have many applications, from project scheduling to software diagrams, in order to produce systems with desired aesthetic properties. The main quality desired for drawings of graphs is readability, and crossing reduction is a fundamental aesthetic criterion for a good graph representation. Incremental procedures are those that preserve the layout of a graph over successive drawings. These methods are particularly useful in areas such as planning and logistics, where updates are frequent. We propose a procedure that integrates variable neighborhood and scatter search that is adapted to the incremental drawing problem in hierarchical graphs. These drawings can be used to represent any acyclical graph. Comprehensive computational experiments are used to test the efficiency and effectiveness of the proposed procedure.

Keywords: Heuristics, metaheuristics, optimization combinatorial, graph drawing.
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A multi-objective VNS for the Generalized Team Orienteering Problem

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Abstract. This work approaches the Generalized Team Orienteering Problem (GTOP) from a multi-objective perspective. The GTOP extends the Generalized Orienteering Problem (GOP), which is a single objective and single-day NP-hard optimization problem. In the GOP, a set of nodes which could be potentially visited is given, each one associated to at least two scores. The travel time between any pair of nodes is known, together with the time budget. The problem consists in finding a closed tour maximizing a weighted sum of different score types, while not exceeding the time limit. The GOP has many practical applications, from surveillance to tourist itinerary design. In the particular version we approach, the single-objective function of the GOP is replaced by a multi-objective function, in addition to considering multiple-day scenarios. To address this problem, we propose a VNS that uses a reduced number of local search operators and performs the calculation of the scores and the required dominance checks in an efficient way. The metaheuristic evaluation is performed on 10 benchmarks, some of them based on real data from Spanish tourist cities. The experiments provide a first approximation to how the different scores could influence the tourist decisions.

Keywords: Orienteering Problem, Variable Neighborhood Search, Multi-objective.
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Improved variable neighbourhood search heuristic for quartet clustering

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Abstract. Given a set of n data objects and their pairwise dissimilarities, the goal of quartet clustering is to construct an optimal tree from the total number of possible combinations of quartet topologies on n, where optimality means that the sum of the dissimilarities of the embedded (or consistent) quartet topologies is

minimal. This corresponds to an NP-hard combinatorial optimization problem, also referred to as minimum quartet tree cost (MQTC) problem. We provide details and formulation of this challenging problem, and propose a basic greedy heuristic that is characterized by a very high speed and some interesting implementation details. The solution approach, though simple, substantially improves the performance of a Reduced Variable Neighborhood Search for the MQTC problem. The latter is one of the most popular heuristic algorithms for tackling the MQTC problem.

Keywords: Combinatorial optimization, Quartet trees, Hierarchical clustering, Metaheuristics, Variable Neighbourhood Search, Graph theory.
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A Trilevel r-Interdiction Multi-Depot Vehicle Routing Problem with Customer Selection

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Abstract. The protection of critical facilities in supply chain networks attracts increasing attention in the OR literature. Critical facilities involve physical assets such as bridges, railways, terminals, hospitals, power stations, and transportation hubs among others. In this study we introduce a trilevel optimization problem for the determination of the most critical depots in a multi-depot vehicle routing network. The problem is modelled as a 'defender-attacker-defender' game from the perspective of the defender who needs to protect a limited number of depots on an existing routing network against interdiction by an adversary agent whom we designate as the attacker. The attacker's objective is to inflict the maximum disruption on this network by annihilating a certain number of unprotected depots beyond repair. We refer to this problem as the trilevel r-interdiction multi-depot vehicle routing problem with customer selection (3LRI-MDVRP). The defender is the decision maker in the upper level problem (ULP) who decides which depots to protect. In the middle level problem (MLP), the attacker chooses r depots to interdict among the unprotected ones. Finally, in the lower level problem (LLP), the decision maker is again the defender who reoptimizes the vehicle routes and thereby selects which customers are to be served in the wake of the depot interdictions. All three levels of the problem have an identical objective function which is comprised of three cost components. (i) Operating or acquisition cost of the vehicles. (ii) Traveling cost incurred by the vehicles. (iii) Outsourcing cost due to unsatisfied demand of customers. The defender aspires to minimize this objective function while the attacker tries to maximize it. As a solution approach to this trilevel discrete optimization problem, we resort to exhaustive enumeration for the ULP and MLP. For the LLP we implement a Variable Neighborhood Search (VNS) adapted to the selective multi-depot VRP. Our results are obtained on a set of 3LRI-MDVRP

instances that are synthetically constructed from standard MDVRP test instances in the literature.

Keywords: Trilevel programming, Variable Neighborhood Search, Multi-Depot Vehicle Routing Problem, Protection, Interdiction, Outsourcing.
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Finding balanced bicliques in bipartite graphs using Variable Neighborhood Search

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Abstract. The Maximum Balanced Biclique Problem (MBBP) consists of identifying a complete bipartite graph, or biclique, of maximum size within an input bipartite graph. This combinatorial optimization problem is solvable in polynomial time when the balance constraint is re- moved. However, it becomes NP–hard when the induced subgraph is required to have the same number of vertices in each layer. Biclique graphs have been proven to be useful in several real-life aplications, most of them in the field of biology, and the MBBP in particular can be applied in the design of programmable logic arrays or nanoelectronic systems. Most of the approaches found in literature for this problem are heuristic algorithms based on the idea of removing vertices from the input graph until a feasible solution is obtained; and more recently in the state of the art an evolutionary algorithm (MA/SM) has been proposed. As stated in previous works it is difficult to propose an effective local search method for this problem. Therefore, we propose the use of Reduced Variable Neighborhood Search. This methodology is based on a random exploration of the considered neighborhoods and it does not require a local search.

Keywords: biclique, Reduced VNS, bipartite
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Parallel Variable Neighborhood Search for the Capacitated Vehicle Routing Problem

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Abstract. The Capacitated Vehicle Routing Problem (CVRP) is a well-known NP-hard combinatorial optimization problem with numerous real-world applications in logistics. In this work, we present a literature review with recent successful parallel

implementations of Variable Neighborhood Search regarding different variants of vehicle routing problems. Furthermore, we propose a new parallel Variable Neighborhood Search (VNS) method for the efficient solution of the CVRP. Finally, we report our findings regarding the proposed parallel solution approach and present promising computational results obtained using various benchmark problem instances.

Keywords: Variable Neighborhood Search, Parallel Computing, Vehicle Routing Problem.
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Solving the Vertex Bisection problem with a Basic Variable Neighborhood Search algorithm

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Abstract. The family of graph partitioning problems consists of finding a partition either of vertices or edges in a way that a particular objective function is optimized. In this work we propose to solve the Vertex Bisection Problem (VBP), which belongs to this family of problems. VBP consists of dividing a graph into two parts, namely B and B', with the same number of vertices (or differing in one if the number of vertices is odd). The objective of VBP is to minimize the number of vertices in B with, at least, one adjacent in B'. This is known as the vertex width of the partition. We apply a Basic Variable Neighborhood Search (BVNS) approach to solve the VBP. In particular, we define three constructive methods and six improvement procedures. We perform the calculation of the objective function following an incremental approach, which substantially reduces the computing time as compared with the direct implementation. In comparison with the state-of-the-art algorithms, our proposal obtains better results for quality of the solutions, spending less execution time. Besides, we have confirmed these results through non-parametric statistical tests.

Keywords: Vertex bisection, Basic Variable Neighborhood Search, Optimization.
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On the k-medoids model for semi-supervised clustering

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Abstract. Clustering is an automated and powerful technique for data analysis. It aims to divide a given set of data points into clusters which are homogeneous and/or well separated. A major challenge with clustering is to define an appropriate clustering criterion that can express a good separation of data into homogeneous groups such that the obtained clustering solution is meaningful and useful to the user. To circumvent this issue, it is suggested that the domain expert could provide background information about the dataset, which can be incorporated by a clustering algorithm in order to improve the solution. Performing clustering under this assumption is known as semi-supervised clustering. This work explores semi-supervised clustering through the k-medoids model. Results obtained by a Variable Neighborhood Search (VNS) heuristic show that the k-medoids model presents classification accuracy compared to the traditional k-means approach. Furthermore, the model demonstrates high flexibility and performance by combining kernel projections with pairwise constraints.

Keywords: k-medoids, semi-supervised clustering, variable neighborhood search.
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How to locate disperse obnoxious facility centers?

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Abstract. The bi-objective obnoxious p-median problem has not been extensively studied in the literature yet, even having an enormous real interest. The problem seeks to locate p facilities but maximizing two different objectives that are usually in conflict: the sum of the minimum distance between each customer and their nearest facility center, and the dispersion among facilities, i.e., the sum of the minimum distance from each facility to the rest of the selected facilities. This problem arises when the interest is focused on locating obnoxious facilities such as waste or hazardous material, nuclear power or chemical plants, noisy o polluting services like airports. To address the bi-objective obnoxious p-median problem we propose a variable neighborhood search approach. Computational experiments show promising results. Specifically, the proposed algorithm obtains high-quality efficient solutions compared to the state-of-art efficient solutions.

Keywords: Location problem, Obnoxious p-median problem, Multi-objective optimization, Variable neighborhood search.

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Less is More: The Neighborhood Guided Evolution Strategies convergence on some classic neighborhood operators

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Abstract. This paper extends some explanations about the convergence of a type of Evolution Strategies guided by Neighborhood Structures, the Neighborhood Guided Evolution Strategies. Different well-known Neighborhood Structures commonly applied to Vehicle Routing Problems are used to highlight the evolution of the moves operators during the evolutionary process of a self-adaptive Reduced Variable Neighborhood Search procedure. Since the proposal uses only few components for its search, we thing is can be seen inside the scope of the recently proposed "Less Is More Approach".

Keywords: Metaheuristics, Neighborhood Structure, Reduced VNS, Evolution Strategies, Less is More, NP-Hard problems.
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A Variable neighborhood search with integer programming for the zero-one Multiple-Choice Knapsack Problem with Setup

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Abstract. This study proposes a new cooperative approach to the Multiple-Choice Knapsack problem with Setup (MCKS) that effectively combines variable neighborhood search (VNS) with an integer programing (IP). Our approach, based on a local serach technique with an adaptive perturbation mechanism to assign the classes to

knapsack, and then if the assignment is identified to be promising by comparing its result to the upper bound, we applied the IP to select the items in knapsack. For the numerical experiment, we generated different instances for MCKS. In the experimental setting, we compared our cooperative approach to the Mixed Integer Programming provided in literature. Experimental results clearly showed the efficiency and effectiveness of our cooperative approach with -0.11% as gap of the objective function and 13 s vs. 2868 s as computation time.

Keywords: Knapsack problem, Setup, Cooperative approach.
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Complexity and Heuristics for the Max Cut-Clique Problem

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Abstract. In this paper we address a metaheuristic for an combinatorial optimization problem. For any given graph $\mathcal{G} = (V, E)$ (where the nodes represent items and links correlations), we want to find the clique $\mathcal{C} \subseteq V$ such that the number of links shared between $\mathcal{C}$ and $V - \mathcal{C}$ is maximized. This problem is known in the literature as the Max Cut-Clique (MCC). The contributions of this paper are three-fold. First, the complexity of the MCC is established, and we offer bounds for the MCC using elementary graph theory. Second, an exact Integer Linear Programming (ILP) formulation for the MCC is offered. Third, a full GRASP/VND methodology enriched with a Tabu Search is here developed, where the main ingredients are novel local searches and a Restricted Candidate List that trades greediness for randomization in a multi-start fashion. A dynamic Tabu list considers a bounding technique based on the previous analysis. Finally, a fair comparison between our hybrid algorithm and the globally optimum solution using the ILP formulation confirms that the globally optimum solution is found by our heuristic for graphs with hundreds of nodes, but more efficiently in terms of time and memory requirements.

Keywords: Combinatorial Optimization Problem, Max Cut-Clique, ILP, GRASP, VND, Tabu Search.
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VNS for tail index estimation

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Abstract. Estimating the tail index of a distribution function with the regularly varying (heavy) tail is a well known and hard problem in statistics, which still attracts considerable attention. Since the first papers od Hill (1975) and Pickands (1975), several estimators have been proposed and studied. However, the estimator with the best statistical properties (the smallest possible bias and mean squared error) in all the situations has not been found. We consider a general linear combination of log-exceedances, which directly generalizes the estimator proposed by Hill. In order to apply this estimator to data, it is necessary to estimate the coefficients of linear combination, as well as the number of exceedances used in the computation. This is done by minimizing the expression for asymptotical mean squared error of the new estimator, which is a nonlinear and nondifferentiable function in some of the variables, with several constraints. We propose a VNS based technique for solving this problem and compare our approach to a simple multistart. We demonstrate on simulated data that choosing a suitable starting point for VNS in many cases leads to an applicable estimator with plausible statistical properties.

Keywords: Tail index estimation, Hill estimator, regular variation, VNS, multistart.
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A GVNS algorithm to solve VRP with optional visits

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Abstract. In this paper we deal with a generalization of the multi-depot capacitated vehicle routing problem namely the multi-depot covering tour vehicle routing problem (MDCTVRP). This problem is considered more challenging since it deals with some situations where it is not possible to visit all the customers with the vehicles routes. In this problem, a customer can receive its demand directly by visiting it along the tour using a set of vehicles located at different depots or by covering it. A customer is considered as covered if it is located within an acceptable distance from at least one visited customer in the tour. The latter can satisfy its demand. We propose a general variable neighborhood search algorithm to solve the MDCTVRP. In this paper we use a variable neighborhood search (VNS) with a variable neighborhood descent (VND) method as a local search. Experiments were conducted on benchmark instances from the literature.

Keywords: Vehicle Routing Problem, Covering, Variable Neighborhood Search.
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Bi-objective VNS in 5G HetNets for Channel Allocation

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Abstract. The paper addresses the concrete problem of the Service-oriented Architecture (SoA) tech-nology utilized in 5G heterogeneous network (HetNet), where users/clients equipped with multiple radio access technology are able to selectjoin the appropriate network on temporary bases with respect to a wide range of requirements like interference, data rates, QoS, latency, prices, etc.

We considered a two-tied network in Radio-Access Technology layer with a small cell that provides capacity, and enable low latency; and a micro-cell that provides basic connectivity and coverage. The resource allocation is centrally coordinated by a common authority, namely the Cognitive Network Provider (CNP). CNP collects the status of the HetNet environment, that consists of primary networks (PNs), each of them providing services to its users, i.e to primary users (PUs). Desirous users, i.e. secondary users (SUs), are contending for available channels in one of the PNs that best suits their needs for bandwidth, data rate, quality of experience (QoE), and price, considering the interference or low latency as constraints of the environment.

The study is based on a bi-objective model for channel allocation problem. In the literature there are attempts to model the problem by aggregating different criteria in one single criterion function without any a priori transformationnormalization, and then to use population based heuristics to achieve an approximate solution. Our approach differs from previous work in its attempt to apply a heuristic to solve the bi-objective problem. We conducted our first experiments using a constructive heuristic, and then we extended it to a bi-objective VNS heuristic, to derive the non-dominated points. The emphasis in not on comparing the performances of the heuristics, rather on identifying pros and cons for applying different techniques for deriving approximate solutions to the original problem, with respect to the number of non-dominated points found in a time frame range, being aware of the fact that the final solution will be embedded as a component in the bigger picture of managing services in 5G HetNets.

Keywords: Variable Neighborhood Search, Bi-objective VNS, applications real world problem, channel allocation, 5G heterogeneous networks, data rate, latency.
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A hybrid VNS-NSGAII for solving the dual resource constrained flexible job shop problem

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Abstract. This paper presents the application of hybrid heuristic, non-dominated sorting genetic algorithm II (NSGAII) combined with variable neighbourhood search (VNS) for solving the multi-objective dual resource constrained flexible job shop problem (DRCFJS). The basic job shop is a problem of scheduling several jobs on several machines where all the jobs have different processing routes. We observed the expanded job shop problem, known as DRCFJS which is characterised by flexibility, which means that more than one machine is available for processing every particular job's operation. Al-so, the problem is double constrained by two types of production resources, machines and workers that need to be assigned to every job's operation. This problem is frequent in small and medium-sized enterprises in the field of small-scale or one-of-a-kind production. The solution of this problem is composed of workers' and machines' assignment to every job's operation, and of determination of the processing sequence of all jobs. We implement the VNS algorithm for improvement of the local search in NSGAII. This hybrid approach unifies benefits of global optimisation in GA and local search ability of VNS. The criteria functions used in the defined multi-objective DRCFJS problem are the makespan – the total length of the schedule, and the absolute sum of earliness and tardiness of all scheduled jobs. These criteria are used for achieving the contemporary just-in-time concept in planning and scheduling.

Keywords: VNS, NSGAII, dual resource constrained flexible job shop.
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A general variable neighborhood search with Mixed VND for the multi-Vehicle multi-Covering Tour Problem

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Abstract. The well-known Vehicle Routing-Allocation Problem (VRAP) receives recently more attention than the classical routing problems. This article deals with a special case of the VRAP named the multi-vehicle multi-Covering Tour Problem (mm-CTP-p). More precisely, the mm-CTP-p is a generalized variant of the multi-vehicle Covering Tour Problem (m-CTP-p). In both problems, the objective is to find a minimum length set of vehicle routes while satisfying the total demands by visiting vertices by the route or covering vertices which does not included in any route. But, in the m-CTP-p, the demand of a vertex can be satisfied with only one coverage

whereas in the mm-CTP-p, a vertex must be covered several times to be completely served . Indeed, a vertex is covered if it lies within a specified distance of at least one vertex of a route. We develop a General Variable Neighborhood Search algorithm (GVNS) with a mixed Variable Neighborhood Descent (mixed-VND) method to solve the problem. Experiments were conducted using benchmark instances from the literature. Extensive computational results on mm-CTP-p problems show the performance of our method.

Keywords: Vehicle routing-allocation problems, multi-covering, Local search, Variable neighborhood descent.
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Variable Neighbourhood Search Based Data Association Filter for Multiple-target Tracking

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Abstract. In this paper, a novel variable neighbourhood search based hybrid data association filter to track multiple targets in a cluttered environment with false alarms is presented. Data association is a technique of simultaneous association of uncertain measurements with known targets. There are several methods used to track multiple targets, where the most widely used is joint probabilistic data association (JPDA) filter. Most of data association techniques are efficient methods, but some of them (Markov Chain Monte Carlo DA, Fuzzy Clustering Means) have tendency to get trapped in local minima. In order to address this problem a new VNS based data association filter for tracking multiple targets is proposed. Simulation experiments based on several case studies are conducted to validate the novel data association algorithm. The proposed technique performance has been compared with conventional joint probabilistic data association (JPDA), Markov chain Monte Carlo DA (MCMCDA) and fuzzy clustering means (FCM) techniques. The simulation results show that the algorithm mostly performed better than the other techniques used for comparison.

Keywords: Variable neighbourhood search, data association, cluttered environment, multiple target tracking.
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Profit maximization of Internet of things provider using variable neighbourhood search

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Abstract. Internet of things (IoT) covers various aspects of collecting and exchanging data between diverse entities. From IoT provider's perspective, one of the most significant issues is how to set the price that maximizes its profit while meeting users' requirements. IoT provider typically offers two pricing options: pay per time period and pay per use. In this paper optimization is done for users charged according to pay per use pricing option. We apply auction-based pricing which is based on users' demand and requirements. It implies that each user is charged per unit of consumption according to the actual usage. We assume that a user pays a threshold price for unit of consumption, which is determined based on sealed-bid auction. The auction is conducted with bidding prices set up in advance within Service Level Agreement (SLA). In this paper we use variable neighbourhood search in order to derive the optimal threshold price that maximizes IoT provider's profit and users' satisfaction.

Keywords: Variable neighbourhood search, profit maximization, Internet of things, price, auction.

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A Hybrid Firefly - VNS Algorithm for the Permutation Flowshop Scheduling Problem

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Abstract. In this paper a Permutation Flowshop Scheduling Problem is solved using a hybridization of the Firefly algorithm with Variable Neighborhood Search algorithm. The Permutation Flowshop Scheduling Problem (PFSP) is one of the most computationally complex problems. It belongs to the class of combinatorial optimization problems characterized as NP-hard. In order to find high quality solutions in reasonable computational time, heuristic and metaheuristic algorithms have been used for solving the problem. The proposed method, Hybrid Firefly Variable Neighborhood Search algorithm, uses in the local search phase of the algorithm a number of local search algorithms, 1-0 relocate, 1-1 exchange and 2-opt. In order

to test the effectiveness and efficiency of the proposed method we used a set of benchmark instances of different sizes from the literature.

Keywords: Permutation Flowshop Scheduling Problem, Firefly Algorithm, Variable Neighborhood Search.
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A VNS approach to solve multi-level capacitated lotsizing problem with backlogging

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Abstract. In this paper a multi-level capacitated lotsizing problem with machine-capacity-constraint and backlogging is studied. The main objective is to minimize the total cost which includes the inventory and delaying costs of produced items. Since the problem under study is NP-hard, a variable neighborhood search (VNS) combined with CPLEX solver is proposed as a solution approach. Neighborhood is changed according to VNS scheme using four different functions and is locally optimized for a set of partial MIP problems that can be easily solved. Finally, extensive computational tests demonstrate that the proposed search algorithm can find good quality solutions for all examined problems. The objective values obtained by the proposed algorithm are comparable to the results of state-of-the art, much more complicated algorithms.

Keywords: Multi-level capacitated lotsizing, Variable neighborhood search, Hybrid approach.
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Using a variable neighborhood search to solve the single processor scheduling problem with time restrictions

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Abstract. We study the single-processor scheduling problem with time restrictions in order to minimize the makespan. In this problem, n independent jobs have to be processed on a single processor, subject only to the following constraint: During any time period of length $\alpha > 0$ the number of jobs being executed is less than or equal to a given integer value B. It has been shown that the problem is NP-hard even for

$B = 2$. We propose the two metaheuristics variable neighborhood search and a fixed neighborhood search to solve the problem. We conduct computational experiments on randomly generated instances. The results indicate that our algorithms are effective and efficient regarding the quality of the solutions and the computational times required finding them.

Keywords: Scheduling, Time Restrictions, Single Processor, Variable neighborhood search.
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Reference point based VNS for multiobjective capacitated vehicle routing

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Abstract. This work presents a heuristic algorithm based on the VNS methodology, which implements a reference point based metric, to generate efficient solutions for a multiobjective capacitated vehicle routing problem (MOCVRP). Reflecting the fact that we want to solve real instances, our method considers four objective functions. In particular, it first obtains an approximation of the Pareto front with an Iterated Greedy metaheuristic, and then, VNS is adapted to the multiobjective setting by maintaining a set of promising solution which may become efficient after the application of a good local search based procedure. In this context, for each pair of non-dominated solutions obtained in the first phase, a reference point is defined by the best values of each solution on each objective function. In this way, VNS is applied to each promising solution with the aim of reducing its distance to the reference point, in order to find additional efficient solutions. We perform extensive experimentation with both real and synthetic instances, and compare our method with the well-known NSGA-II solver.

Keywords: Reference Point VNS, CVRP multiobjective, Iterated Greedy.
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VNS for optimizing the structure of a logical function in IBA framework

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Abstract. Interpolative Boolean algebra (IBA) is a [0,1]-valued generalization of Boolean algebra consistent with Boolean frame. In IBA framework, a logical function is determined by its structure and values of attributes. Formally, any logical function is defined as a scalar product of the vector of atomic elements and the structural vector. The vector of atomic elements consists of all realizations of IBA atomic elements (the simplest elements in Boolean algebra). On the other hand, the structural vector is binary and determine the structure of the expression, i.e. whether an atomic element is included in a logical function or not. In this paper, we aim to utilize variable neighborhood search (VNS) method for optimizing the structure of a logical function in IBA framework. In fact, the idea is to determine which realization of the structural vector provides the best accuracy for a particular prediction problem. The prediction model is a logical function that is descriptive, easy to interpret and analyze, which are the main benefits of the proposed method. To evaluate performance of the presented approach, the comparison of prediction results is made to simple linear and multiple regression.

Keywords: Interpolative Boolean algebra, logical function, variable neighborhood search, prediction.
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A VNS-based Algorithm with Adaptive Local Search for the MDVRP

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Abstract. The Multi-Depot Vehicle Routing Problem (MDVRP) is a variant of VRP that consists in designing a set of vehicle routes to serve all customers, such that the maximum number of vehicle per depot, the vehicle capacity and the maximum time for each route are respected. The objective is to minimize the total cost of transportation. This paper presents an algorithm, named VNSALS, based on the Variable Neighborhood Search (VNS) with Adaptive Local Search (ALS) for solving it. The main procedures of VNSALS are perturbation, ALS and cluster refinement. The shaking procedure of VNS is important to diversify the solution and escape from local minimum. In its turn, the ALS procedure consists in memorizing the

results found after applying a local search and using this memory to select the most promising neighborhood for the next local search application. The choice of the neighborhood is very important to improve the solution in heuristic methods because the complexity of the local search is high and expensive. On the other hand, the reallocation of the customers keeps the clusters more balanced. The proposed algorithm is tested using classical instances of the MDVRP. The obtained results are analyzed for concluding the paper.

Keywords: Multi-Depot Vehicle Routing Problem, Adaptive Local Search, Variable Neighborhood Search.
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General Variable Neighborhood Search for the Scheduling Heterogeneous Vehicles in Agriculture

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Abstract. A new variant of Vehicle Scheduling Problem (VSP), denoted as Vehicle Scheduling Problem with Heterogeneous Vehicles (VSP-HV), arising when optimizing the sugar beet transportation in a sugar factory in Serbia is introduced. The objective of the considered VSP-HV is to minimize the time required for daily transportation of sugar beet by heterogeneous vehicles under problem-specific constraints. General Variable Neighborhood Search (GVNS) is designed as a solution method for the considered problem. The computational study is conducted on real-life instances as well as the set of generated instances of larger dimensions. The Mixed Integer Quadratically Constraint Programming (MIQCP) model is developed and used within commercial Lingo 17 solver to obtain optimal or feasible solutions for small-size real-life problem instances. Experimental results show that the proposed GVNS quickly reaches all known optimal solutions or improves the upper bounds of feasible solutions on small-size instances. On larger problem instances, for which Lingo 17 could not find feasible solutions, GVNS provided its best solutions for limited CPU time.

Keywords: Vehicle scheduling problem, Single depot, Heterogeneous vehicles, Variable neighborhood search, Transportation in agriculture.
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Basic VNS algorithms for solving the pollution location inventory routing problem

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Abstract. This work presents a new variant of the Location Inventory Routing Problem (LIRP), called Pollution LIRP (PLIRP). The PLIRP considers both economic and environmental impacts. A Mixed Integer Programming (MIP) formulation is employed and experimental results on ten randomly generated small-sized instances using CPLEX are reported. Furthermore, it is shown that, CPLEX could not compute any feasible solution on another set of ten randomly generated medium-sized instances, with a time limit of five hours. Therefore, for solving more computationally challenging instances, two Basic Variable Neighborhood Search (BVNS) metaheuristic approaches are proposed. A comparative analysis between CPLEX and BVNS on these 20 problem instances is reported.

Keywords: Variable Neighborhood Search, Location Inventory Routing Problem, Green Logistics.

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A Variable Neighborhood Descent heuristic for the multi-quay Berth Allocation and Crane Assignment Problem under availability constraints

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Abstract. In this paper, we consider the integrated Berth Allocation and Crane Assignment problem, with availability constraints and high tides restrictions, in bulk port context. We were inspired by a real case study of a port owned by our industrial partner. The objective is to minimize the total penalty of tardiness. First, we implemented a greedy heuristic to compute an initial solution. Then, we proposed a sequential Variable Neighborhood Descent (seq-VND) for the problem. In addition, We compared the efficiency of different scenarios for the seq-VND.

Keywords: Berth allocation, Crane Assignment, Variable Neighborhood Descent, Bulk port.

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A GRASP-VNS for solving a Vehicle Routing Problem for Waste Collection

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Abstract. This work analyses the application of a GRASP/VNS hybrid in the optimization of real waste collection in the island of La Palma (Canary Islands, Spain). The objective is to minimize some eco-efficiency indicators of the environmental impact of the collection strategy. We first exploit historic data to estimate the fill level of the containers every day and later we use the meta-heuristic procedure to design the collection routes. The waste containers are of two types, paper-carton and plastic packaging, and the collection is made separately with the same fleet of vehicles. The purpose is to collect those containers with the highest fill level subject to temporary or length constraints in the routes. The instances are designed using true location of the containers and fill levels estimations on different planning horizon. The travel times between container locations are obtained combining the travel times and distances extracted through Google Maps API web services with those obtained from the database of the company that is actually performing the collection. The computational experiments reveal the optimization technique allows improving the current collection process according with several performance indicators.

Keywords: VNS, GRASP, Waste Collection.
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Primal-dual VNS for large p-center problem

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Abstract. Primal-dual VNS (P-D-VNS) is a VNS variant for solving large combinatorial optimization problems that provides lower and upper bounds of the heuristic solution. After finding primal solution by VNS, the infeasible dual is found for which the primal and the dual have the same objective values. Then the VNS search continues in the dual space. If the gap between the primal and the dual values is small, some branch and bound method can even close the gap and find the exact solution. In this paper we follow general steps of the P-D-VNS for solving large p-center discrete location problem. Computational results on usual test instances demonstrate the ability of P-D-VNS for solving large p-center problems.

Keywords: Variable Neighborhood Search, Primal-dual methods, p-center.
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GVNS applied to the Weighted Fair Sequences Problem

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Abstract. The Weighted Fair Sequences Problem (WFSP) is an optimization problem that has been recently defined in the literature. It covers a large number of applications in different areas, ranging from automobile production on a mixed-model assembly line to the sequencing of interactive applications to be aired in a Digital TV environment. The WFSP, which is part of the class of scheduling problems called fair sequences, was proved to be NP-hard by Pessoa et al. (2018), and an iterative solution method was proposed for it. This paper proposes the first heuristic solution for the WFSP, based on a general variable neighborhood search approach. Computational experiments on the benchmark instances show that the proposed metaheuristic outperforms the above-mentioned iterative method both in terms of solution quality and efficiency.

Keywords: Scheduling, Fair Sequences, Metaheuristics.
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An adaptive VNS and Skewed GVNS approaches for School Timetabling Problems

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Abstract. The problem to make a timetable in schools is widely known and it appears in all educational institutions. Due to its complexity, it is usually solved by heuristic methods. In this work, we developed two algorithms based on the Variable Neighborhood Search (VNS) metaheuristic. The first one, named Skewed GVNS (SGVNS), uses Variable Neighborhood Descent (VND) as a local search method. The second one, so-called Adaptive VNS, is based on VNS and probabilistically chooses the neighborhoods to do local searches, with the probability being higher for the more successful neighborhoods. The computational experiments show a good adherence of these algorithms to the problem, especially comparing them with previous works with the same metaheuristic and with the results of the winner of the International Timetabling Competition of 2011.

Keywords: School Timetabling, Variable Neighborhood Search, Skewed GVNS, International Timetabling Competition.

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Skewed Variable Neighborhood Search Method for the Weighted Generalized Regenerator Location Problem

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Abstract. This paper deals with the Weighted Generalized Regenerator Location Problem (WGRLP) that arises from the design of optical telecommunication networks. During the transmission of optical signal, its quality deteriorates with the distance from the source, and therefore, it has to be regenerated by installing regenerators at some of the nodes in the network. The WGRLP involves weights assigned to potential regenerator locations that reflect the costs of regenerator deployment. The objective of WGRLP is to minimize the sum of weights assigned to locations with installed regenerators, while ensuring a good quality communication among the given subset of terminal nodes. As telecommunication networks usually involve large number of nodes, an efficient optimization method is required to deal with real-life problem dimensions. In this paper, a Skewed Variable Neighborhood Search method (SVNS) is proposed as solution approach for the WGRLP. The designed SVNS uses adequate data structures for solution representation and efficient procedures for objective function update, feasibility check, and solution repair. Computational results on the WGRLP data set from the literature show that the proposed SVNS reaches all known optimal solutions on small and medium size instances in short running times and outperforms existing heuristic approaches for the WGRLP. In addition, the results of SVNS on large scale WGRLP instances, which are not considered in the literature so far, are presented. The obtained computational results indicate the potential of SVNS as solution approach to WGRLP and similar network design problems.

Keywords: Weighted generalized regenerator location problem, Skewed variable neighborhood search, Optical networks, Telecommunication.
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A VNS-based Algorithm with Adaptive Local Search for the MDVRP

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Abstract. This paper presents an implementation of the Variable Neighborhood Search (VNS) metaheuristic for solving the optimization version of the Multidimensional Multi-way Number Partitioning Problem (MDMWNPP). This problem consists in distributing the vectors of a given sequence into k disjoint subsets such that the sums of each subset form a set of vectors with minimum diameter. The proposed VNS for solving MDMWNPP has good performance over instances with three and four subsets. A comparative study of the results found from the application of the proposed VNS and an implementation of a Memetic Algorithm (MA) is carried out, running in the same proportional time interval. A statistical analysis involving this comparison ends the paper.

Keywords: Multidimensional Multi-way Number Partitioning Problem, Metaheuristic, Number Partitioning Problem, Combinatorial Optimization.
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Studying the impact of perturbation methods on the efficiency of GVNS for the ATSP

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Abstract. In this work the impact of three shaking procedures on the performance of a GVNS metaheuristic algorithm for solving the Asymmetric Travelling Salesman Problem (ATSP) is examined. The first shaking procedure is a commonly used in literature perturbation method. The second one is a quantum-inspired shaking method, while the third one is a random-restart method. The shaped GVNS schemes are tested both with first and best improvement and either with a time limit of one and two minutes. Experimental analysis show that the two first methods perform equivalently and much better than the random-restart approach, using the best improvement strategy. By using the first improvement, the first method again perform

much better than the other two while second method's results are closer to third's method.

Keywords: Metaheuristics, VNS, GVNS, Optimization, TSP, aTSP, Perturbation Comparisons, Performance Study.
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New VNS variants for the Online Order Batching Problem

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Abstract. The Order Batching Problem (OBP) can be considered a family of optimization problems related to the retrieval of goods in a warehouse. The original and most extended version of the problem consists in minimizing the total time needed to collect a group of orders. However, this version has been evolved with many other variants, where the restrictions and/or the objective function might change. In this paper, we deal with the Online Order Batching Problem (OOBP) version, which introduces the novelty to the OBP of considering orders that have arrived to the warehouse once the retrieval of previous orders has started. This family of problems has been deeply studied by the heuristic community in the past. Notice, that solving any variant of the OBP include two important activities: grouping the orders into batches (batching) and determining the route to follow by a picker to retrieve the items within the same batch (routing). We review the most outstanding proposals in the literature for the OOBP variant and we propose a new version of a competitive Variable Neighborhood Search (VNS) algorithm to tackle the problem.

Keywords: Online Order Batching Problem, VNS, OOBP.
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An Evolutionary Variable Neighborhood Descent for addressing an electric VRP variant

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Abstract. Variable neighborhood searches and evolutionary techniques have shown their effectiveness when dealing with many combinatorial optimisation problems. This study proposes to combine these two techniques for addressing the routing problem using electric and modular vehicles. This is a recent problem that aims to overcome recharging battery constraints while maintaining a certain performance regarding to the fleet cost and the traveled distance. An experimental study on benchmark instances is provided to show the relevance of the proposed algorithm.

Keywords: Evolutionary Algorithm, BCRC Crossover, Variable Neighborhood Descent, Modular Electric Vehicles.
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Detecting weak points in networks using Variable Neighborhood Search

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Abstract. Recent advances in networks technology requires from advanced technologies for monitoring and controlling weaknesses in networks. Networks are naturally dynamic systems to which a wide variety of devices are continuously connecting and disconnecting. This dynamic nature force us to maintain a constant analysis looking for weak points that can eventually disconnect the network. The detection of weak points is devoted to find which nodes must be reinforced in order to increase the safety of the network. This work tackles the α separator problem, which aims to find a minimum set of nodes that disconnect the net- work in subnetworks of size smaller than a given threshold. A Variable Neighborhood Search algorithm is proposed for finding the minimum α separator in different network topologies, comparing the obtained results with the best algorithm found in the state of the art.

Keywords: Alpha-separator, Reduced VNS, betweenness
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Notes

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6th International Conference
on Variable Neighborhood Search

Sithonia, Halkidiki, Greece

October 4-7, 2018

http://vns2018.uom.gr

Organizers:

University of Macedonia Research Committee

CMOR Computational Methodologies & Operations Research

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