University of Groningen

Exact and heuristic methods for optimization in distributed logistics

Schrotenboer, Albert

DOI:
[10.33612/diss.112911958](https://doi.org/10.33612/diss.112911958)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2020

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Schrotenboer, A. (2020). *Exact and heuristic methods for optimization in distributed logistics*. [Thesis fully internal (DIV), University of Groningen]. University of Groningen, SOM research school.
<https://doi.org/10.33612/diss.112911958>

Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

Exact and Heuristic Methods for Optimization in Distributed Logistics

Albert Harm Schrotenboer

Publisher: University of Groningen
Groningen, The Netherlands

Printed by: Ipskamp Printing
Enschede, The Netherlands

ISBN: 978-94-034-2290-9 (printed version)
978-94-034-2289-3 (electronic version)

© 2019, Albert H. Schrottenboer

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system of any nature, or transmitted in any form or by any means, electronic, mechanical, now known or hereafter invented, including photocopying or recording, without prior written permission from the copyright owner.

university of
 groningen

Exact and Heuristic Methods for Optimization in Distributed Logistics

PhD thesis

to obtain the degree of PhD at the
University of Groningen
on the authority of the
Rector Magnificus Prof. C. Wijmenga
and in accordance with
the decision by the College of Deans.

This thesis will be defended in public on

Thursday 6 February 2020 at 14:30 hours

by

Albert Harm Schrotenboer

born on 7 July 1991
in Hoogeveen

Supervisor

Prof. I.F.A. Vis

Co-supervisor

Dr. E. Ursavas

Assessment committee

Prof. R. H. Teunter

Prof. M. W. P. Savelsbergh

Prof. R. Dekker

To Aukje

You will always leave a light on in our hearts

Contents

1	Introduction	1
1.1	The Operations Research perspective	5
1.2	Offshore wind maintenance logistics	7
1.3	E-commerce operations	10
1.4	Overview of manuscripts	12
I	Offshore wind logistics	15
2	A branch-and-price-and-cut algorithm for resource constrained pickup and delivery problems	17
2.1	Introduction	18
2.2	Problem description	22
2.2.1	Mixed integer programming formulation	23
2.2.2	Set covering formulation	26
2.3	Valid inequalities	28
2.3.1	Column-dependent constraints approach	30
2.3.2	Separating resource exceeding route inequalities	36
2.3.3	Other valid inequalities	37
2.4	Pricing problems	38
2.4.1	The pricing problem	38
2.4.2	Incorporating the dual values	39
2.4.3	The pulse algorithm for PP	41
2.5	Branch-and-price-and-cut algorithm	45
2.5.1	Initial solution	45
2.5.2	Branching and node selection strategy	46
2.6	Computational experiments	47
2.6.1	Benchmark characteristics	48

2.6.2	Root node relaxations	50
2.6.3	Full model comparison	51
2.6.4	Ignoring technician costs	54
2.6.5	Short service times	54
2.7	Conclusions	57

3 Coordinating technician allocation and maintenance routing for offshore wind farms 59

3.1	Introduction	60
3.2	Problem description	64
3.2.1	The Technician Allocation and Routing Problem (TARP)	64
3.2.2	The Technician Allocation and Routing Problem with Fixed Allocations (TARP-F)	67
3.2.3	The Technician Allocation and Routing Problem with Given Allocations (TARP-G)	67
3.2.4	Preprocessing: cost and travel restructuring	67
3.3	Adaptive Large Neighborhood Search	68
3.3.1	Destroy operators	69
3.3.2	Repair operators	71
3.3.3	Destroy and repair procedure	72
3.3.4	Initial solution	73
3.3.5	Acceptance criterion	73
3.3.6	Shaking procedure	74
3.3.7	Differences between TARP, TARP-F, and TARP-G	74
3.4	Two-stage ALNS performance	74
3.4.1	Benchmark instances	75
3.4.2	Parameter tuning	76
3.4.3	The impact of the destroy operators	76
3.4.4	Computational results	79
3.5	Managerial insights	80
3.5.1	Simulation set-up	80
3.5.2	Simulation outcomes	82
3.6	Conclusions	85
	Appendices	87
3.A	Parameter calibration	87
3.B	Simulation study set-up	89

4	Mixed Integer Programming models for planning maintenance at offshore wind farms under uncertainty	91
4.1	Introduction	92
4.1.1	Literature Review	94
4.1.2	Contributions and outlook	97
4.2	Problem Formulation	97
4.2.1	System description	98
4.2.2	The second stage problem	100
4.2.3	Two-stage stochastic programming formulation	106
4.3	Modeling decisions for the second-stage problem	108
4.3.1	Special Case I: Single wind farm	109
4.3.2	Special Case II: Single wind farm and dedicated vessels	110
4.3.3	Special Case III: Single wind, dedicated vessels, and bundle preprocessing	111
4.3.4	Special Cases IV and V: Multiple farms and bundle preprocessing . .	112
4.4	Numerical Results	113
4.4.1	Benchmark instances for the second-stage models	114
4.4.2	A comparison of second-stage special cases	115
4.4.3	Computational results of the SMFTPO	121
4.5	Conclusion	124
	Appendices	127
4.A	Monolithic formulation for solving the SMFTPO	127
4.B	Additional MIP formulations of special cases	128
4.B.1	Special Case I: Single wind farm	128
4.B.2	Single wind farm case with dedicated vessels	129
4.B.3	Bundle Preprocessing	131
4.B.4	Bundle selection in basic formulation	132
II	E-commerce logistics	135
5	Order picker routing in the e-commerce era	137
5.1	Introduction	138
5.2	Problem description	140
5.2.1	Single order picker	141
5.2.2	Multiple order pickers and interaction effects	142
5.3	Hybrid Genetic Algorithm	144
5.3.1	Update Phase	144
5.3.2	Mutation Phase	146

5.3.3	Crossover Phase	147
5.3.4	Education and Selection Phase	148
5.4	Hybrid Genetic Algorithm with Interaction Effects	148
5.5	Numerical experiments	150
5.5.1	Performance of the Hybrid Genetic Algorithm	151
5.5.2	Performance of the Hybrid Genetic Algorithm with interaction effects	154
5.6	Conclusions	157
6	Integration of returns and decomposition of customer orders in e-commerce warehouses	159
6.1	Introduction	160
6.2	Literature Review	163
6.3	Problem Definition	166
6.3.1	Mixed Integer Programming Formulation	167
6.3.2	Extended MIP formulations	172
6.4	Adaptive Large Neighborhood Search	174
6.4.1	Generic repair heuristic (CI heuristic)	175
6.4.2	Initial Solution	176
6.4.3	Operators	177
6.4.4	MIP-based improvements	181
6.4.5	Overall heuristic structure	182
6.5	Numerical Results	182
6.5.1	Benchmark data sets	183
6.5.2	Parameter tuning	184
6.5.3	Computation times	185
6.5.4	Benchmark models	186
6.5.5	Solutions to the G-JOBASPR instances	187
6.5.6	The effect of multiple threads	190
6.5.7	Sensitivity of the order picker's capacity	191
6.5.8	Impact of the order split-up costs	192
6.5.9	Cost partitioning with tight deadlines	193
6.5.10	Impact of the MIP operators and results verification	194
6.6	Conclusions	195
7	Two-stage robust network design with temporal characteristics	197
7.1	Introduction	198
7.1.1	Time-invariant vehicle paths	200
7.1.2	Two-stage robust optimization with integer second stage.	201

7.1.3	Network design problems	202
7.1.4	Contributions and outlook	204
7.2	Problem formulation	205
7.2.1	Problem statement	205
7.2.2	Time-expanded network and second stage decisions	206
7.2.3	Two-stage Robust formulation	210
7.3	A lower bound approach	211
7.4	The single-stage RNDP as upper bound	213
7.4.1	The uncertainty set	213
7.4.2	A MIP-based upper bound	214
7.5	Experimental insights	216
7.5.1	Potential of time-invariant vehicle paths	216
7.5.2	Numerical examples	218
7.6	Conclusion	220
8	Concluding remarks	223
8.1	Offshore wind logistics	224
8.1.1	Conclusions	224
8.1.2	Discussion and future research	226
8.2	E-commerce logistics	228
8.2.1	Conclusions	229
8.2.2	Discussion and future research	230
	Bibliography	233
	Summary	245
	Samenvatting	247
	Curriculum Vitæ	253