



Universiteit
Leiden
The Netherlands

Transformations for polyhedral process networks

Meijer, S.

Citation

Meijer, S. (2010, December 8). *Transformations for polyhedral process networks*. Retrieved from <https://hdl.handle.net/1887/16221>

Version: Corrected Publisher's Version

License: [Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

Downloaded from: <https://hdl.handle.net/1887/16221>

Note: To cite this publication please use the final published version (if applicable).

Transformations for Polyhedral Process Networks

Sjoerd Meijer

Transformations for Polyhedral Process Networks

Proefschrift

ter verkrijging van

de graad van Doctor aan de Universiteit Leiden,

op gezag van Rector Magnificus prof.mr. P.F. van der Heijden,

volgens besluit van het College voor Promoties

te verdedigen op woensdag 8 december 2010

klokke 16:15 uur

door

Sjoerd Meijer

geboren te Leiderdorp

in 1979.

Samenstelling promotiecommissie:

promotor	Prof.dr. Ed F. Deprettere	Universiteit Leiden
co-promotor	Dr. Todor Stefanov	Universiteit Leiden
overige leden:	Prof.dr. Harry Wijshoff	Universiteit Leiden
	Prof.dr. Joost Kok	Universiteit Leiden
	Prof. Dr.-Ing. Jürgen Teich	Universität Erlangen-Nürnberg
	Prof.dr. Gerard Smit	Universiteit Twente
	Prof.dr. Henk Corporaal	Technische Universiteit Eindhoven

Transformations for Polyhedral Process Networks

Sjoerd Meijer. -

Thesis Universiteit Leiden. - With index, ref. - With summary in Dutch

ISBN 978-90-9025792-1

Copyright ©2010 by Sjoerd Meijer, Leiden, The Netherlands.

Cover design by Senny Yu.

All rights reserved. No part of the material protected by this copyright notice may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, recording or by any information storage and retrieval system, without permission from the author.

Printed in the Netherlands

Contents

1	Introduction	1
1.1	Problem Statement	5
1.2	Contributions	7
1.3	Related Work	9
1.4	Outline	15
2	Background	17
2.1	Polyhedra	17
2.2	Lexicographic Order	19
2.3	Static Affine Nested-Loop Programs	21
2.4	Extracting the Polyhedral Model from SANLPs	23
2.5	Polyhedral Process Networks	24
2.6	Validity of Transformations	29
3	Process Splitting Transformations	31
3.1	Process Splitting: Definitions, Notations, and Examples	32
3.2	Challenges of Applying the Process Splitting Transformation	35
3.3	Partitioning Metrics	38
3.3.1	Computation and Communication Costs	38
3.3.2	Initial Delay	39
3.3.3	Production Period	40
3.3.4	Data Transfers	42
3.3.5	Additional Control Overhead	42
3.4	Compile-time Selection of Splitting Transformation	43
3.5	Case-Studies	50
3.5.1	Single Diagonal Dependence	51
3.5.2	Matrix Multiplication with Multiple Dependencies	56

3.5.3	Four Producers with Delays	59
3.6	Discussion and Summary	62
4	Process Merging Transformations	65
4.1	Process Merging: Definitions	65
4.2	Challenges of Applying the Process Merging Transformation	66
4.3	Restrictions on the Throughput Modeling	69
4.4	Throughput Modeling	70
4.4.1	Process Throughput and Throughput Propagation	70
4.4.2	Isolated Throughput of a (Compound) Process	72
4.4.3	FIFO Channel Throughput	74
4.4.4	Aggregated FIFO Throughput	75
4.4.5	System Throughput Calculation Algorithm	77
4.5	Case-Studies	78
4.5.1	Merging Light-Weight Producers	78
4.5.2	Merging Processes in Networks with Different Data Paths	81
4.6	Discussion and Summary	82
5	Applying Transformations in Combination	85
5.1	Impact of the Transformation on Performance Results	87
5.1.1	Transforming a PPN to Create More Processes	87
5.1.2	Transforming a PPN to Reduce the Number of Processes	89
5.1.3	The Optimization Pitfall: Performance Degradation	90
5.2	Compile-Time Solution for Transformation Ordering	91
5.2.1	Creating Load-Balanced Tasks	93
5.2.2	Selecting Processes for Transformations	94
5.3	Exploiting Data-Level Parallelism	95
5.3.1	Stateful Processes	97
5.3.2	Cycles	97
5.4	Case-Studies	99
5.4.1	QR Decomposition: a PPN with Stateful Processes and Cycles	100
5.4.2	Transforming Perfectly Balanced PPNs	102
5.5	Discussion and Summary	105
6	Executing PPNs on Fixed Programmable MPSoC Platforms	111
6.1	The Programmable Platforms	112
6.2	Realizing FIFO Communication	114
6.3	Performance Results	118
6.4	Discussion and Summary	123
7	Conclusions	125

Contents	ix
Bibliography	130
Index	140
Acknowledgments	143
Samenvatting	145
Curriculum Vitae	147

