Flow Logic for Process Calculi

Flow Logic is an approach to statically determining the behavior of programs and processes. It borrows methods and techniques from Abstract Interpretation, Data Flow Analysis and Constraint Based Analysis while presenting the analysis in a style more reminiscent of Type Systems. Traditionally developed for programming languages, this article provides a tutorial development of the approach of Flow Logic for process calculi based on a decade of research.

We first develop a simple analysis for the π-calculus; this consists of the specification, semantic soundness (in the form of subject reduction and adequacy results), and a Moore Family result showing that a least solution always exists, as well as providing insights on how to implement the analysis. We then show how to strengthen the analysis technology by introducing reachability components, interaction points, and localized environments, and finally, we extend it to a relational analysis.

A Flow Logic is a program logic—in the same sense that a Hoare’s logic is. We conclude with an executive summary presenting the highlights of the approach from this perspective including a discussion of theoretical properties as well as implementation considerations.

The electronic supplements present an application of the analysis techniques to a version of the π-calculus incorporating distribution and code mobility; also the proofs of the main results can be found in the electronic supplements.
From Explicit to Symbolic Types for Communication Protocols in CCS
We study communication protocols having several rounds and expressed in value passing CCS. We develop a type-based analysis for providing an explicit record of all communications and show the usual subject reduction result. Since the explicit records can be infinitely large, we also develop a type-based analysis for providing a finite, symbolic record of all communications. We show that it correctly approximates the explicit record and prove an adequacy result for it.

General information
State: Published
Organisations: Language-Based Technology, Department of Informatics and Mathematical Modeling, Technische Universität München
Authors: Nielson, H. R. (Intern), Nielson, F. (Intern), Kreiker, J. (Ekstern), Pilegaard, H. (Intern)
Pages: 74-89
Publication date: 2012

Host publication information
Title of host publication: Formal Modeling: Actors, Open Systems, Biological Systems : Essays Dedicated to Carolyn Talcott on the Occasion of Her 70th Birthday
Publisher: Springer
ISBN (Print): 978-3-642-24932-7
Series: Lecture Notes in Computer Science
Number: 7000
ISSN: 0302-9743
Main Research Area: Technical/natural sciences
Conference: Symposium in honor of Carolyn Talcott, Menlo Park, California, USA, 01/01/2012
DOIs:
We present the ongoing work on the pathway analysis of a stochastic calculus. Firstly we present a particular stochastic calculus that we have chosen for our modeling - the Interactive Markov Chains calculus, IMC for short. After that we specify a few restrictions that we have introduced into the syntax of IMC in order to make our analysis feasible. Finally we describe the analysis itself together with several theoretical results that we have proved for it.

**General information**
State: Published
Organisations: Language-Based Technology, Department of Informatics and Mathematical Modeling
Authors: Skrypnyuk, N. (Intern), Nielson, F. (Intern), Pilegaard, H. (Intern)
Number of pages: 106
Pages: 7-10
Publication date: 2009

**Host publication information**
Title of host publication: 21st Nordic Workshop on Programming Theory : NWPT 2009
Place of publication: Lyngby
ISBN (Electronic): 978-87-643-0565-4
Main Research Area: Technical/natural sciences
Workshop: 21st Nordic Workshop on Programming Theory, Lyngby, Denmark, 14/12/2009 - 14/12/2009
Electronic versions:
wpt09_submission_27.pdf
Source: orbit
Source-ID: 257284
Publication: Research › Conference abstract in proceedings – Annual report year: 2009

**Transition systems: Hvordan virker en colaautomat?**

**General information**
State: Published
Organisations: Language-Based Technology, Department of Informatics and Mathematical Modeling
Authors: Pilegaard, H. (Intern), Nanz, S. (Intern), Nielson, F. (Intern), Nielson, H. R. (Intern)
Pages: 63-79
Publication date: 2009

**Host publication information**
Title of host publication: Matematiske Horisonter
ISBN (Print): 9788764304534
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 257276
Publication: Education - peer-review › Book chapter – Annual report year: 2009

**Pathway Analysis for BioAmbients**

**General information**
State: Published
Organisations: Language-Based Technology, Department of Informatics and Mathematical Modeling
Authors: Pilegaard, H. (Intern), Nielson, F. (Intern), Nielson, H. R. (Intern)
Pages: 92-130
Publication date: 2008
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Journal of Logic and Algebraic Programming
Volume: 77
Issue number: 1-2
ISSN (Print): 1567-8326
Ratings:
Relational Analysis for Delivery of Services

Many techniques exist for statically computing properties of the evolution of processes expressed in process algebras. Static analysis has shown how to obtain useful results that can both be checked and computed in polynomial time. In this paper we develop a static analysis in relational form which substantially improves the precision of the results obtained while being able to deal with the full generality of the syntax of processes. The analysis reveals a feasible complexity for practical examples and gives rise to a fast prototype. We use this prototype to automatically prove the correct delivery of messages for the implementation of an accident service, which is based on multiplexed communication, a crucial feature of global computing applications.

General information
State: Published
Organisations: Language-Based Technology, Department of Informatics and Mathematical Modeling
Authors: Nielson, F. (Intern), Nielson, H. R. (Intern), Bauer, J. (Intern), Nielsen, C. R. (Intern), Pilegaard, H. (Intern)
Relational Analysis of Correlation

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Language-Based Technology
Authors: Bauer, J. (Intern), Nielson, F. (Intern), Nielson, H. R. (Intern), Pilegaard, H. (Intern)
Pages: 32-46
Publication date: 2008

Host publication information
Title of host publication: Static Analysis : Proceedings of 15th International Symposium, SAS 2008
Publisher: Springer
Editors: Alpuente, M., Vidal, G.

Series: Lecture Notes in Computer Science
Number: 5079
Main Research Area: Technical/natural sciences
Conference: 15th International Static Analysis Symposium , Valencia, Spain, 16/07/2008 - 16/07/2008
Source: orbit
Source-ID: 222468
Publication: Research - peer-review › Article in proceedings – Annual report year: 2008

Language Based Techniques for Systems Biology
Process calculus is the common denominator for a class of compact, idealised, domain-specific formalisms normally associated with the study of reactive concurrent systems within Computer Science. With the rise of the interaction-centred science of Systems Biology a number of bio-inspired process calculi have similarly been used for the study of bio-chemical reactive systems. In this dissertation it is argued that techniques rooted in the theory and practice of programming languages, language based techniques if you will, constitute a strong basis for the investigation of models of biological systems as formalised in a process calculus. In particular it is argued that Static Program Analysis provides a useful approach to the study of qualitative properties of such models. In support of this claim a number of static program analyses are developed for Regev’s BioAmbients – a bio-inspired variant of Cardelli’s Ambient Calculus that incorporates all features of Milner’s π-calculus: The property of spatial reachability, which is related to the function of cellular transport mechanisms, is addressed by two traditional Control Flow Analyses (CFAs). The simpler of the two, a mono-variant analysis (0CFA), is context insensitive, while the other, a poly-variant analysis (2CFA), is context-sensitive. These analyses compute safe approximations to the set of spatial configurations that are reachable according to a given model. This is useful in the qualitative study of cellular self-organisation and, e.g., the effects of receptor defects or drug delivery mechanisms. The property of sequential realisability, which is closely related to the function of biochemical pathways, is addressed by a variant of traditional Data Flow Analysis (DFA). This so-called ‘Pathway Analysis’ computes safe approximations to the set of reaction sequences that is realisable according to given model. This is useful in the qualitative study of the metabolic pathways that emerge from a group of connected biochemical agents. Technically, these approaches are complementary, but the analyses all overapproximate the set of run-time enabled reactions. This is used in an iterative narrowing scheme that achieves considerable synergy between CFA and DFA, and dramatically improves the results of both. The specified analyses are proved correct with respect to the semantics of BioAmbients, and their strength is illustrated by application to abstract models of biological phenomena: One is a model of the LDL degradation pathway, where it is shown that the analyses are able to pinpoint the effects of certain genetic defects that are known to be associated to cardiovascular disease. The other is a model of genetic transcription that relies only on the π calculus fragment of BioAmbients. In both cases the analyses compute very precise estimates of the temporal structure of the underlying pathways; hence they are applicable across a family of widely used bio-ware languages that descend from Milner’s Calculus of Communicating Systems. The presented set of analyses constitutes a nice toolbox for the analysis of biological models. The individual tools range in complexity from low polynomial to exponential, while the precision scales similarly. Thus, the toolbox may provide useful information at all stages of a models lifetime, including development, where one is interested in frequent quick estimates, verification, and prediction, where one is willing to wait longer for more precise estimates.

General information
State: Published
Organisations: Computer Science and Engineering, Department of Informatics and Mathematical Modeling, Language-Based Technology
Authors: Pilegaard, H. (Intern), Nielson, F. (Intern), Nielson, H. R. (Intern)
Publication date: Dec 2007
Active Evaluation Contexts for Reaction Semantics

What is a free name in a process algebra?
Context Dependent Analysis of BioAmbients

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Computer Science and Engineering
Authors: Pilegaard, H. (Intern), Nielson, F. (Intern), Nielson, H. R. (Intern)
Publication date: 2006

Host publication information
Title of host publication: Emerging Aspects of Abstract Interpretation 2006
Main Research Area: Technical/natural sciences
Links:
http://www2.imm.dtu.dk/pubdb/p.php?4809
Source: orbit
Source-ID: 191561
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006
Static analysis of a Model of the LDL degradation pathway

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Computer Science and Engineering
Authors: Pilegaard, H. (Intern), Nielson, F. (Intern), Nielson, H. R. (Intern)
Publication date: 2005

Host publication information
Title of host publication: Third International Workshop on Computational Methods in Systems Biology (CMSB'05)
Publisher: University of Edinburgh
Main Research Area: Technical/natural sciences
Links:
http://www2.imm.dtu.dk/pubdb/p.php?4193
Source: orbit
Source-ID: 185736
Publication: Research - peer-review › Article in proceedings – Annual report year: 2005

Spatial Analysis of BioAmbients
Programming language technology can contribute to the development and understanding of Systems Biology by providing formal calculi for specifying and analysing the dynamic behaviour of biological systems. Our focus is on BioAmbients, a variation of the ambient calculi developed for modelling mobility in computer systems. We present a static analysis for capturing the spatial structure of biological systems and we illustrate it on a few examples.

General information
State: Published
Organisations: Language-Based Technology, Department of Informatics and Mathematical Modeling
Authors: Nielson, H. R. (Intern), Nielson, F. (Intern), Pilegaard, H. (Intern)
Pages: 69-83
Publication date: 2004

Host publication information
Title of host publication: Proceedings of Static Analysis Symposium 2004 (SAS'04)
Publisher: Springer Verlag
Main Research Area: Technical/natural sciences
Conference: Proceedings of Static Analysis Symposium 2004 (SAS'04), 01/01/2004
Links:
http://www.springerlink.com/app/home/issue.asp?wasp=56we0cgmwp6rl8f4jf3&referrer=nav&nav_page_all.x=1&absolute page=1&pagecount=2&backto=journal,156,1837;linkingpublicationresults,1:105633,1;
Source: orbit
Source-ID: 154648
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

The Succinct Solver Suite

General information
State: Published
Organisations: Computer Science and Engineering, Department of Informatics and Mathematical Modeling
Pages: 251-265
Publication date: 2004

Host publication information
Title of host publication: Proc. TACAS'04
Publisher: Springer Verlag
Main Research Area: Technical/natural sciences
Conference: TACAS'04, 01/01/2004
Source: orbit
Source-ID: 154649
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004
A feasibility Study: The Succinct Solver v2.0, XSB Prolog v2.6, and Flow-Logic Based Program Analysis for Carmel

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Pilegaard, H. (Intern)
Publication date: 2003

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
imm3193.pdf
Links:
Source: orbit
Source-ID: 58716
Publication: Research › Report – Annual report year: 2003

An Approach to Analyzing Availability Properties of Security Protocols

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Computer Science and Engineering
Authors: Pilegaard, H. (Intern), Hansen, M. R. (Intern), Sharp, R. (Intern)
Pages: 337-373
Publication date: 2003
Main Research Area: Technical/natural sciences

Publication information
Journal: Nordic Journal of Computing
Volume: 10
Issue number: 4
ISSN (Print): 1236-6064
Ratings:
BFI (2016): BFI-level 1
BFI (2015): BFI-level 1
BFI (2014): BFI-level 1
BFI (2013): BFI-level 1
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
BFI (2009): BFI-level 1
BFI (2008): BFI-level 1
Original language: English
Source: orbit
Source-ID: 58462
Publication: Research - peer-review › Journal article – Annual report year: 2003

Using Interval Logic and Isabelle/HOL for Analyzing Real-TimeProperties of Security Protocols

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Computer Science and Engineering
Authors: Pilegaard, H. (Intern), Hansen, M. P. (Intern), Sharp, R. (Intern), Vain et al., J. (ed.) (Ekstern)
Pages: 84-86
Publication date: 2002
Projects:

**Specification and Programming Languages for Biological Systems**

Department of Informatics and Mathematical Modeling  
Period: 01/10/2003 → 13/12/2007  
Number of participants: 5  
Phd Student:

Pilegaard, Henrik (Intern)  
Supervisor:

Nielsen, Hanne Riis (Intern)  
Main Supervisor:

Nielsen, Flemming (Intern)  
Examiner:

Hillston, Jane (Ekstern)  
Ingolfsdottir, Anna (Ekstern)

**Financing sources**

Source: Internal funding (public)  
Name of research programme: DTU-lønnet stipendie  
Project: PhD