WP4: Domain-specific languages

for System Dynamics Models

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GRACeFUL DSL Work Package Final review

Presented by Patrik Jansson, 2018-03-07.

Technical achievements w.r.t. WP objectives and tasks,

We have worked mainly on T4.4 and T4.5 of the DSL work package:

- T4.4 implement a middleware for connecting the DSL to the CFP layer
- T4.5 build a testing and verification framework for RATs

This resulted in two deliverables which were both handed in on time:

- D4.3: Translation of concept map descriptions to system dynamics models for the CFP layer
- D4.4: Testing and verification framework for RATs with applications to the CRUD case study

Dissemination:

- Reports, tools, and associated open source code on GitHub including examples and install instructions (through a Docker image).
- Scientific papers: four published in 2017, one under review
- Lecture notes: for BSc course "Domain Specific Languages of Mathematics"

GSS: Domain Specific Languages as "tools for thinking"

- a "tweet-sized GSS definition" (from 2013):

   GSS is about developing systems, theories, languages and tools for computer-aided policy making with potentially global implications.

- In GRACeFUL we do several levels of "tools for thinking"
  - Editor: facilitate group model building (using the GRACeFUL tool): to build trust, mutual understanding, shared view
  - DSL: get computer feedback on model building blocks & combinations which "make sense"
    - Types: cannot connect a Boolean port with a Number port
    - Constraints: cannot reuse the same area as park and parking
  - Test: test & verification of the software and communication layers
    - Ultimately intended to build trust in the software tools

Deliverable D4.4: Testing and verification framework

- D4.4 presents a framework for testing and verifying *communicating systems*.
- This framework is based on three parts:
  - declarative programming with strong types (in Haskell),
  - property-based testing in general (using QuickCheck), and
  - the SessionCheck tool for testing communicating systems in particular.
- The strong type system of Haskell and the property-based testing tool QuickCheck are off-the-shelf techniques developed by others but adapted for GRACeFUL by WP4.
- The main new contributions were
  - Typed Values (for communication betwen GRACe and the front-end),
  - SessionCheck (specifying and testing communicating systems), and
  - property-based testing of GRACe programs (connecting to the solver backend) .

Links: PDF, Text source

Deliverable D4.4: Testing and verification framework, cont.

Typed Values

- Short description in D4.4, Section 3
- Source code
- Example use of Typed Values

SessionCheck

SessionCheck was developed by Maximilian Algehed as part of his MSc in Computer Science at Chalmers U. of Tech.

- Short description in D4.4, Section 4
- Full MSc thesis (PDF)
- GitHub repository

Property-based testing of GRACe programs (GCMP)

- Short description in D4.4, Section 5
- Source code
- Example of property definitions
- Example executable

Research publications (progress beyond state-of-the-art)

Five GRACeFUL-relevant papers were published or submitted in 2017, see details in Appendix 1:

- Paper A was accepted to LMCS in Oct. 2016 and published in March 2017.
- Paper B was accepted for publication in JFP 2017-09-20, published online 2017-10-24.
- Paper C was published and presented at FHPC 2017.
- Paper D was published and presented at PLAS 2017.
- Paper E is under review for Earth System Dynamics.

Lecture notes: "Domain Specific Languages of Mathematics"

- BSc level course developed in parallell with GRACeFUL
- Patrik Jansson and Cezar Ionescu
- Lecture notes: 150 pages
- From the abstract: "... encourage the students to approach mathematical domains from a functional programming perspective:
  - to identify the main functions and types involved and, when necessary, to introduce new abstractions;
  - to give calculational proofs;
  - to pay attention to the syntax of the mathematical expressions;
  - and, finally, to organize the resulting functions and types in domain-specific languages.

Organization and personnel

- Site leader: Prof. Patrik Jansson, working 20% for GRACeFUL
- Lecturer: Dr. Alex Gerdes, working 40% for GRACeFUL from 2017-01
- Project assistants (100% from 2017-07; 50% from 2017-07.)
  - Sólrún Einarsdóttir; Maximilian Algehed
- Student research assistants (at 20% each, until 2017-03; until 2017-07):
  - Björn Norgren; Oskar Abrahamsson, Sólrún Einarsdóttir, Maximilian Algehed

Good starting point for early stage researchers:

- C. Ionescu: now Assoc. Prof in Oxford
- A. Gerdes: now Lecturer at UGOT
- O. Abrahamsson, M. Algehed: now PhD students at Chalmers
- S. Einarsdóttir: now ProjAss at Chalmers

Meetings and events

- 2017-02: Chalmers org. the 5th half-yearly GRACeFUL meeting (in Gbg.)
- 2017-03: Patrik participated at the GRACeFUL Y2 review (in Brussels)
- 2017-05: Alex and Maximilian participated in WP2-3-4 work sprint in Delft
- 2017-07: Sólrún participated in the 6th 1/2-y. GRACeFUL meeting in Nantes
- 2017-09: Patrik, Sólrún, Alex and Maximilian attended the International Conference on Functional Programming (ICFP) in Oxford
- 2017-09: Sólrún participated in the model-building work sprint in Leuven
- 2017-10: Maximilian attended the Conference on Computer and Communications Security (CCS) in Dallas
- 2017-11: Patrik and Sólrún participated in GRACeFUL evaluation work sprint in Delft
- 2017-12: Patrik participated in Workshop on Lightweight Verification for Complex Systems (LiVe4CS) in Glasgow
- 2017-12: Patrik and Alex participated in "GSS in H2020 and beyond" (the GRACeFUL final event) in Brussels.
  - Keynote by Patrik Jansson, and presentation by Alex Gerdes
- 2018-01: Patrik teaching the BSc course "Domain Specific Languages of Mathematics", using lecture notes developed with support from GRACeFUL

Summary / Questions?

Deliverables:

- D4.3: Translation of concept map descriptions to system dynamics models for the CFP layer
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- GRACeFUL editor, GRACe DSL, SessionCheck for test & verification

Appendix 1: publication details

Paper A:

Sequential decision problems, dependent types and generic solutions Authors:
Nicola Botta, Patrik Jansson, Cezar Ionescu, David R. Christiansen, Edwin Brady
Published in LMCS: Logical Methods in Computer Science

Paper B:

Contributions to a computational theory of policy advice and avoidability
Authors: Nicola Botta, Patrik Jansson, Cezar Ionescu
Published in JFP: Journal of Functional Programming

Paper C:

VisPar: Visualising Dataflow Graphs from the Par Monad
Authors: Maximilian Algehed and Patrik Jansson
Presented at FHPC 2017: 6th ACM SIGPLAN International Workshop on
Functional High-Performance Computing

Appendix 1: publication details, cont.

Paper D:

Encoding DCC in Haskell
Authors: Maximilian Algehed and Alejandro Russo
Presented at PLAS 2017: ACM SIGSAC Workshop on Programming Languages and Analysis for Security

Paper E:

The impact of uncertainty on optimal emission policies
Authors: Nicola Botta, Patrik Jansson, Cezar Ionescu
https://www.earth-syst-dynam-discuss.net/esd-2017-86/