Domain-Specific Languages for Global Systems Science

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"Chalmers, for a sustainable future."

Background: Some workshops in DSL@GSDP (2011–13

1. "Domain Specific Languages for Economical and Environmental Modelling (DSL4EE)" 2011, Marstrand, Sweden.
2. "ICT challenges to Global Systems Science" (with Ulf Dahlsten), Brussels, 2012.
3. "Computer Science meets GSS", Brussels, 2012.
4. "Models and Narratives in GSS", Brussels, 2012.
5. "GSS modelling and data", Brussels, 2013.
6. "Formal Languages and Integrated Problem Solving procedures in GSS", Brussels, 2013.

GSDP = Global Systems Dynamics and Policy, EU project

DSL = Domain Specific Language

Background: the DSL WP @ GSDP.eu (2010–13)

We have

- initiated an international community around **Global Systems Science (GSS)**
- developed domain-specific high-level concepts for **multi-agent modelling**, **sequential decision problems** and for computational **vulnerability** assessment
- successfully applied software specification to **economy theory** and to **climate impact research**

GSDP = Global Systems Dynamics and Policy, EU project

DSL = Domain Specific Language

What is a Domain Specific Language (DSL)?

- A DSL is an abstraction of a particular domain, supporting a domain specialist in building a model.
- An expression in a DSL can be seen as a formalised notion, a program, or a specification.
- Such expressions can often be executed, but also analysed as structured data.

DSL examples:

- Mathematics: Euclidean geometry — a DSL about points, lines, circles, etc.
- Mathematics: Arithmetic expressions (like $(x + y)/2$)
- Natural language: dates (Oct. 11, last Wed. of March, etc.)
- Computer tools: Excel, General Algebraic Modeling System (GAMS), ...

Example DSL: financial contracts

Basic building blocks: c_1 = "I pay you 1 USD now" is a simple contract

Combinators:

- delay a contract until a certain date
- scale by a constant factor
- "and": adding contracts: $c_1 + c_2$
- "or": choosing between contracts: choice(c_1, c_2)
- ...

The resulting description looks like an arithmetic expression, or a functional program.

[A DSL for financial contracts (Peyton Jones, Eber & Seward, ICFP 2000)]

LexiFi contract description language (2014: Bloomberg licenses)

Future plans: EU-project GRACeFUL (2015–2017)

GRACeFUL will use DSLs to build *Rapid Assessment Tools*, in order to support political decision-making in the typical context of GSS, involving multiple stakeholders faced with inter-disciplinary, global challenges.

The key difficulty is that the stakeholders describe problems in high-level terms such as *hazard*, *risk*, *vulnerability*, *financial contract*, *adaptation* and *mitigation*, etc., which are rarely the terms which describe the available data or scientific models.

In GRACeFUL, the translation from the language of stakeholders to the language of data and models is carried out by a DSL.

Translations generate meaning: high level concepts are interpreted in the underlying programming layer.

ICT for Global Systems Science

- HPC: parallel, scalable, high-level, visual, correct
- Big Data: trust?, privacy?, open?, understanding?
- Programs, Tests, and Proofs: find faults, avoid failures
- Narratives of Hope: conviction, communication, participation

(Section "3. Enabling Knowledge Technologies" from [Jaeger, 2013B].)

GSS reports

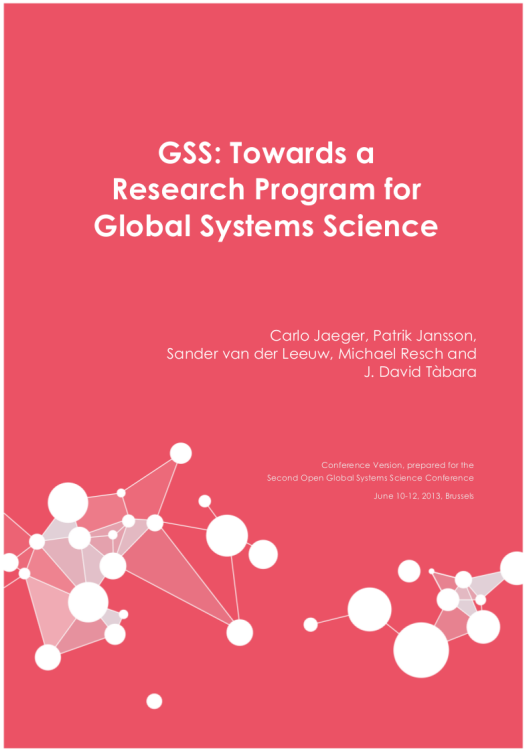

Figure :
[Jaeger, 2013B]

The main outcomes of the GSDP project were the community around and the reports about "Global Systems Science" done in collaboration with policy makers and researchers in several other projects (EU projects EUNOIA, FOC, INSITE, MULTIPLEX, NESS, and the G3M project, funded by the German BMU).

[Jaeger, 2013A]
Edited by: C. Jaeger, P. Jansson, S. van der Leeuw, M. Resch, J. D. Tàbara and R. Dum. *GSS Orientation paper – background material*.

[Jaeger, 2013B]
C. Jaeger, P. Jansson, S. van der Leeuw, M. Resch and J. D. Tàbara. *GSS: Towards a Research Program for Global Systems Science*.