# Group Proposal

Dr. Levi Lúcio

January 11, 2019

**Abstract**

We propose the creation of new nachwuchs-Kompetezfeld at fortiss in the area of Domain Specific Languages (DSLs).

## 1 Name

Intelligent Domain-Specific Systems (IDS2)

## 2 Mission

**Increasingly build better DSLs to tackle industrial problems by: 1) applying them to implement and support technology transfer projects at fortiss, and 2) evaluating their practical impact.**

## 3 Need

Computer languages are pervasive in software and systems engineering, to the point that software engineers become unaware that the choice of the language set to use plays a major role in projects' success.

The IDS2 group aims at making DSLs a primary theme of concern at fortiss. Many projects implemented at fortiss have a strong language development component. As as such the group will be flexible in the range of projects it will acquire and develop. The cross-section between IDS2 and other groups at fortiss is wide: learning to design better languages will empower ourselves and other scientists at fortiss to better transfer their results into industry. Additionally, DSLs are a powerful tool to add robustness to fortiss' contributions in software engineering.

Better technology transfer implies economical benefits for our industrial partners and ultimately more business for fortiss itself.

## 4 Business Model

Industry is constantly on the lookout for automation that can provide an edge regarding their competitors. This is particularly true in Bavaria,

where large automotive, aerospace and software companies exist and compete in a globalised market.

While it is expected and understood that new techniques and tools will provide such competitive edge, even large companies with dedicated research departments cannot perform their own research in-house due to time or expertise constraints.

The IDS2 group will work hand-in-hand with industry to provide solutions to software development problems that may be solved using domain-specific languages. This is a proven business model: for example itemis AG or PROTOS GmbH are currently using it with success. Both companies are expert in their own modelling frameworks (MPS and eTrice respectively) and provide domain-specific solutions based on those tools. Their areas of expertise of their clients range from automotive, to aerospace, health, heavy machinery or manufacturers of power tools.

Given fortiss' technology transfer mission, IDS2 does not intend to specialize in one specific technological platform but rather to build expertise around the the construction and evaluation of Domain-Specific Languages. In particular, we intend on leveraging and experimenting with machine learning as well as with practical formal methods in order to consistently provide innovative and cutting-edge solutions.

When implementing projects with the industry we will follow a formula that has proven successful in the past: for each project we intend on building a prototype focused on solving one specific problem, delivering the solution in a fashion such that the advantages of the research idea are clearly transmitted to the industry. In practice, this means that our focus will not be on building an encompassing framework where all solutions may be plugged in, but rather to impress our clients with clean and clear-cut solutions to well-specified problems. Technology will be used opportunistically and towards specific goals.

We strongly believe that such an approach will be impactful, as it is well understood that the industry does not use prototypes built by fortiss directly – they rather re-implement the research idea for their proprietary toolchains when the research is deemed to be useful. Equally important, such an approach will allow us to build a range of impressive prototypes that will not only serve as a presentation portfolio for the group, but will also allow us to attract more business for fortiss.

# 5 Scientific Contribution

Anecdotally, at the PAINS workshop at MODELS 2018, an interesting discussion raged between a high-profile DSL proponent and a top-level BMW manager. While the DSL proponent insisted that the (MPS-based) technology was ready and could serve as a "silver bullet" of sorts, the BMW manager replied that the attempts of using DSLs at his company where "hit-and-miss" and that even when DSLs did prove successful, it was not understood why. A question from that same manager that was particularly thought-provoking was: "how do I build and abstraction and know that it is a good one?". A more general criticism to the DSL approach in general was: "quality standards are missing, how do I to judge

or trust your processes of building DSLs while making decisions that will benefit my company?".

**Summary** From the condensed state of the art in the !!! ATTACHED DOCUMENT !!! , we can identify the following tends:

- For almost two decades professional DSL workbench builders have consistently reported case studies of application of DSLs to industrial problems, some of those case studies being highly successful. The same DSL builders do nonetheless mention that obtaining the data for validating the DSL after shipment is difficult [**?**].
- During that same period academia as struggled to provide evidence that the promises of DSLs in terms of increased productivity hold. Only recently, partly due to the arrival of mature DSL workbenches produced by professional software, is actual quantification of properties of DSLs such as e.g. usability becoming possible. Experimental validation of DSLs based on established theory is still underexplored [**?**].
- The DSL workbenches developed by academia are, thus far, insufficient to scientifically validate the premises of the DSL-based software development. This is on the one hand due to the poor quality of the tooling produced by academia [**?**], and on the other hand to very low access to real industrial use cases. Most of the surveys we describe above use as study material other academic papers, leading to starvation of information on real DSL commercial usage.
- With the notable exceptions of the work of Tolvanen and Kelly and Vlter mentioned above in this section, the bridges between the academia and industry in the DSL domain are brittle.

!!! MAKE REF TO PIC !!!

IDS2 will be in a privileged position to find answers to the questions above. The proposed main members of the group have considerable experience with DSL workbenches, modelling and verification, both through their studies and their professional accomplishments. Additionally, we rely on a national and international academic and industrial network that is stable and currently growing.

By developing DSLs for the industry as the main business model, we have and will be exposed to the difficulties in the conception of DSLs, in their adoption and evaluation in practice.

**Our main goal is to build a conceptual and systematic framework to build DSLs and the right level of abstraction for the task at hand, as well as evaluating their impact in the productivity of the industry and discovering best practices.**

RQ1: What is the quality of an abstraction in a DSL? RQ2: How do formal methods and machine learning help out?

Our mid-to-longterm goal is to inseminate the community with the practical experiences and struggles of applying DSLs in practice, leading to the theoretical establishment of the domain. fortiss is a very privileged

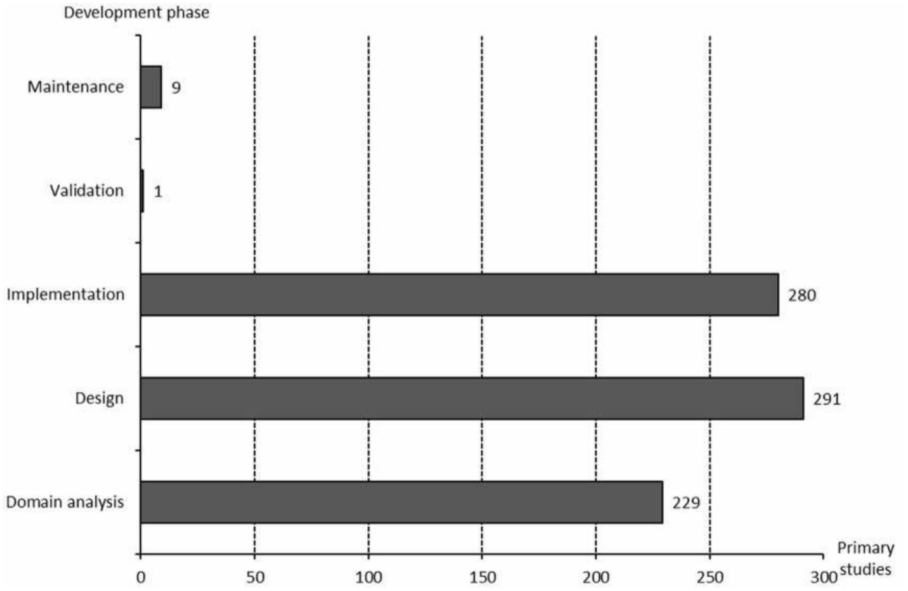


Figure 1: Distribution of 810 scientific contributions according to the phases of DSL construction they cover (extracted from [**?**])

context to do this, as we have the kind of access to projects and partners that occurs very seldom in academia.

# 6 Proposed Group Members

- Dr. Levi Lúcio (group lead)
- Dr. Saad Bin Abid (topic leader for process modelling and machine learning)
- Sudeep Kanav (topic leader for formal methods in practice)
- Ananya Misra (HiWi)
- Vishal Mahajan (HiWi)

Dr. Saad Bin Abid and Sudeep Kanav have expressed keen interest on becoming part of the IDS2 group. They are nonetheless members of MbSE and are expected to work part-time for IDS2 where synergies exist. Depending on acquired funds in 2019 and personal and group interests the percentage of time they work for each group might be subjected to adjustments.

# 7 Synergies with other groups at fortiss

Domain-Specific Languages are a cross-cutting theme at fortiss. All competence fields at fortiss deal with DSLs in one form or the other, even or

despite doing it unknowingly.

- The obvious synergy of IDS2 is with the MbSE group: MbSE has a model-centric view on systems and software engineering and builds languages using model-driven techniques. Its main current theme is design-space exploration and the modelling of embedded systems, but other themes such as requirements engineering, formal methods or security are also being pursued. ID2S can be of great assistance to MbSE by bringing systematic notions of language construction and evaluation to the development table. A collaboration that is already ongoing is the exploration of machine learning (in the context of the MAGNET project) to deliver support to users of AF3.
- Common work is also ongoing with the AS group, in the form of the FaktorBUILD project proposal. Some of the work of AS relies on probabilistic programming to model situations where incomplete knowledge must be reliably used to make decisions in real-time. Here, IDS2 may help in constructing DSLs at an adequate level of abstraction such that the IDE provided to users of factor graphs can leverage good abstractions, static analyses and formal methods to increase the productivity of factor graph programmers.
- The collaboration with the i4 group has been so far very successful, having lead to the implementation (together with Vincent Aravantinos) of a tool providing DSLs to express industrial capabilities. Such capabilities, or skills, can be subsequently be matched to automatically automatically synthesize controllers for industrial machines. Upcoming work for 2019 in the area will aim at connecting the completed DSL-based tool to AutomationML and 4Diac in order to connect the work with outside formats while providing simulation capabilities.

# Appendix A Context

The proposal for the formation of this group stems from three years of work at fortiss developing DSLs in the context of several projects. The three main members of the foreseen group (Dr. Levi Lúcio, Dr. Saad Bin abid and Sudeep Kanaav) all have extensive experience working together both for the IETS3 the CBMD and the MAGNET projects.

## A.1 Completed Projects

- IETS3
  - Consortium: fortiss, itemis, ZF, Diehl aerospace
  - Running time, funding and personnel: 2 years / 300K Euro / 3 people

## A.2 Running Projects

- CBMD (as project leader)
  - Consortium: fortiss, PROTOS, SQMi, University of Augsburg
  - Running time, funding and personnel: 2 years / 190K Euro / 2 people
- MAGIC (as project leader)
  - Consortium: fortiss, University of Montral
  - Running time and funding: 2 years / 10K Euro + 40K Euro (Eigenforshungsgeld) / 3 people
- MAGNET (as project leader)
  - Consortium: fortiss
  - Running time, funding and personnel: 6 months / 70K Euro / 8 people Eigenforshungsgeld
- ARTEMIS (as project leader)
  - Consortium: fortiss, Airbus
  - Running time, funding and personnel: 6 months / 75KEuro / 2 people (Levi + HiWi)
- BaSys4.0 (as software developer for the “industrial skills” theme )

## A.3 Projects in the Acquisition Pipeline

- FaktorBUILD
  - Consortium: fortiss, University of Lübeck, Siemens, LMU, ?
  - Running time, funding and personnel: 3 years / 400K Euro / 3 people (Levi + Dhiraj + HiWi)
- Follow-up for CBMD
  - Consortium: fortiss, PROTOS, ?
- Follow-up for ARTEMIS

  - Consortium: fortiss, Airbus
- H2020, project on "agility in model-based software engineering"
  - Consortium: fortiss, University of Antwerp, University Nova de Lisboa, TU Wien, Hasso-Platner Institut, Telecom-Paristech, Unit Bilisim Technologies

# Appendix B Network

Here I will describe the main currently active research and industrial connections (others exist that may be reactivated at need):

**Inside fortiss:**

- HCE (Yuanting Liu and team, project MAGNET)
- SD (Tahira Iqbal and Parisa Elahidoost, project MAGNET and requirements engineering)
- i4 (project MAGIC, networking with University of Montreal)
- AS (Dhiraj Gulati and Vincent Aravantinos, on BaSys and FactorBUILD)

**Academic**:

- University of Montréal, Canada (project MAGIC)
- University of Namur, Belgium (tutorial and paper on machine learning and formal verification)
- University of Antwerp, Belgium (proposal for H2020)
- LMU, Germany (with Prof. Dirk Beyer in the context of the FaktorBUILD proposal)
- University of Lübeck, Germany (with Prof. Philipp Rostalski in the context of the FactorGraph proposal)
- TU Wien (with Manuel Wimmer in the context of model transformations)

**Industrial:**

- PROTOS (KMU) (in the context of the CBMD project)
- Rolls-Royce (in the context of the EARS-related work)
- Siemens (in the context of the FaktorBUILD proposal)
- Festo (in the context of the BaSys project)
- ABB (in the context of the BaSys project)

# Appendix C Plan for the first year of activity

In the first year of activity we intend on solidifying the group by building on existing results and enlarging the scope of our national and international network, both at the academic and industrial levels. In particular, we aim at achieving the following goals:

## C.1 Research:

- Establish a set of criteria for the quality of DSLs in practice. In particular, we are interested in understanding which measurable criteria can be used to facilitate the adoption of DSLs in the industry.
- Evaluate the usage of machine learning in the context of requirements engineering and in general as a means to aid in the construction and operation of good and reliable DSLs.
- Establish an ongoing collaboration with Prof. Dirk Beyer from the LMU in Munich. Prof. Beyer is an expert in formal methods and is part of the consortium for the FaktorBUILD project. He is, in particular, very enthusiastic about applying his CPAchecker C model checker to examples coming from Airbus Defense in the context of the ARTEMIS project. Publishing with Prof. Beyer will also be pursued.
- Evaluate the prototype developed for the MAGNET project in the real-world scenario of tutorials of AF3. Calibrate the suggestions provided by the machine learning algorithm in function of such an evaluation.
- Write one or more articles on the results of the MAGNET project.
- Evaluate the usage of machine learning in the context of requirements engineering and in general as a means to aid in the construction and operation of good and reliable DSLs.
- Establish a set of criteria for the quality of DSLs in practice. In particular, I am interested in understanding which measurable criteria can be used to facilitate the adoption of DSLs in the industry.
- Write one or more articles on the results of the skills (Fähigkeiten) work-package of the BaSys project.
- Continue research on the topic of Process-Aware model driven development environments to be implemented in AF3. Complete the ongoing journal paper on process-aware model-driven development environments.
- Help Sudeep Kanav in establishing his PhD research topic by publishing results on compositional model checking at top venues. Continue Sudeep's scientific training.
- Provide Tatiana Chuprina with the right tools such that she can finish her thesis proposal in the area of requirements engineering.

## C.2 Project acquisition:

- Build on our existing collaboration with Airbus defense by delivering excellent results for the ARTEMIS project and acquiring a second project in the context of model checking C code based on EARS requirements.
- Acquire one or more national and/or international projects. This work will be based on current acquisition efforts for a BMBF and an H2020 projects (as described in section A.3).
- Acquire a project on the continuation fn CBMD on the compositional verification of models of embedded software. This is well underway and desired by PROTOS GmbH (as described in sections A.2 and A.3).
- Acquire a project with an industrial partner (PROTOS is a promising option) on applying the results of MAGNET Eigenforshungs project in practice.
- Work in the direction of establishing a funded consortium with Professors Eugene Syriani and Michalis Famelis from the University of Montréal. A collaboration with those researchers is already in place in the context of the MAGIC project (as described in A.2) with the goal of acquiring a large Canadian-Germany partnership project[1].

## C.3 Technical:

- Build a prototype tool in MPS to generate LTL from EARS requirements and model-check C code written for those requirements.
- Build a release-ready prototype of a recommender system for AutoFOCUS3 that can be effectively used in tutorials on the tool given to industry or academia.
- Complete the development of the skill-matching and controller synthesis prototype for BaSys. The prototype will semi-automatically generate a controller for a robotic arm in 4Diac. A demonstrator of the complete chain from skill definition down to robot arm movement will be built based on virtual robotic arm simulator provided by Festo AG.
- Integrate compositional model checking in the eTrice tool, such that it can be used in production by PROTOS.

## C.4 Organisation:

- Contribute to and aid in the delivery of tutorials for AF3.
- Contribute to the organization of MODELS 2019 in Munich.
- Conduct interviews leading to the the hiring of post-docs, PhD students, Msc students or HiWis.

[1] http://www.nserc-crsng.gc.ca/International-Internationale/CanadaGermany_call-Appel_CanadaAllemagne_fra.asp