**RESULTS AND GOALS**

A tool-assisted fully automated domain-specific design approach for energy-aware stencil codes

**Overall charter**

- Domain-specific language ExaSlang and transformation framework
- Scalability up to full breadth of the JUQUEEN supercomputer
- Low-level optimizations for BlueGene/Q and Intel CPUs
- Performance forecast via product-line sampling and machine learning

**Further Goals**

- Exascale technology for a broader range of PDEs
- Energy efficiency at all layers of abstraction
- Performance/power trade-offs on exascale machines
- Exploitation of heterogeneous and hybrid architectures

**WORK AREAS**

A. Algorithmic Engineering
   - Efficient data structures for PDEs
   - Convergence prediction (ExaSlang)
   - Evaluation of the results compiled using the generated code (AAM, LSS)

B. Domain-Specific Representation and Modeling
   - Representation of known models (ExaSlang)
   - Metaprogramming (Meta)

C. Domain-Specific Optimization and Generation
   - Compilation of exascale target platforms
   - Automatic analysis and validation targeting exascale applications
   - Automatic consideration of energy consumption for exascale systems

D. Polyhedral Optimization and Code Generation
   - Automatic generation of efficient code for exascale systems
   - Automatic consideration of energy consumption for exascale systems

E. Target-Specific Code Optimization and Generation
   - Code generation for heterogeneous target platforms
   - Performance prediction (ExaSolvers)

F. Evaluation and Demonstration (all groups)
   - Proof of concept and performance
   - Performance/power trade-offs on exascale machines

G. Rapid Prototyping of Stencil DSLs
   - An internal DSL for ExaStencils
   - Case studies

**DESIGN FLOW**

- Problem Knowledge
- Domain-Specific Model
- ExaSlang IR
- ExaStencils
- Load Balancing
- Domain-Specific Bi-Directional Transformation
- Model Transformation
- Code Generation
- Optimization
- Performance Evaluation

**JAPAN COLLABORATION & RESEARCH PLAN**

- **Collaboration with Japan:**
  - Embedding ExaSlang 4 in a JVM-based language (Java/Scala)
  - Porting of ExaStencils technology to new domains
  - Insights into trade-offs of internal vs. external DSL approaches
  - Compilation and run-time performance
  - Domain-specific modeling and programmer productivity

**Research Plan:**

- Automatic consideration of energy consumption for exascale systems
- Automatic analysis and validation targeting exascale applications
- Automatic generation of efficient code for exascale systems
- Automatic identification of optimal stencil-code configurations

**SUPERCOMPUTING POWER:**

- **JUQUEEN,** Jülich Research Centre (TOP500-11, Nov. 2015)
- **SuperMUC,** Leibniz Computing Centre (TOP500-23, Nov. 2015)
- **TSUBAME 2.5,** Tokyo Institute of Technology (TOP500-25, Nov. 2015)

**Collaboration in DFG Priority Programme SPPEXA:**

- **EXASTEEL:** performance prediction
- **EXASOLVERS:** parallel-in-time methods
- **TERRA-NEO:** code generation and discretization
- **EXA-DUNE:** variability extraction and variability-aware testing