Motivation and Approach

- Accelerate stencil computation (nearest neighbors used for computation) algorithms:
  - Image Filter
  - Option Pricing
  - Nanophotonics
  - Fluid Dynamics

- Algorithms share the property of regular memory access pattern
- Allow transparent usage of accelerators by domain experts
- Support multiple architectures e.g.: Multi-Cores, GPUs, FPGAs, ...
- Separating the algorithm description from mapping to hardware architecture (by high-level language (DSL))
- Introducing the novel concept of domains and subdomains
- Efficient code generation by input and output representation

Domain and Subdomain concept

- Real world problems consist of regions with different properties
- Discretization of continuous problem space
- Mapping of regions to domains and subdomains with arbitrary:
  - Geometry
  - Position in space
  - Operations
  - Properties (e.g. Constants)
- Subdomains have a hierarchically relationship to domains
- Share properties with parent domain
- Modeling of border properties by domain concept
- Example: micro disk cavity in a perfect metallic environment

Real-world example

- Realistic nanophotonic device
- Vacuum microdisk cavity enclosed in a perfect metallic environment (two subdomains)
- Point-like time-dependent inhomogeneity (optical dipole point source)
- Using Maxwell PDEs to describe evolution of electromagnetic fields
- Numerical approximation by Finite-Difference Time-Domain method (FDTD)
- Known analytic solution (Whispering Gallery Modes)
- Modeling of different materials by subdomain concept

\[
\begin{align*}
E_0[x] = & \text{ca} \cdot E_0[y] + \text{ch} \cdot (H_x[x] - H_y[x] - dz) \\
E_1[x] = & \text{ca} \cdot E_0[y] + \text{ch} \cdot (H_x[x] - dz) - H_y[x] \\
H_1[x] = & \text{da} \cdot H_x[x] + \text{db} \\
(E_0[x] + dy) - E_0[x] + E_0[y] - E_0[x] + dx)
\end{align*}
\]

Computed energy density

Outlook / Future Work

- Support more novel hardware architectures
- Optimization strategies for complex memory access pattern

Contact

Björn Meyer, Christian Plessl and Jens Förstner

Björn.meyer@uni-paderborn.de
Phone: +49 5251 604383