[redacted]

pystencils

Automatic Generation, Optimization and Analysis of Stencil Codes

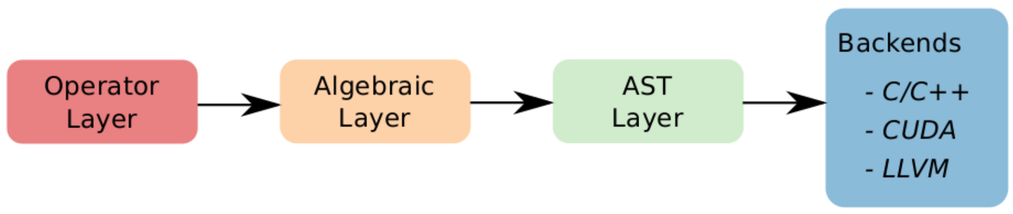
Motivation

- Abstract description of a model
- Platform independent implementation
- Highly optimized compute kernels for HPC software
- Needed: **Abstraction without performance penalty**

Solution: Generation of compute kernels with pystencils

- Increases maintainability & enables fast prototyping
- Simplification and optimization with parameters known at compile time
- Easily extendible with SymPy
- Various target language platforms: C++, CUDA, LLVM

Abstraction Layers



- Operator Layer:

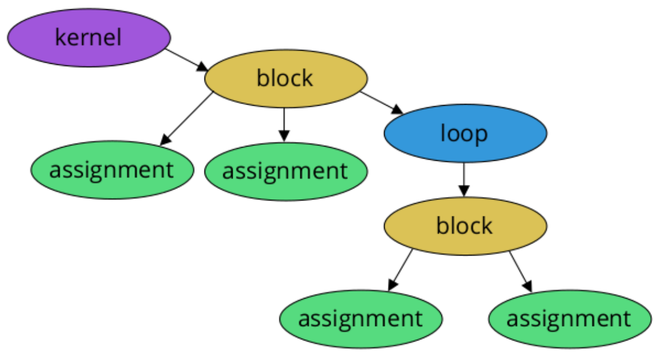
$$\nabla \cdot (vc) - div(D \nabla c) + \partial_t c_C$$

c : scalar field; v : vector field

- Algebraic Layer:

$$-4c_C D + c_C - \frac{c_E v_E^0}{2} + c_E D - \frac{c_N v_N^1}{2} + c_N D + \frac{c_S v_S^1}{2} + c_S D + \frac{c_W v_W^0}{2} + c_W D$$

- AST Layer:



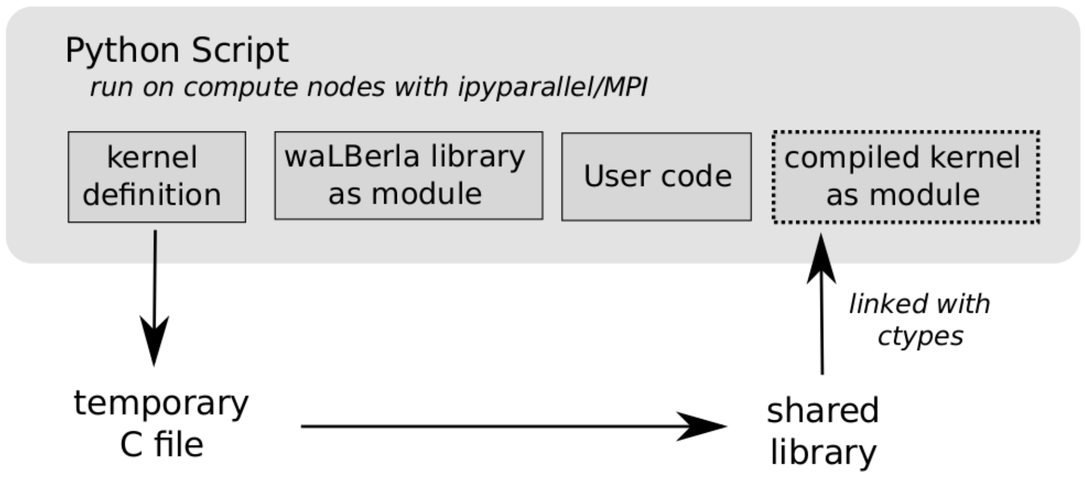
- Backend:

Code example

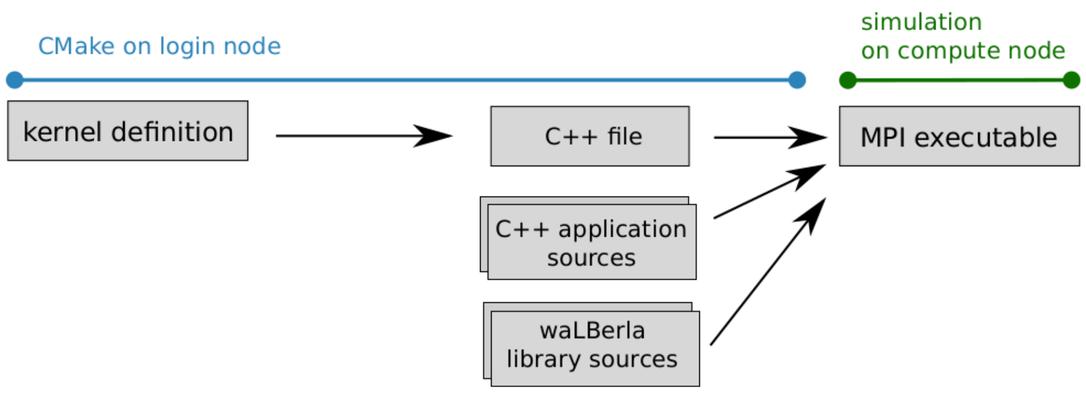
```
advDiffPde = transient(c) - diffusion(c, sp.Symbol('D')) +
             advection(c, v)
discretize(advDiffPde)
```

$$-3c_C - \frac{c_E v_E^0}{2} + c_E - \frac{c_N v_N^1}{2} + c_N + \frac{c_S v_S^1}{2} + c_S + \frac{c_W v_W^0}{2} + c_W$$

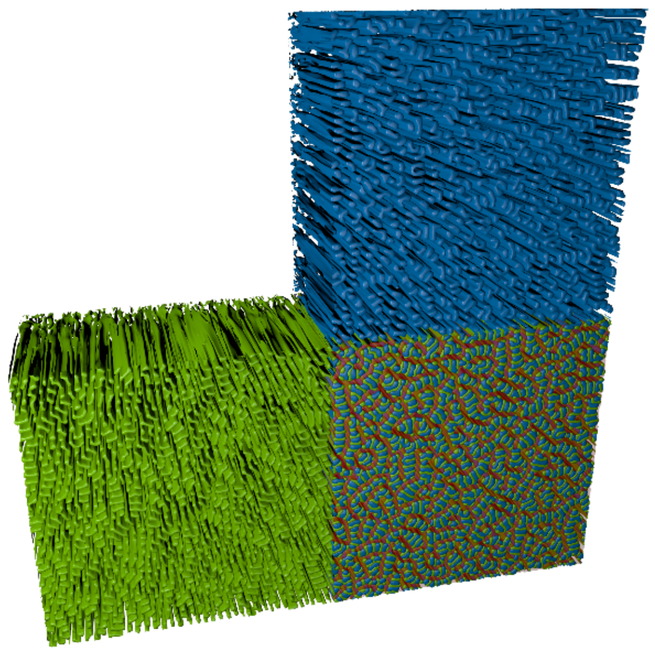
Python wrapper



waLBerla app



Example: Phase-field simulation [1]



Phase-Field Simulation for Ternary Eutectic Directional Solidification on SuperMUC

Analysis and Benchmarking with kerncraft [2]

- Benchmark - Automatic performance evaluation in MFLOP/S, MLUP/S and MIT/S
- Roofline & ECM Model - Kernel evaluation, performance estimation, bottleneck localization

Acknowledgements

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References

[1] [redacted]

[2] Julian Hammer et al. “Automatic Loop Kernel Analysis and Performance Modeling with Kerncraft”. In: *Proceedings of the 6th International Workshop on Performance Modeling, Benchmarking, and Simulation of High Performance Computing Systems*. PMBS ’15. ACM, 2015, 4:1–4:11.

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