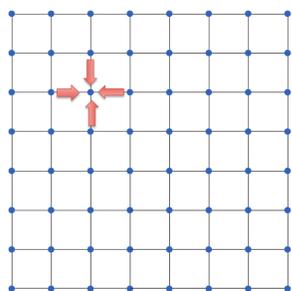


Abstract

Physis is an application framework that automatically translates structured grid code into scalable parallel implementation code for GPU-equipped clusters. A small set of declarative constructs allows the user to express stencil computations in a portable and implicitly parallel manner. User code written in Physis DSL is automatically translated to actual implementation code in CUDA and MPI. We demonstrate effectiveness of the framework using Tsubame.

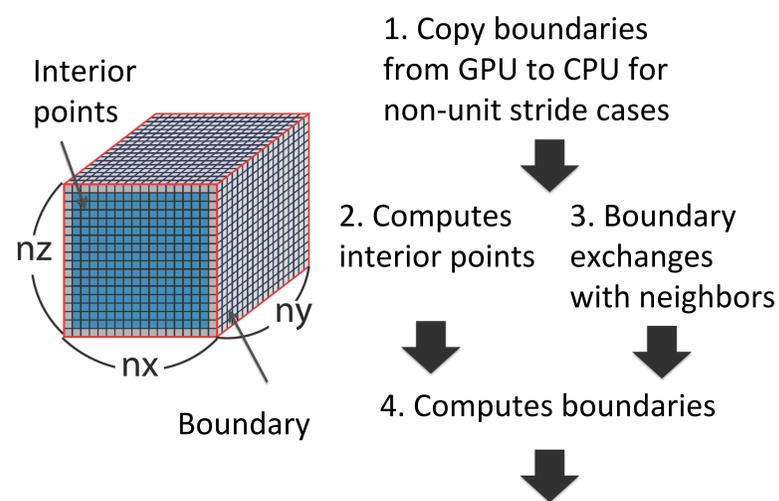
Stencil Computations



- Iteratively updates grid points using neighbors
- A fundamental computation pattern in scientific simulations

Optimizations

Automatic overlapping of computation and boundary exchanges



Physis DSL

Multidimensional Dense Grid Types

- PSGrid1DFloat, PSGrid2DFloat, PSGrid3DFloat
- PSGrid1DDouble, PSGrid2DDouble, PSGrid3DDouble

Intrinsics for Operating with Grids

- PSGridNew, PSGridFree
- PSGridGet, PSGridSet
- PSGridCopyin, PSGridCopyout
- PSGridEmit
- PSReduce
- PSGridMap, PSGridRun

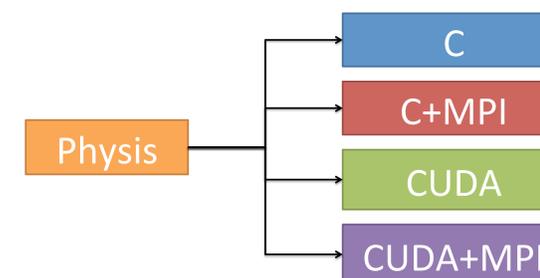
Stencil Kernels

- C functions expressing a single flow of scalar execution on grid points with some restrictions
- Executed over rectangular domains

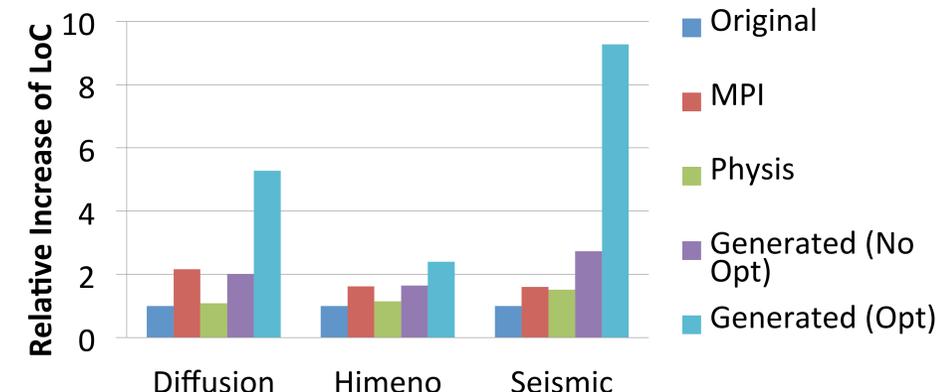
```
void diffusion(const int x, const int y, const int z,
              PSGrid3DFloat g1, PSGrid3DFloat g2,
              float t) {
    float v = PSGridGet(g1,x,y,z)
    +PSGridGet(g1,x-1,y,z)+PSGridGet(g1,x+1,y,z)
    +PSGridGet(g1,x,y-1,z)+PSGridGet(g1,x,y+1,z)
    +PSGridGet(g1,x,y,z-1)+PSGridGet(g1,x,y,z+1);
    PSGridEmit(g2,v/7.0*t);
}
```

DSL Translator

- Based on the ROSE compiler framework
- Domain-specific optimizations
- Target-specific code generation and optimizations
- Automatic parallelization



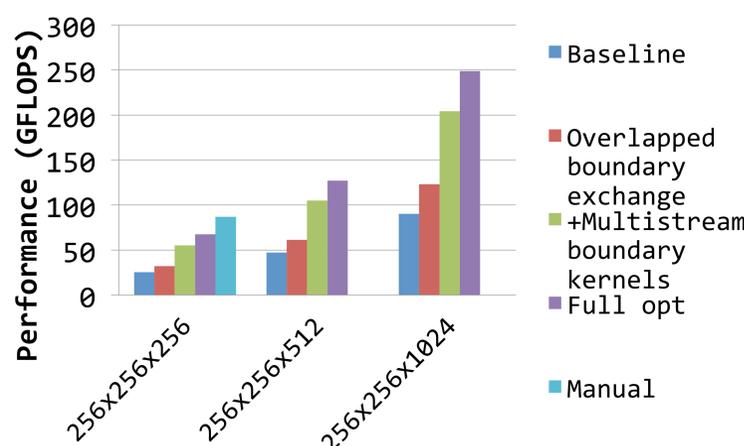
Productivity Study



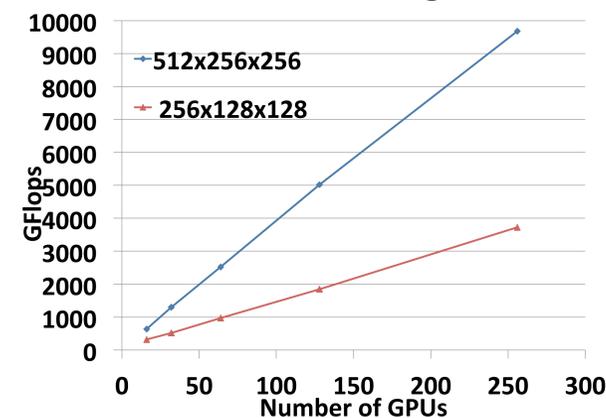
Performance Results

- Performance evaluation with the 7-point diffusion kernel
- Tested on Tsubame (3 M2050 GPUs per node, interconnected with dual-link QDR Infiniband)

Optimization Effects



Weak Scaling



Strong Scaling

