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.

Physis DSL

**Multidimensional Dense Grid Types**
- PSGrid1DFloat, PSGrid2DFloat, PSGrid3DFloat
- PSGrid1DDouble, PSGrid2DDouble, PSGrid3DDouble

**Intrinsics for Operating with Grids**
- PSGridNew, PSGridFree
- PSGridCopyin, PSGridCopyout
- PSReduce
- PSGridGet, PSGridSet, PSGridEmit
- PSGridMap, PSGridRun

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

```c
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);
}
```

Physis DSL Translator

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

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

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