Legacy code base on HPC accelerators

Source-to-source translation for column based numerical algorithms

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The objective
Target a broad range of HPC architectures including accelerators (such as GPUs or FPGAs) and achieve good computational performance from a single code base.

The code base
Developed for physical parameterizations (“physics”) of the Integrated Forecasting System (IFS) but concept applicable for larger class of column based numerical algorithms.
- Different programming paradigms and environments
- Hardware-specific optimization (loop order, block size, ...)
- Large and complex code base needs to be adapted

The challenge
- No data dependencies between columns
- Expectation: up to 38% of operational cost in the future

The approach
- Apply source-to-source translation to apply bespoke transformations to Fortran source code
- Feed into downstream tools (such as CLAW or MaxCompiler) to produce hardware-specific versions
- Exploit single column abstraction to reorder horizontal and vertical loops as required for target architecture

Loki: a tool for user-guided automated source-to-source translation
- Purpose-built in Python for the IFS
- Offers an API to encode custom transformations
- Bespoke internal representation (IR) based on trees
- Two-level IR: Expression trees based on Pymbolic; custom data structures for statements / control flow
- Traverse and transform IR using visitors

Use case: CLOUDSC on GPU and FPGA
- Operational cloud microphysics parameterisation
- FPGA (Maxeler MAX 5 DFE (Xilinx V9P)): Automated Fortran to C translation, then hand ported to MaxJ
- GPU (Nvidia Quadro GV100 Volta): OpenACC offload directives, optimized for GPU
- FPGA throughput 2.5x (3x) higher than CPU and 2x (2.8x) higher than GPU for DP (SP)

Outlook
- Batch translation of physical parameterisations
- Fully automated source-to-source translation of CLOUDSC to an FPGA version
- Extend to other column based algorithms in the IFS


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