Asynchronous Many-Task Programming Models for the Earth System: Couplers and Ocean/Ice
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Motivation

Programming Models for Complex Earth System Models
Earth System models like the Energy Exascale Earth System Model (E3SM) have typically utilized standard domain decomposition approaches with an MPI+OpenMP programming model. Unfortunately, the E3SM and other models have difficulty exposing enough parallelism in this approach and load-balancing the system is difficult. The Coupling Approaches for Next-Generation Architectures (CANGA) project is working to exploit a number of advantages of task-parallel programming models.

Computational Advantages
• Exploit additional parallelism
• Improve load balancing
• Fault tolerance
• Map tasks to hardware elements

Scientific Advantages
• Better manage complexity
• Improved extensibility (add tasks)
• Ability to couple at process level, not component
• Manage multiple time, space scales

Approach

Create a prototype coupled E3SM model in a task-parallel paradigm

FleCSI and Legion:
Flexible Computation Science Infrastructure (LANL)
• C++ framework
• Supports tasking runtimes (Legion, HPX, CHARM++)
• Provides control, execution and data models
Legion (Stanford, LANL, NVidia)
• Based on logical regions (intersection index/field spaces)
• Task-based run-time with efficient DAG generation
• Apparently sequential semantics

Coupler Level (Top-down):
• Create prototype coupler
• Replicate existing component coupling
• Push downward to expose more processes

Component Level (Bottom Up):
• Create task-parallel versions of ocn, ice, land
• Break up further into finer scale tasks
• Generate task hierarchy for coupler layer

Progress

Prototype Coupler:
• Created Regent/Legion prototype w/ stub models
• Demonstrated dependency graph and parallel execution
• FleCSI prototype reading data models in progress

Prototype Ocean Model:
• Completed Regent prototype with all existing ocean function interfaces
• Generated initial dependency graph based on interfaces
• FleCSI specialization layer for MPAS-Ocean framework and data types in progress

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