PSyclone - Separation of Concerns for Existing Fortran Code

Joerg Henrichs (BOM)
R.Ford, A.Porter, S.Siso (STFC – UK)
I. Kavcic (UK Met Office)
Next Generation Modelling Systems

• UK Met office decided on complete redesign of their forecast models
  - LFRic: new weather and climate modelling system
• International cooperation between UK Met Office, STFC (UK), BOM, NIWA (NZ), KMA (Korea), NCMRWF (India), Oak Ridge/US Air Force
• Maintainable HPC code:
  - Single source science code
  - Performance portability
  - Separate science code from optimisation and parallelisation
PSyclone

- Developed by STFC, UK, together with BOM
- Domain specific language embedded in Fortran
- Separation of Concerns:
  - Natural Science
  - Computational Science
- Optimisation and parallelisation is done using PSyclone scripts (python)
- Targets MPI, OpenMP, OpenACC, OpenCL, FPGA, …
PSyclone Design

- Needs specially designed code or refactoring of existing code
Using PSyclone for Existing Fortran Code

• Developed for NEMO (3d Ocean Code)
• Parses existing Fortran code, and detects kernels
  - No refactoring required
  - Creates internal representation
• Automatically adds threading parallelisation, e.g. OpenMP or OpenACC using python scripts
  - MPI parallelisation from the original source code remains
Difficulties Using PSyclone for Existing Code

• Detecting Kernels
  - Relies on strict coding standards, e.g. loop variable naming

• PSyclone does not control distributed memory infrastructure
  - Must be using existing MPI parallelisation

• Dependency analysis needed
  - Determination of shared/private variables when threading
  - Correctness of transformations
Used PSyclone with NEMO API on ROMS

- ROMS (Regional Ocean Model), 2D test case (1613x463)
  - MPI or OpenMP, but not hybrid
- Hybrid version should result in better scalability
- Automatically applied optimised OpenMP directives
  - Create large parallel regions with several parallel loops
  - Use schedule=dynamic
- No changes to source code required
  - Except some improvements to NEMO
Original Profile
Profile of PSyclone Hybrid Version
Performance on BOM's Cray XC 40 System:

<table>
<thead>
<tr>
<th>Number of Nodes</th>
<th>Original ROMS</th>
<th>PSyclone ROMS 1 thread</th>
<th>PSyclone ROMS 2 threads</th>
<th>PSyclone ROMS 4 threads</th>
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Results and Summary

• PSyclone's separation of concerns can be used for well designed existing Fortran code of certain domains
• PSyclone scripts can be used to apply parallelisation and optimisation
• No code modification required
• Currently investigating operational ROMS ensembles for Stormsurge (959x463)
  - At this stage a ~2% performance improvement
  - Work in progress