ECP SOLLVE: OpenMP Validation and Verification Testsuite

Felipe Cabarcas and Swaroop Pophale
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Andrew Kallai, Felipe Cabarcas, Sunita Chandrasekaran
Swaroop Pophale, Seyong Lee, David E. Bernholdt
SOLLVE V&V Current Team

- Andrew Kallai
- Felipe Cabarcas
- Sunita Chandrasekaran

CPU
- Outside the project contributors
  - AMD
  - Tobias Schuele (Siemens) for his feedback and engagement with the tests
- Former project members
  - Nolan Baker, Michael Carr, Nikhil Rao, Jaydon Reap, Kristina Holsapple, Joshua Hoke Davis, Thomas Huber, Jose M. Monsalve

- Swaroop Pophale
- Seyong Lee
- David E. Bernholdt
SOLLVE V&V Objectives

• Tests implementations of new features introduced in OpenMP 4.5+
• Checks conformance to the specification
  – Peer reviewed, publicly available
• Highlights ambiguities in the OpenMP specification
• Reports status of implementations on primary ECP target platforms
  – Help application and compiler developers
• Exemplifies the use of the new features in OpenMP
• Abstracts application kernels as tests
Latest OpenMP Specification: 5.2

- Released November 2021
  - Around 27 modifications (new features, deprecated features, behavior changes)
  - Some of these modifications to the specification are implemented in open source compilers
    - LLVM status [https://clang.llvm.org/docs/OpenMPSupport.html](https://clang.llvm.org/docs/OpenMPSupport.html)
  - Leads to writing tests from scratch, with no compilers to test with
- 6.0 specification is scheduled to be released on November 2024
OpenMP V&V Testsuite repository

- Clone the repo https://github.com/SOLLVE/sollve_vv
- Setup your environment (install or ‘module load’ your compilers)
- Use our make commands to compile and run a single test or the whole suite
  - Running a single test:
    ```
    make CC=clang CXX=clang++ FC=flang-new OMP_VERSION=5.2 SOURCES=test_name all
    ```
  - Running the entire suite
    ```
    make CC=clang CXX=clang++ FC=flang-new OMP_VERSION=5.2 all
    ```
# Tests and Coverage

## Number of Tests

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>C++</th>
<th>Fortran</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5</td>
<td>116</td>
<td>14</td>
<td>103</td>
<td>233</td>
</tr>
<tr>
<td>5.0</td>
<td>180</td>
<td>21</td>
<td>126</td>
<td>318</td>
</tr>
<tr>
<td>5.1</td>
<td>89</td>
<td>4</td>
<td>19</td>
<td>108</td>
</tr>
<tr>
<td>5.2</td>
<td>15</td>
<td>2</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>397</td>
<td>30</td>
<td>252</td>
<td>679</td>
</tr>
</tbody>
</table>

## Approximated coverage of requested features

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>C++</th>
<th>Fortran</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>5.0</td>
<td>88%</td>
<td>100%</td>
<td>88%</td>
</tr>
<tr>
<td>5.1</td>
<td>87%</td>
<td>100%</td>
<td>40%</td>
</tr>
<tr>
<td>5.2</td>
<td>84%</td>
<td>100%</td>
<td>19%</td>
</tr>
</tbody>
</table>

- The testsuite not only contains tests for the new features of each specification, but also commonly used combinations by developers.
- We have given priority to requested features over complete coverage.
# Systems and Compilers Regularly tested

<table>
<thead>
<tr>
<th>System</th>
<th>Perlmutter</th>
<th>Summit</th>
<th>Frontier</th>
<th>Sunspot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>NERSC</td>
<td>ORNL</td>
<td>ORNL</td>
<td>ANL</td>
</tr>
<tr>
<td>CPU / GPU</td>
<td>AMD / NVIDIA</td>
<td>IBM / NVIDIA</td>
<td>AMD / AMD</td>
<td>Intel / Intel</td>
</tr>
<tr>
<td>GNU (gcc/gfortran)</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>LLVM (clang/flang-new)</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>AMD ROCM (amdclang/amdflang)</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>HPE/Cray (cce)</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>IBM (xlc, xlf)</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>NVIDIA (nvc, nvfortran)</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>INTEL (icpx, ifx)</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

[https://crpl.cis.udel.edu/ompvvsollve/results/](https://crpl.cis.udel.edu/ompvvsollve/results/)
These results were last reviewed October 18, 2022

Compilers tested on respective systems:
- Svera: IBM POWER9, GPU: NVIDIA V100, CPU: 24-core (3.2), LNUM: 18.6.0, LLVM: 0.0.0, IBM Linux (OSI)
- Frontier: CPU: AMD EPIC X3, CPU: AMD EPIC X6, CPU: 24-core, AMPALANG (OSI), LINUX (OSI)
- Perlmutter: CPU: AMD Milan, GPU: NVIDA A100 - GPU: 32.0, NPLIER: 32.0, CPU: 32.0, LNUM: 18.6.0, LLVM: 0.0.0
- Summit: CPU: Intel Xeon Sapphire, GPU: Intel Pont Vecchio - NTEL Compiler (10.0)

Radar Results:

<table>
<thead>
<tr>
<th>Compilers</th>
<th>Test system</th>
<th>Compiler</th>
<th>OMP version</th>
<th>Compiler result</th>
<th>Runtime result</th>
</tr>
</thead>
<tbody>
<tr>
<td>clang 18.0.0</td>
<td>frontier</td>
<td>clang++ 18.6.0</td>
<td>4.6</td>
<td>PASS</td>
<td>PASS</td>
</tr>
<tr>
<td>clang 18.0.0</td>
<td>perlmutter</td>
<td>clang++ 18.6.0</td>
<td>4.6</td>
<td>PASS</td>
<td>PASS</td>
</tr>
<tr>
<td>clang 18.0.0</td>
<td>frontier</td>
<td>cc 18.0.0</td>
<td>4.6</td>
<td>PASS</td>
<td>PASS</td>
</tr>
<tr>
<td>clang 18.0.0</td>
<td>perlmutter</td>
<td>cc 18.0.0</td>
<td>4.6</td>
<td>PASS</td>
<td>PASS</td>
</tr>
<tr>
<td>clang 18.0.0</td>
<td>frontier</td>
<td>g++ 13.1.0</td>
<td>4.6</td>
<td>PASS</td>
<td>PASS</td>
</tr>
<tr>
<td>clang 18.0.0</td>
<td>perlmutter</td>
<td>g++ 13.1.0</td>
<td>4.6</td>
<td>PASS</td>
<td>PASS</td>
</tr>
</tbody>
</table>
Overall Results

Frontier (EPYC/MI250X)
- CCE 16.0.6
- LLVM 18.0.0
- ROCM 5.7.0

Perlmutter (EPYC/A100)
- CCE 16.0.6
- GNU 12.1.1
- LLVM 18.0.0
- NVHPC 23.1

Summit (POWER 9/V100)
- GNU 13.2.1
- LLVM 18.0.0
- NVHPC 22.11
- XLC 16.0.1

Sunspot (Xeon/Ponte Vecchio)
- ICX 17.0.0
Results OpenMP 4.5

Frontier (EPYC/M1250X)

- CCE 16.0.6
- LLVM 18.0.0
- ROCM 5.7.0

Perlmutter (EPYC/A100)

- CCE 16.0.6
- GNU 12.1.1
- LLVM 18.0.0
- NVHPC 23.1

Summit (POWER 9/V100)

- GNU 13.2.1
- LLVM 18.0.0
- NVHPC 22.11
- XLC 16.01

Sunspot (Xeon/Ponte Vecchio)

- ICX 17.0.0
Results OpenMP 5.0
Results OpenMP 5.1
Results OpenMP 5.2

Frontier (EPYC/MI250X)

Perlmutter (EPYC/A100)

Summit (POWER 9/V100)

Sunspot (Xeon/Ponte Vecchio)
Beyond V&V testsuite

- At UD: Aaron Jarmusch, Aaron Liu and Vaidhyanathan Ravichandran are
  - Integrating regression and stress testing into the SOLLVE V&V Testsuite
  - Creating a CI infrastructure to test LLVM OpenMP on GPU systems
    - Running SOLLVE V&V, Heckbench and AMD’s Smoke
    - Focusing on offloading for AMD and NVIDIA GPU systems
      - https://gitlab.e4s.io/uo-public/llvm-sollve/-/pipelines
      - Using a system @ University of Oregon
  - Creating an LNT
    - LLVM Nightly Testing: a set of client and server tools for monitoring the performance of software over its lifecycle
    - http://lnt.llvm.org/
### Pipelines

<table>
<thead>
<tr>
<th>Status</th>
<th>Pipeline</th>
<th>Created by</th>
<th>Stages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passed</td>
<td>Merge branch 'force-build-off' into 'main' #9812</td>
<td>00:47:09 14 hours ago</td>
<td><img src="https://gitlab.e4s.io/uo-public/llvm-sollve/-/pipelines" alt="status" /></td>
</tr>
<tr>
<td>Passed</td>
<td>Merge branch 'force-build-off' into 'main' #9795</td>
<td>00:46:49 1 day ago</td>
<td><img src="https://gitlab.e4s.io/uo-public/llvm-sollve/-/pipelines" alt="status" /></td>
</tr>
<tr>
<td>Passed</td>
<td>Merge branch 'force-build-off' into 'main' #9787</td>
<td>00:47:20 2 days ago</td>
<td><img src="https://gitlab.e4s.io/uo-public/llvm-sollve/-/pipelines" alt="status" /></td>
</tr>
<tr>
<td>Passed</td>
<td>Changing the tests that are being run for ... #9785</td>
<td>00:48:07 2 days ago</td>
<td><img src="https://gitlab.e4s.io/uo-public/llvm-sollve/-/pipelines" alt="status" /></td>
</tr>
<tr>
<td>Passed</td>
<td>Merge branch 'force-build-off' into 'main' #9779</td>
<td>00:54:18 3 days ago</td>
<td><img src="https://gitlab.e4s.io/uo-public/llvm-sollve/-/pipelines" alt="status" /></td>
</tr>
<tr>
<td>Passed</td>
<td>hecbench, sollve sv: checkout specific com... #9763</td>
<td>00:46:58 3 days ago</td>
<td><img src="https://gitlab.e4s.io/uo-public/llvm-sollve/-/pipelines" alt="status" /></td>
</tr>
</tbody>
</table>

[View on GitLab](https://gitlab.e4s.io/uo-public/llvm-sollve/-/pipelines)
Thank you for listening
openmp.org  OpenMP API specs, forum, reference guides, and more

link.openmp.org/sc23  OpenMP SC23 booth talk videos and presentations