Early Experiences in using OpenMP 4 for SPEC ACCEL

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SPEC HIGH PERFORMANCE GROUP (HPG)

• Develops benchmarks that represent high-performance computing applications for standardized, cross-platform performance evaluation.

• Current Benchmarks
  – SPEC OMP2012, SPEC MPI2007, SPEC ACCEL 1.0, 1.1

• Working toward OpenMP 4 SPEC ACCEL 1.2
  – Portable across architectures (host, GPUs, XeonPhi)
  – Works with at least two compilers

• Active members:
  – NVIDIA*, SGI, Intel*, IBM*, AMD, Argonne*, ORNL*, HZDR, Oracle, University of Delaware, University of Virginia, RWTH Aachen University, University of Illinois, Indiana University, TU Dresden

*Present at the DOE workshop
OpenMP 4.0 – Performance Portability (Meeting in Berlin)

• We had a meeting and discussed a strategy on how to write “performance portable” style in OpenMP 4
  – Initially members had different views.
  – We agreed on some “guidelines” on how to write portable code
  – We used these “guidelines” and successfully parallelized the 16 benchmarks with OpenMP 4
### SPEC ACCEL: OpenMP 4 Candidates*  
*(SPEC/HPG – Confidential)*

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<th>OpenACC Benchmarks</th>
<th>Language</th>
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<td>C</td>
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<td>504.olbm</td>
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<tr>
<td>514.omriq</td>
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<tr>
<td>553.clvrleaf</td>
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<td>556.sp</td>
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<tr>
<td>557.csp</td>
<td>C</td>
<td>NPB</td>
<td>Scalar Peta-d solv</td>
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<td>C, Fortran</td>
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<td>C</td>
<td>NPB</td>
<td>BTS 3D PDE</td>
</tr>
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</table>
Guidelines – To write OpenMP 4 “Performance Portable Style”

• Use OpenMP 4 “Accelerator Model”

• Do not specify:
  – # of teams
  – # thread_limit,
  – # of threads – in parallel regions
  – SIMD length
  – dist_schedule – in distribute
  – loop schedules – in parallel do

• Compiler implementers should pick these values to enable performance portability
Guidelines – To write OpenMP 4 “Performance Portable Style”

• For level-1 loopnest
  • #pragma target teams distribute parallel for simd

• For perfectly nested loops
  – Use the following nesting of parallelism
    #pragma omp target teams distribute parallel for collapse(N)
    for(i=0;....)
      for(j=0;....)
        #pragma omp simd
          for(k=0;...)

• Parallelize the inner loops always with SIMD
• Do not collapse inner loops
Guidelines for OpenMP 4

• Reductions
  – Reduction variables need to be mapped to/from
    #pragma omp target map(tofrom:sum)
    #pragma omp teams distribute parallel for reduction(+:sum)
    for(....)
      sum = sum + ....

• Privatization
  – We should only privatize only at a nesting level
    #pragma omp teams distribute parallel for // private(yy, zz)
    for(i= .... )
      for(j= ... )
    #pragma omp simd private(yy,zz)
    for(z= ...
      yy =
      zz =
Guidelines for OpenMP 4

- Don’t merge target regions if they have dependences across loop nests (otherwise do)
  
  ```
  #pragma omp target teams distribute parallel for
  for(i=…)
    a[i] =
  #pragma omp target teams distribute parallel for
  for(i=…)
    b[i] =
  ```

- To:

  ```
  #pragma omp target teams
  #pragma omp distribute
  for(i=…)
    a[i] =
  #pragma omp distribute
  for(i=…)
    b[i] =
  ```
Example – jacobi.f – Portable OpenMP

!$omp target map(tofrom: error)
!$omp teams distribute parallel do reduction(+:error)
  do j = 2,m-1
!$omp simd private(resid)
    do i = 2,n-1
      resid = [computes resid from I,j-arrays]
      error = error + resid*resid
    end do
  enddo
!$omp end teams distribute parallel do
!$omp end target
Preliminary results are showing

• If you want performance portability in your codes across platforms:
  – USE OPENMP 4.0 “Accelerator Model”
  – This includes:
    • GPUs
    • Xeon Phi (self-hosted)
    • CPUs

• Compilers should tune and pick code for a given architecture – unless you want to auto-tune.

• Compilers are still working on their OpenMP implementations and few support multiple architectures for OpenMP 4.0 accelerator model