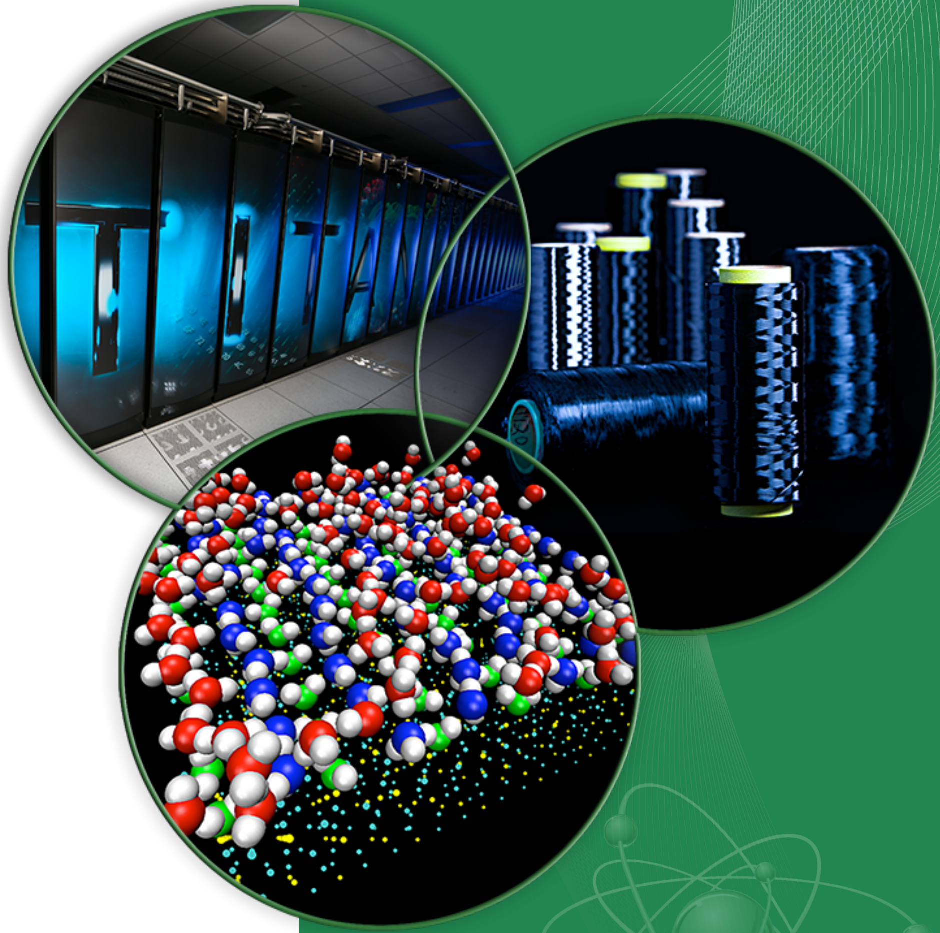
Early Experiences in using OpenMP 4 for SPEC ACCEL



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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)

OpenACC Benchmarks	Language	Origin	Domain
503.ostencil	C	Parboil, University of Illinois	Thermodynamics
504.olbm	C	Parboil, University of Illinois	CFDm Lattice Boltzmann
514.omriq	C	Rodinia, University of Virginia	Medicine
550.md	Fortran	Indiana University	Molecular Dyn.
551.palm	Fortran	Leibniz University of Hannover	Large-eddy sim.
552.ep	C	NAS Parallel Benchmarks (NPB)	Embarrassing P.
553.clvrleaf	C, Fortran	Atomic Weapons Establishments	Hydrodynamics
554.cg	C	NPB	Conjugate Grad.
555.seismic	Fortran	GeoDynamics.org	Seismic Wave Modeling (PDE)
556.sp	Fortran	NPB	Scalar Peta-d solv
557.csp	C	NPB	Scalar Peta-d solv
559.miniGhost	C, Fortran	Sandia National Laboratory	Finite difference
560.ilbdc	Fortran	SPEC OMP2012	Fluid Mechanics
563.swim	Fortran	SPEC OMP2012	Weather
570.bt	C	NPB	BTS 3D PDE

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 loopnests (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