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kokkos

Kokkos Resilience

EXASCALE COMPUTING PROJECT

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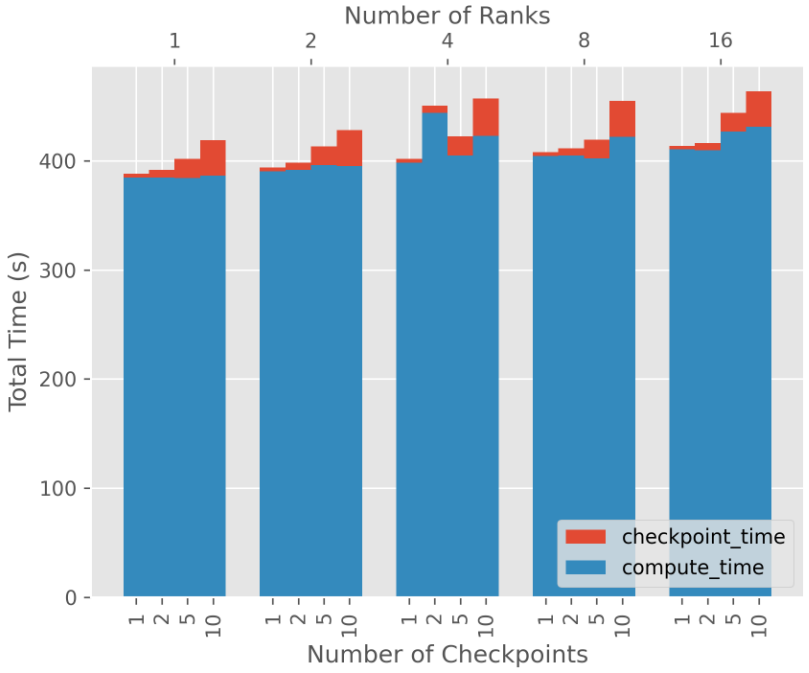
Resilience in the Exascale Era

- As we enter the Exascale era, mean time between failures (MTBF) increase
  - Soft/hard failures
  - Fail slow
  - Errors may be a result of hardware problems, application bugs, system errors, etc.
- Can we take advantage of “Kokkos-ization” of programs to add in resilience capabilities?
  - Allow Kokkos::Views to easily be checkpointed
  - Make parallel constructs resilient

Checkpointing

- Goal: automatically checkpoint Kokkos::Views with little/no boilerplateTrack usage of Kokkos::View inside kernels
  - Compile time with limited run-time component: negligible performance impact (0.6s overhead with 256 views)
  - Automatically register views that are used inside of the functor passed to KokkosResilience::checkpoint
    - No explicit calls needed to bind views to checkpoint storage
    - Automatic detection of recovery conditions
  - Handle deep copy from device to host automatically
  - Minimize checkpoint by analyzing usage (e.g. const views)
  - Can group multiple kernels into one checkpoint region
- Efficient configurable backend for checkpointing
  - VeloC backend for efficient asynchronous checkpointing
    - Need to ensure that VeloC environment is set up (server process)
  - C++ IO for dependency-less checkpointing



Example timing on MiniMD application over 1000 timesteps

Adding Automatic Checkpointing

Without Checkpointing

```
1  int i = 0;
2
3  while(i < ITER_TIMES) {
4    le = doWork(np, rank, M, nbLines, g, h);
5    if ((i % REDUCED) == 0)
6      MPI_Allreduce(&le, &ge, 1, MPI_DOUBLE, MPI_MAX,
       ↪  MPI_COMM_WORLD);
7    if (ge < PRECISION)
8      break;
9    i++;
10 }
```

With KokkosResilience::checkpoint

```
1  auto i = 1 + KokkosResilience::latest_version( *ctx,
   ↪  "heatdis" );
2
3  while(i < ITER_TIMES) {
4    KokkosResilience::checkpoint(ctx, "heatdis", i,
5      [=, &le, &ge]() {
6        le = doWork(np, rank, M, nbLines, g, h);
7        if ((i % REDUCED) == 0)
8          MPI_Allreduce(&le, &ge, 1, MPI_DOUBLE, MPI_MAX,
           ↪  MPI_COMM_WORLD);
9    } );
10   if (ge < PRECISION)
11     break;
12   i++;
13 }
```

Resilient Execution Spaces

```
1  using view_type = Kokkos::View<double*, KokkosResilience::ResCudaSpace>;
2
3  view_type data("data", N);
4  Kokkos::RangePolicy<KokkosResilience::ResCuda> rp(0, N);
5
6  Kokkos::parallel_for(rp, KOKKOS_LAMBDA(const int i) {
7      data(i) = i;
8  });
```

- Execution and memory space for resilient kernel execution
- Mitigate soft errors in kernels by triplicating kernel execution
- Three step execution
  - Triplicate view data
  - Concurrent kernel execution for each copy
  - Recombine via voting; abort if all three differ

Conclusion

- Ongoing effort to add resilience to Kokkos programs
  - Goal is to mitigate effects of decreased MTBF as we move to exascale
- Capabilities
  - Automatic checkpoint/restart of views with minimal boilerplate
  - Resilient kernel execution
- One of our primary goals is ease of use and simplicity of adding resilient capabilities to existing Kokkos programs
- Please contact me (nmmoral@sandia.gov) or Keita Teranishi (knteran@sandia.gov) for questions