Reproducible Reductions in OpenMP with SPRAY

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Flexible reductions with SPRAY

- Originally intended for sparse array reductions like this:

```cpp
#pragma omp parallel for reduction(+:res)
for(int i=0, i<n; i++) {
    res[idx(i)] += ...
}
```

- Default OpenMP: Create copy of `res` on each thread
- Customized behavior with SPRAY: Atomic updates, block-wise lazy privatization...
Flexible reductions with SPRAY

• Originally intended for sparse array reductions like this:

```cpp
class BlockReduction {
  // ...
}

res = spray::BlockReduction(res_orig)
#pragma omp parallel for reduction(+:res)
for(int i=0, i<n; i++) {
    res[idx(i)] += ...
}
```

• Default OpenMP: Create copy of `res` on each thread
• Customized behavior with SPRAY: Atomic updates, block-wise lazy privatization...
Reproducibility

• Common reviewer / user question: Are SPRAY reductions reproducible?

• Different kinds of reproducibility:
  • Run-to-run: Same executable, runtime, machine, settings, static schedule
  • Portable: Same code, but different compiler, thread count, dynamic schedule, etc

• OpenMP can be “run-to-run” reproducible depending on setup
• SPRAY offers “portable” reproducibility
Reproducible reductions with SPRAY

- Reduction variable is wrapped in SPRAY reducer object:
  
  ```cpp
  res = spray::ReproReduction(res_orig)
  #pragma omp parallel for reduction(+:res)
  for(int i=0, i<n; i++) {
    res += ...
  }
  ```


- Constant factor overhead in time/memory

- Same result regardless of schedule, thread count, compiler
Overhead of reproducible reductions

- Depending on thread and iteration count, 1.5x or >3x slowdown
- Other approaches (progressive, store&pair) are faster, but require instrumentation or support by compiler / OpenMP run time
Questions?

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