Obtaining the Last Values of Conditionally Assigned Privates

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(* at submission time)
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#pragma omp simd lastprivate(x)
for(int i=0; i<N; i++){
  x = A[i];
  ...
}

// use of x.

⇒ x is A[N-1].

Unspecified isn’t very useful. Can we do better?

#pragma omp simd lastprivate(x)
for(int i=0; i<N; i++){
  if (A[i]>0) {
    x = A[i];
    ...
  }
}

// use of x.

Problem

• The value from `lastprivate(list)` clause is unspecified if the list item is not assigned in the last iteration.

• Typically, what programmer wants under such circumstances is the value from the last iteration that actually performed the assignment.

```c
#pragma omp simd lastprivate(x)
for(int i=0; i<N; i++){
    if (A[i]>0){ // may be FALSE for i=N-1.
        x = A[i];
        // possible use of x
    }
}
// use of x.
```
# Does ORDERED construct help?

```c
#pragma omp simd
for(i=0;i<N;i++){
    if (i<2){
        #pragma omp ordered simd
        { x = i }
    } // x is 1 here. Good.
} // use of x after the loop
```

X needs to be shared, but it could work for this case.....
#pragma omp simd
for (i=0; i<N; i++) {
    if (i<2) {
        #pragma omp ordered simd
        { x = i }
    } // x is 1 here. Good.
    if (i<1) {
        #pragma omp ordered simd
        { x = i }
    } // x is 0 again. Bad.
}

// use of x after the loop

Unfortunately, this doesn’t go too far.
Why ORDERED Failed?

- Each ORDERED is individually processed.
- Even if an ORDERED assigns at iter-N1, the next ORDERED can override it at iter-N2, where N2 < N1.

Therefore, something at loop-level is needed to support multiple assignments.
How does ICC auto-vec handle it?

- Local reduce, per vector element, of last valid value and last assigned index
- Global reduce after the end of the vector loop

➔ It's a bit more elaborate than typical reduction, but it almost look like reduction.
➔ Same concept applicable to threading? Absolutely!
How does ICC auto-vec handle it?

```c
int foo(int *A, int N){
  int i, x = 0;
  for (i=0;i<N;i++){
    if (A[i]>0){
      x = A[i];
    }
  }
  return x;
}
```

Not exactly tracking the loop index value, but vector code can afford to use element position within vector register.
Can we then call it a reduction???

```c
#pragma omp simd reduction(=:x)
for(i=0;i<N;i++){  
    if (cond(i)){  
        x = …  
    }
}
// use of x after the loop
```

- Informal poll is showing that some people are allergic to calling it a reduction.

- Lastprivate() is already taken, and it’s more efficient if it can be used.
  - We can’t change lastprivate().
  - Something that can coexist with lastprivate() is needed.
How about `lastvalue()` clause?

```c
#pragma omp simd lastvalue(x)
for(i=0;i<N;i++){
    if (cond(i)){
        x = ...  
    }
}
// use of x after the loop
```

- Other than the name and lack of reduction op, it’s the same as “assignment reduction.”
- Applicable to any construct where `lastprivate()` makes sense.
- Actual operation is reduction-like. As such, construct should also support reduction.
Should we support list item appearing as an R-value?

- If we were to call it a reduction, we wouldn’t like to see it outside of reduction operation (which is assignment in this case).
- Some optimizations are easier to perform if we know R-value usage does not exist.
- Programmer can introduce new privates and mechanically get rid of R-value usages of the list items.
- Is this good enough reasons for not supporting R-value usage?
  - At least, this is worth explicitly discussing.
Can we have aggregates as list item?

- Yes, we should.
- However, unlike `lastprivate()`, `lastvalue()` has bookkeeping overhead.
  - There is a limit to what we can feasibly do. Need to strike a right balance.
- Supporting something like below would be prohibitively expensive.

```c
#pragma omp simd lastvalue(A)
for (i=0; i<N; i++){
    if (B[i]>0) { A[i] = ... }
    j = ...
    if (C[i]>0) { A[j] = ... }
}
```
What should we do with aggregates?

• List item as the unit of book-keeping
• No runtime check for matching against list item
• Whole array/struct as a list item should be supported
• Avoid supporting array subsection
• Support one array element as long as the subscript is compile time constant.
• Individual struct field should be supported
What’s Next?

• Now that we defined the clause that keeps track of two values to perform something similar to reduction, can we do max location? Can we go more than 1-D?

```c
for(i=0;i<N;i++){
    if (max<A[i]){
        max = A[i];
        loc = i;
    }
}
// use of loc.
```
Other Ideas We are Working On

- Vectorization of Indirect Calls
- Compress/Expand
- Conflict
- Loop w/ early exits
- Generalized Induction
Shameless Advertisement

• Today at 4:45pm: Panel Discussion

• Friday at 9:50am: Compress/Expand and Conflict
Summary of Proposal

1. `lastvalue(list)` clause syntax and spelling

2. Applicability same as `lastprivate clause (for, simd, for simd, ...)`

3. Aggregate variable as list item allowed, but subject to limitations to minimize book-keeping overhead.