CISC 372: Parallel Computing OpenMP, Part 2

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 - a variable cannot be both shared and private

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- default(shared)
 - if not listed, the variable is shared
- there are rules specifying what happens if you don't have a default clause
 - but ignore them for now
 - explicitly declare every variable used in the region as either private or shared

hello2.c

#include <omp.h>
#include <stdio.h>

```
int main (int argc, char *argv[]) {
 int nthreads, tid;
 #pragma omp parallel private(nthreads, tid)
  Ł
   tid = omp_get_thread_num();
   printf("Hello World from thread = %d\n", tid);
   if (tid == 0) { // only master
     nthreads = omp_get_num_threads();
     printf("Number of threads = %d\n", nthreads);
    }
 } // end of parallel region
```

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 - or it may give you fewer
- if you really need to know how many there are, ask
 - int omp_get_num_threads()

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- ▶ if you want the private x to be initialized with the value the original x had:
 - use firstprivate
- clause: firstprivate(v1,v2,...)
 - declares v1,v2,... to be not only private, but to be initialized with global value
 - see initial2.c

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construct. An OpenMP executable directive ... and the associated statement, loop or structured block, if any, not including the code in any called routines. That is, in the lexical extent of an executable directive.

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Sec. 2.14.3.3, private clause:

The value ... of the original list item will change only

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beware! when you access a "private" variable outside of the construct

you may be accessing the original copy; see semiprivate.c

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Work-sharing

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 - single: let only one thread execute a block

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for (init-expr; var relop b; incr-expr)
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syntactic restrictions on the for statement:

- init-expr: var = expr, integer type
- relop is one of: <, <=, >, >=
- b is a loop-invariant integer expression
- incr-expr has one of a few forms; see OpenMP 4.0 Standard, Section 2.6

- ++var
- ▶ var++
- --var
- ▶ var--
- ▶ var += incr
- ▶ var -= incr
- var = var + incr
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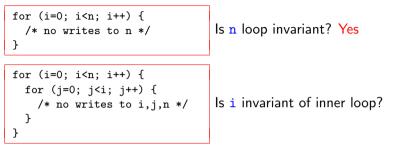
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- however incr could have different values in different loop executions

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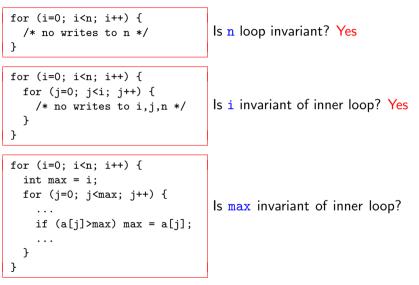
```
for (i=0; i<n; i++) {
    /* no writes to n */
}</pre>
```

Is n loop invariant?

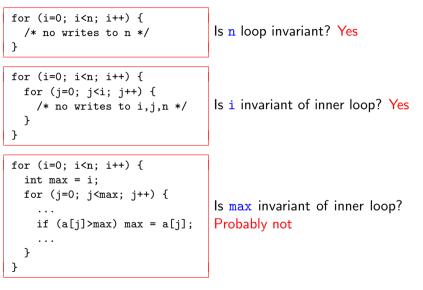


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 - if a clause is applicable to parallel and for
 - if it has the same meaning for each (e.g., shared), no problem
 - otherwise, undefined behavior

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make a variable private and initialize it in every thread

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lastprivate(v1,v2,...)

make a variable private and copy the final value of variable in the last iteration back to the shared variable at end

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- schedule: options to control how iterations are distributed to threads
- nowait: remove the barrier at the end of the loop

collapse(n): apply directive to next n loops in a loop nest

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 - \triangleright n is an expression that evaluates to a positive integer
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Correct:

```
#pragma omp for collapse(2)
for (i=0; i<n; i++)
for (j=0; j<m; j++)
    a[i][j] = 2*b[i][j];</pre>
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Assume a and b are disjoint arrays. Can this loop be parallelized with an OpenMP for construct?

```
for (i=0; i<n && a[i]>0; i++)
  b[i] = b[i] - a[i];
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Assume a and b are disjoint arrays. Can this loop be parallelized with an OpenMP for construct?

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for (i=0; i<n && a[i]>0; i++)
  b[i] = b[i] - a[i]:
```

No (non-standard condition)

Assume a and b are disjoint arrays. Can this loop be parallelized with an OpenMP for construct?

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for (i=1; i<n; i++)</pre>
  b[i] = b[i] - a[i] + b[i-1] - a[i-1]
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```
for (i=1; i<n; i++)</pre>
  b[i] = b[i] - a[i] + b[i-1] - a[i-1]
No (data race)
```

Assume a, b, and c are disjoint arrays. Can this loop be parallelized with an OpenMP for construct?

```
for (i=1; i<n; i++)</pre>
  c[i] = b[i] - a[i] + b[i-1] - a[i-1]
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for (i=1; i<n; i++)</pre>
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Yes

Can this loop be parallelized with an OpenMP for construct?

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for (i=1; i<n; i+=k)</pre>
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