

COMPUTATIONAL MATH, SCIENCE AND ENGINEERING DEPARTMENT

MICHIGAN STATE
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OpenMP sync

```

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8576 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000

```

CMSE 822, FS21, W.F. Punch

OMP Synchronization

- High level synchronization:
 - critical
 - atomic
 - barrier
 - ordered
- Low level synchronization
 - flush
 - locks (both simple and nested)



critical

A critical section marks a mutual exclusion of a stmt/block

- inside a parallel region
- only 1 thread can execute the block
- any other arriving thread waits
 - no order here, either entering or waiting



warnings on critical

- there are warnings online that a critical section has "considerable overhead"
 - in any event, mutexs slow things down.
- if you don't say otherwise, every critical section shares the same underlying mutex
 - one blocked critical blocks **every critical**



critical naming

```
#pragma omp critical(my_name)
```

You can name your critical sections and they will then have a separate mutex.



Atomic

The phrase "atomic" refers to the original meaning of the word, which is "indivisible".

An atomic operation is guaranteed to not be "divisible" among threads.

- if one thread starts the operation, no other thread can interfere until the atomic operation finishes.



limited form of syn

As such, an atomic is usually a single operation on a variable, such as incrementing it or something similar.

Typically atomic operations are fast, much faster than a critical though limited in what they can do.



OMP atomic ops

- An atomic construct is limited to a single statement using:
 - $+$, $*$, $-$, $/$, $\&$, \wedge , $|$, \ll , \gg




```
int ic, i, n;  
ic = 0;  
#pragma omp parallel shared(n,ic) private(i)  
    for (i=0; i++, i<n)  
    {  
        #pragma omp atomic  
        ic = ic + 1;  
    }
```

“ic” is a counter. The atomic construct ensures that no updates are lost when multiple threads are updating a counter value.

```
int ic, i, n;  
ic = 0;  
#pragma omp parallel shared(n,ic) private(i)  
    for (i=0; i++, i<n)  
    {  
        #pragma omp atomic  
        ic = ic + bigfunc();  
    }
```

- The atomic construct does not prevent multiple threads from executing the function bigfunc() at the same time.

barriers

Barriers are a little strange since implicit barriers are everywhere already, but you can place one in code and all threads have to reach the barrier before any thread can move on



nowait

- stop the implicit barrier at the end of a loop so that the work can move forward.



collapse

- Rules are that the loops have no work in them except in the bottom loop level (not intervening code).
- runs all the loop code as one loop



ordered

There is no guarantee in a for construct that the work is done "in order" of the for loop.

However, we can "force" a part of the code to come out in "iteration order"



single/master or `if(id==0)`

- single means only 1 thread will run the block ever
 - implicit barrier
- master means only the master will run the block ever
 - no barrier
- you can also check the thread number and have one thread do the work.



locks

Locks differ from critical sections in that you can lock *data* with a lock.

Locks are expensive to set up and use!



lock functions

- `omp_init_lock(omp_lock_t *)` – initialize a lock
 - `omp_set_lock(omp_lock_t*)` – wait until the lock is available, then set it. No other thread can set the lock until it is released
 - `omp_unset_lock(omp_lock_t*)` – unset (release) the lock
 - `omp_destroy_lock(omp_lock_t*)` – The reverse of `omp_init_lock`
- 