Lecture 8

Programming Shared Memory II

Synchronization Primitives; Mutex

Ceng505 *Parallel Computing* at November 29, 2010

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Thread Basics: Passing Arguments I

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- This structure contains all of the arguments, and then a pointer is passed to that structure in the *pthread_create*() routine.

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- All arguments must be passed by reference and cast to (void *).

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- For cases where multiple arguments must be passed, this limitation is easily overcome by creating a **structure**.
- This structure contains all of the arguments, and then a pointer is passed to that structure in the *pthread_create*() routine.
- All arguments must be passed by reference and cast to (void *).
- Threads have non-deterministic start-up and scheduling.
- How can you safely pass data to newly created threads?

Thread Basics: Passing Arguments II

- **Example:** Demonstrates how to pass a simple integer to each thread.

```
long *taskids[NUM_THREADS];

for(t=0; t<NUM_THREADS; t++)
{
   taskids[t] = (long *) malloc(sizeof(long));
   *taskids[t] = t;
   printf("Creating thread %ld\n", t);
   rc = pthread_create(&threads[t], NULL, PrintHello, (void *) taskids[t]);
   ...
}
```

Figure: Passing single argument to thread function.

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```
struct thread_data{
   int  thread_id;
   int  sum;
   char *message;
};

struct thread_data thread_data_array[NUM_THREADS];

void *PrintHello(void *threadarg)
{
   struct thread_data *my_data;
   ...
   my_data = (struct thread_data *) threadarg;
   taskid = my_data->thread_id;
   sum = my_data->sum;
   hello_msg = my_data->message;
   ...
}

int main (int argc, char *argv[])
{
   ...
   thread_data_array[t].thread_id = t;
   thread_data_array[t].sum = sum;
   thread_data_array[t].message = messages[t];
   rc = pthread_create(&threads[t], NULL, PrintHello,
        (void *) &thread_data_array[t]);
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int main (int argc, char *argv[])
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Each thread receives a *unique instance* of the structure.

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- In other words, the threads evaluating the corresponding board positions must be canceled.

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- In other words, the threads evaluating the corresponding board positions must be canceled.
- Posix threads provide this cancellation feature.
- A thread may cancel itself or cancel other threads.

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- It is not guaranteed that the specified thread will receive or act on the cancellation. Threads can protect themselves against cancellation.
- When a cancellation is actually performed, cleanup functions are invoked for reclaiming the thread data structures.

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- It is not guaranteed that the specified thread will receive or act on the cancellation. Threads can protect themselves against cancellation.
- When a cancellation is actually performed, cleanup functions are invoked for reclaiming the thread data structures.
- The **pthread_cancel** function returns after a cancellation has been sent. The cancellation may itself be performed later.

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- Function **pthread_join** which suspends execution of the calling thread until the specified thread terminates.

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1    int
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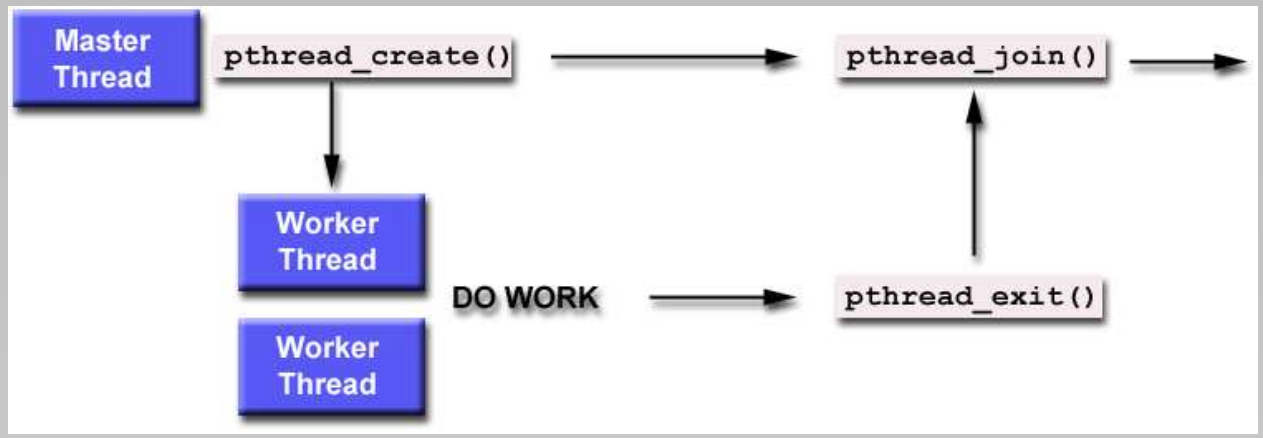

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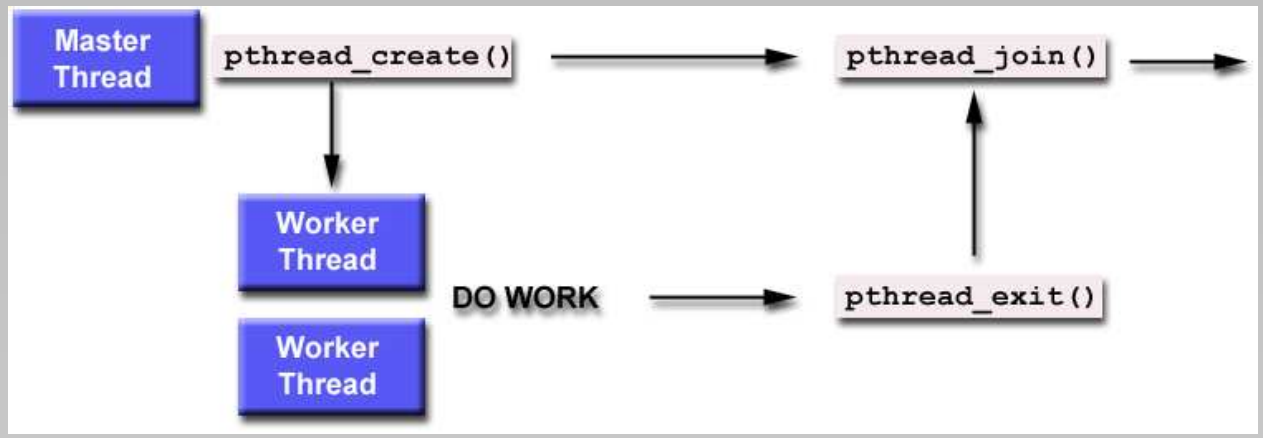

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- On a successful call to **pthread_join**, the value passed to **pthread_exit** is returned in the location pointed to by *ptr*.

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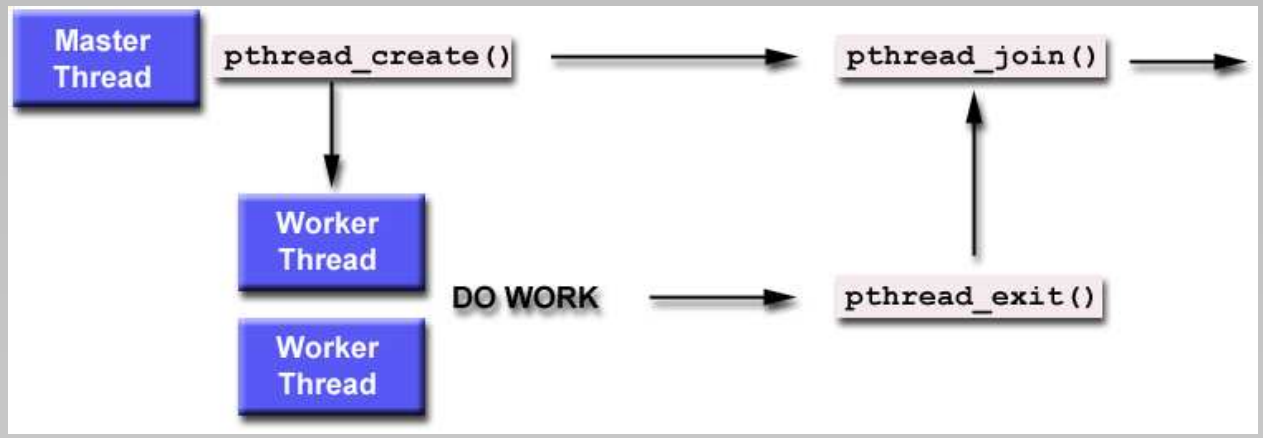

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- On a successful call to **pthread_join**, the value passed to **pthread_exit** is returned in the location pointed to by *ptr*.
- On successful completion, **pthread_join** returns 0, else it returns an error-code.

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- If a thread requires joining, consider explicitly creating it as joinable (portability).
- If you know in advance that a thread will never need to join with another thread, consider creating it in a detached state (resources).

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- If another thread starts executing the same function at this point, a non-reentrant function might not work as desired.

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- These tasks work together to manipulate data and accomplish a given task.
- When multiple threads attempt to manipulate the same data item,
- the results can often be **incoherent** if proper care is not taken to synchronize them.

Synchronization Primitives: Mutex II

- Consider the following code fragment being executed by multiple threads.

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- So called because the result of the computation depends on the race between competing threads.

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- Depending on which thread executes first, the value of *best_cost* at the end could be either 50 or 75.
- There are two problems here:
  1. non-deterministic nature of the result;
  2. more importantly, the value 75 of *best_cost* is inconsistent in the sense that no serialization of the two threads can possibly yield this result.

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- Many statements that seem atomic in higher level languages such as C may in fact be non-atomic.
  - i.e., a statement of the form $global\_count += 5$ may comprise several assembler instructions and therefore must be handled carefully.
- Threaded APIs provide support for implementing critical sections and atomic operations using **mutex**-locks (mutual exclusion locks).

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  - If the mutex-lock is already locked, the process trying to acquire the lock is **blocked**.
  - This is because a locked mutex-lock implies that there is another thread currently in the critical section and that no other thread must be allowed in.
  - When a thread leaves a critical section, it must unlock the mutex-lock so that other threads can enter the critical section.

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  - To access the shared data, a thread must first try to acquire a mutex-lock.
  - If the mutex-lock is already locked, the process trying to acquire the lock is **blocked**.
  - This is because a locked mutex-lock implies that there is another thread currently in the critical section and that no other thread must be allowed in.
  - When a thread leaves a critical section, it must unlock the mutex-lock so that other threads can enter the critical section.
- All mutex-locks must be initialized to the unlocked state at the beginning of the program.

Synchronization Primitives: Mutex VI

- The function **pthread_mutex_lock**;

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- If the mutex-lock is already locked, the calling thread blocks; otherwise the mutex-lock is locked and the calling thread returns.

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- If the mutex-lock is already locked, the calling thread blocks; otherwise the mutex-lock is locked and the calling thread returns.
- A successful return from the function returns a value 0. Other values indicate error conditions such as deadlocks.

Synchronization Primitives: Mutex VII

- The function **pthread_mutex_unlock**;

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- On leaving a critical section, a thread must **unlock the mutex-lock** associated with the section.

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- On leaving a critical section, a thread must **unlock the mutex-lock** associated with the section.
- If it does not do so, no other thread will be able to enter this section, typically resulting in a deadlock.

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- The function **pthread_mutex_unlock**;

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- On leaving a critical section, a thread must **unlock the mutex-lock** associated with the section.
- If it does not do so, no other thread will be able to enter this section, typically resulting in a deadlock.
- On calling **pthread_mutex_unlock** function, the lock is relinquished and one of the blocked threads is **scheduled** to enter the critical section.

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  2. Dynamically, with the **pthread_mutex_init()** routine. This method permits setting mutex object attributes, *attr*.
- If a programmer attempts a **pthread_mutex_unlock** on a previously unlocked mutex or one that is locked by another thread, the effect is undefined.

Synchronization Primitives: Mutex IX

- The function **pthread_mutex_init**;

```
1    int
2    pthread_mutex_init (
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- The attributes of the mutex-lock are specified by *lock_attr*.

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- The mutex is initially unlocked.
- The attributes of the mutex-lock are specified by *lock_attr*.
- If this argument is set to *NULL*, the default mutex-lock attributes are used (normal mutex-lock).

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- It is therefore important to minimize the size of critical sections and to handle critical sections and shared data structures with extreme care.
- It is often possible to reduce the idling overhead associated with locks using an alternate function, *pthread_mutex_trylock*.
- It does not have to deal with queues associated with locks for multiple threads waiting on the lock.

Synchronization Primitives: Overheads of Locking II

- The function **pthread_mutex_trylock**;

```
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2    pthread_mutex_trylock (
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```


Synchronization Primitives: Overheads of Locking II

- The function **pthread_mutex_trylock**;

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- This function attempts a lock on *mutex_lock*.

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1    int
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  - If it is already locked by another thread, **instead of blocking** the thread execution, it returns a value *EBUSY*.

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  - If it is already locked by another thread, **instead of blocking** the thread execution, it returns a value *EBUSY*.
  - This allows the thread to **do other work** and to poll the mutex for a lock.
- Furthermore, **pthread_mutex_trylock** is typically much faster than **pthread_mutex_lock** on typical systems.