

CSE 333 – SECTION 9

Threads

HW4

- How's HW4 going? Any Questions?

Threads

- Sequential execution of a program.
- Contained within a process.
- Multiple threads can exist within the same process.
 - Every process starts with one thread of execution, can spawn more.
- Threads in a single process share one address space
 - Instructions (code)
 - Static (global) data
 - Dynamic (heap) data
 - Environment variables, open files, sockets, etc.

POSIX threads (Pthreads)

- The POSIX standard provides APIs for creating and manipulating threads.
- Part of the standard C/C++ libraries, declared in `pthread.h`

Core pthread functions

- `pthread_create(thread, attr, start_routine, arg)`
- `pthread_exit(status)`
- `pthread_join(thread, value_ptr)`
- `pthread_cancel (thread)`

pthread_create

```
#include <pthread.h>

int pthread_create( pthread_t *thread,
                  const pthread_attr_t *attr,
                  void *(*start_routine) (void *),
                  void *arg );
```

- `pthread_create` creates a new thread and calls `start_routine` with `arg` as its parameter.
- `pthread_create` arguments:
 - **thread:** Pointer to a unique identifier for the new thread. (output parameter)
 - **attr:** An attribute object that may be used to set thread attributes. Use NULL for the default values.
 - **start_routine:** The C routine that the thread will execute once it is created.
 - **arg:** A single argument that may be passed to `start_routine`. It must be passed by reference as a pointer cast of type `void`. NULL may be used if no argument is to be passed.
- Compile and link with `-pthread`.

Terminating Threads

- There are several ways in which a thread may be terminated:
 - The thread returns normally from its starting routine; Its work is done.
 - The thread makes a call to the `pthread_exit` subroutine - whether its work is done or not.
 - The thread is canceled by another thread via the `pthread_cancel` routine.
 - The entire process is terminated due to making a call to either the `exec()` or `exit()`.
 - If `main()` finishes first, without calling `pthread_exit` explicitly itself.

pthread_exit

```
void pthread_exit (void *retval);
```

- Allows the user to terminate a thread and to specify an optional termination status parameter, *retval*.
- In subroutines that execute to completion normally, you can often dispense with calling `pthread_exit()`.
- **Calling `pthread_exit()` from `main()`:**
 - If `main()` finishes before the threads it spawned, and does not call `pthread_exit()` explicitly, all the threads it created will terminate.
 - To allow other threads to continue execution, the main thread should terminate by calling `pthread_exit()` rather than `exit()`.

pthread_join

```
int pthread_join(pthread_t thread, void **retval);
```

- Synchronization between threads.
- `pthread_join` blocks the calling thread until the specified thread terminates and then the calling thread joins the terminated thread.
- Only threads that are created as joinable can be joined; a thread created as detached can never be joined. (Refer `pthread_create`)
- The target thread's termination return status can be obtained if it was specified in the target thread's call to `pthread_exit()`.

Demo: *pthreads.cc*

mutex

- `pthread_mutex_init(mutex,attr)`
- `pthread_mutex_lock(mutex)`
- `pthread_mutex_unlock(mutex)`
- `pthread_mutex_destroy(mutex)`

Demo: *total_locking.cc*

Boost library

- Used in the homework to help facilitate dealing with strings. Some uses include:
 - Trimming
 - Regex (Pattern matching)
 - Splitting
 - Replacing
- API: http://www.boost.org/doc/libs/1_57_0/doc/html/string_algo/reference.html
- Sample Code:

Demo: *boostexample.cc*

C++ threads

- Not used for the exercise, but is a simpler thread library for C++:
 - `#include <thread>`
 - Still compile with `-pthread`

Demo: *threads.cc*

Section exercise (not to be turned in)

- Create a program that spawns two or three different threads, each of which prints a numeric sequence.

Examples:

- First n odd numbers
 - First n factorials
 - First n primes
- Use pthread.cc for ideas, but the structure might not be the same.
 - Can you do something in the threads (maybe sleep()) so that different runs of the program don't always produce the same output?