Threads

Lecture 9

Threads

- Threads are lightweight processes
- Each process can execute several threads
  - The threads execute independently
  - Threads share the global variables and OS resources
  - Each thread has its own stack and follow its own execution flow

Threads

- In practice
  - Main program creates threads
    - By specifying an entry point function and an argument.
  - The main program and each created thread run independently.
    - They share global variables.
    - They do not share local variables.

Threads

- Example of functions to handle threads
  - Creation
  - Exit
  - Cancellation
  - Synchronization

Threads

- Example
  - Alternating threads
    - Creates 3 threads
    - Let the system execute them in a round-robin fashion
    - Wait for them to finish at main

Threads

Threads

Threads

- Need synchronization
- Solution:
  - Lock
  - Conditional variables
  - Semaphores

Locking

- Sharing variables
  - Requires mutual exclusion
  - Lock/unlock to avoid a race condition
- Have one lock for each independent critical region

Locking

```
//No synchronization -->> BAD!!

int count = 0;

void *update ( )
{
        int     i;

        for (i = 0; i < 1000; i++)
        {
            count++;
        }
}
```

```
//Using lock

int count = 0;

void *update ( )
{
      int    i;

      for (i = 0; i < 1000; i++)
      {
            lock
            count++;
            unlock
      }
}
```

pthread library

- We will use the Linux pthread library
  - Main information
    - man pthread
  - There are man pages for specific functions
  - Include ".h" file as shown in the man page: #include <pthread.h>
  - Compile using -lpthread

pthread library

- Operations

```
#include <pthread.h>

pthread_t thread;

int pthread_create (
              pthread_t *restrict thread,              // thread id
              const pthread_attr_t *restrict attr,     // attributes
              void *(*start_routine)(void *),          // function
              void *restrict arg);                     // argument
```

pthread library

- Operations

void pthread_exit (void *value_ptr);

int pthread_join (pthread_t thread, void **value_ptr);

pthread library

- Example using pthreads
  - Alternating threads
    - Creates 3 threads
    - Let the system execute them in a round-robin fashion
    - Wait for them to finish at main

pthread library

pthread library

pthread -- mutex lock

- Functions

```
pthread_mutex_t mutex = PTHREAD_MUTEX_INITIALIZER;

INIT
int pthread_mutex_init (pthread_mutex_t *restrict mutex,
                        const pthread_mutexattr_t *restrict attr);
LOCK
int pthread_mutex_lock (pthread_mutex_t *mutex);

UNLOCK
int pthread_mutex_unlock (pthread_mutex_t *mutex);
```

pthread -- mutex lock

```
//No synchronization -->> BAD!!

int count = 0;

void *update ( )
{
        int     i;

        while (i = 0; i < 1000; i++)
        {
            count++;
        }
}
```

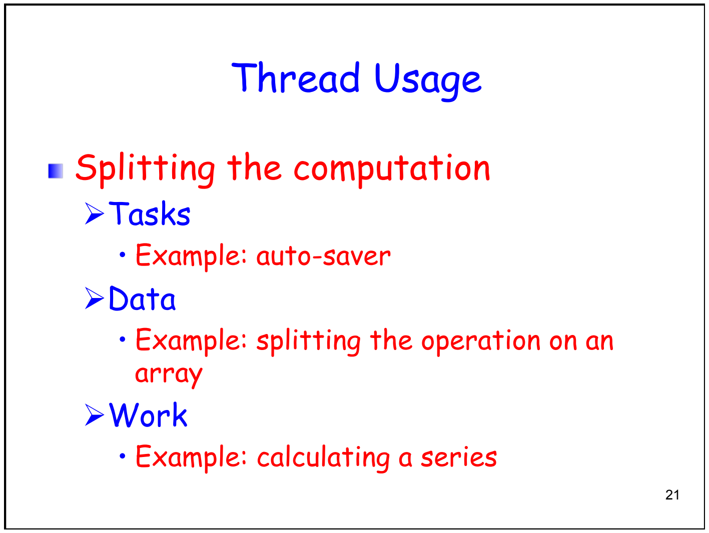
```
//Using mutex lock
//pthread_mutex_init called in main

int count = 0;
pthread_mutex_t mutex =
    PTHREAD_MUTEX_INITIALIZER;

void *update ( )
{
      int     i;

      while (i = 0; i < 1000; i++)
      {
           pthread_mutex_lock (&mutex);
           count++;
           pthread_mutex_unlock (&mutex);
      }
}
```

Threads -- Deadlocks

- Danger!
  - When one or more threads are waiting for one another and no thread can proceed
- Example
  - One thread is waiting for itself
  - Two threads are waiting for each other
  - Several threads are waiting for one another in a cycle

Performance considerations

- Thread creation is expensive
- Each thread has its own stack
- Lock contention requires skills to keep as many threads as possible running



Thread Usage

- Splitting the computation
  - Tasks
    - Example: auto-saver
  - Data
    - Example: splitting the operation on an array
  - Work
    - Example: calculating a series