Lecture 7

Programming Shared Memory I

Why Threads?

Ceng505 *Parallel Computing* at November 22, 2010

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- Processes contain information about program resources and program execution state.

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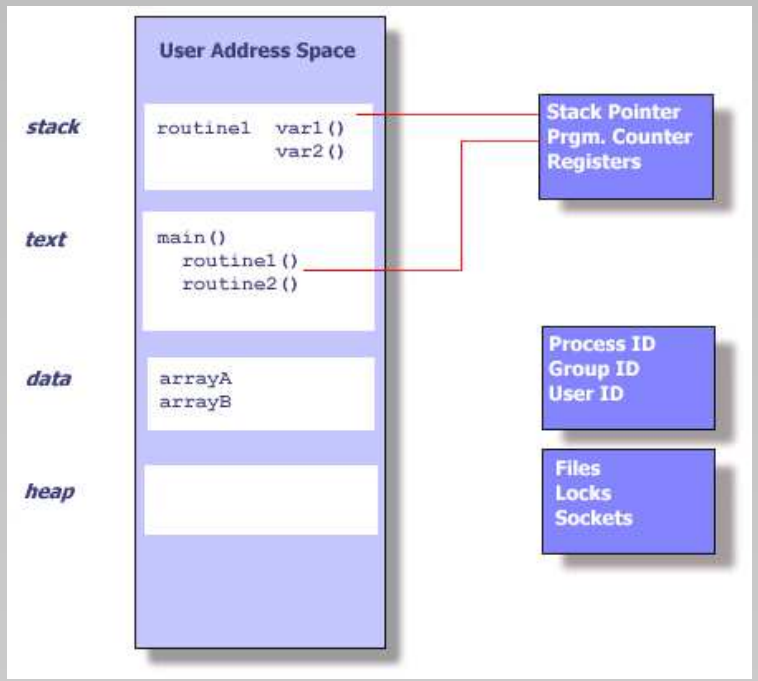

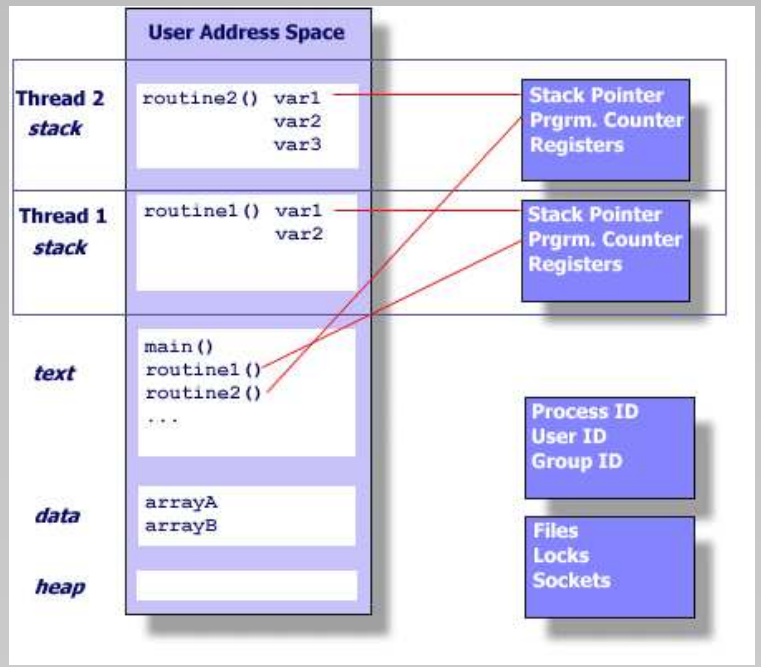

Figure: Left: Unix process. Right: Threads within a Unix process.

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- A thread is "lightweight" because most of the overhead has already been accomplished through the creation of its process.

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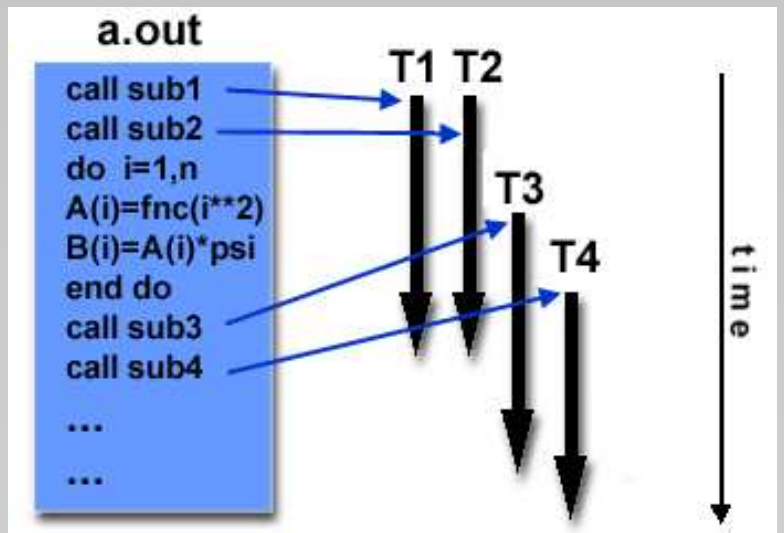

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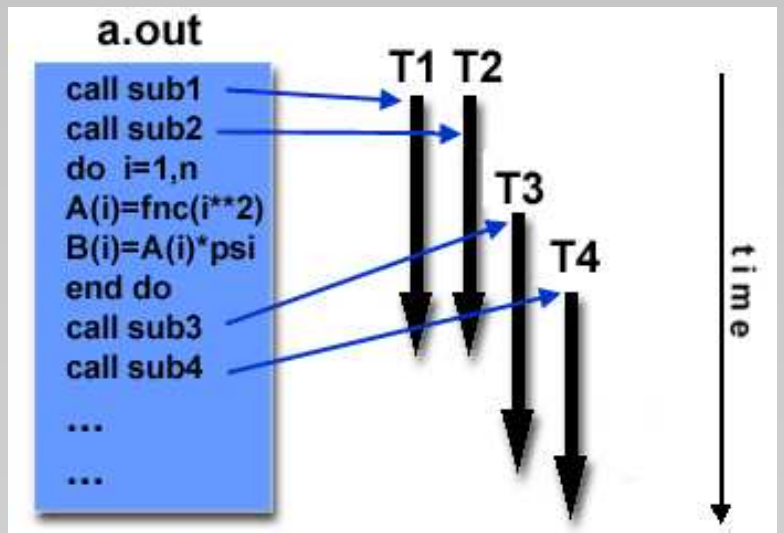

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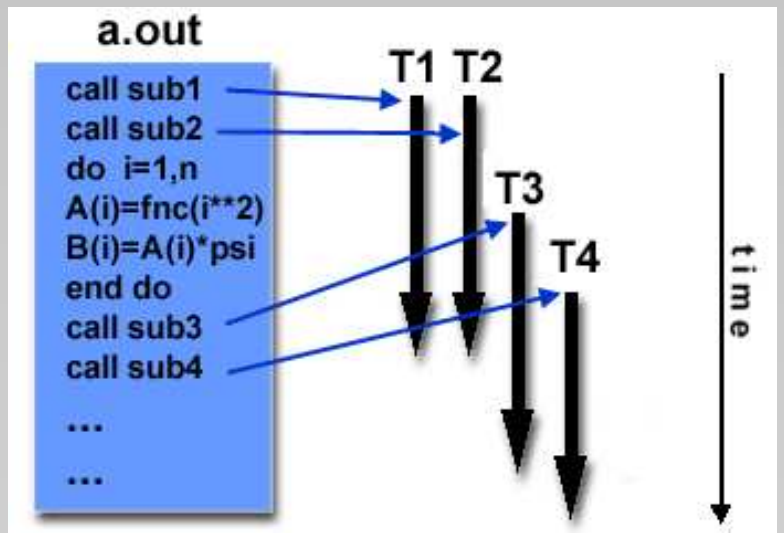

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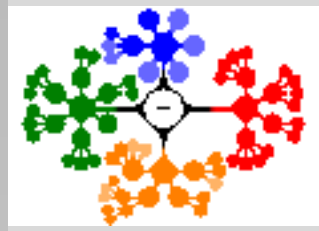

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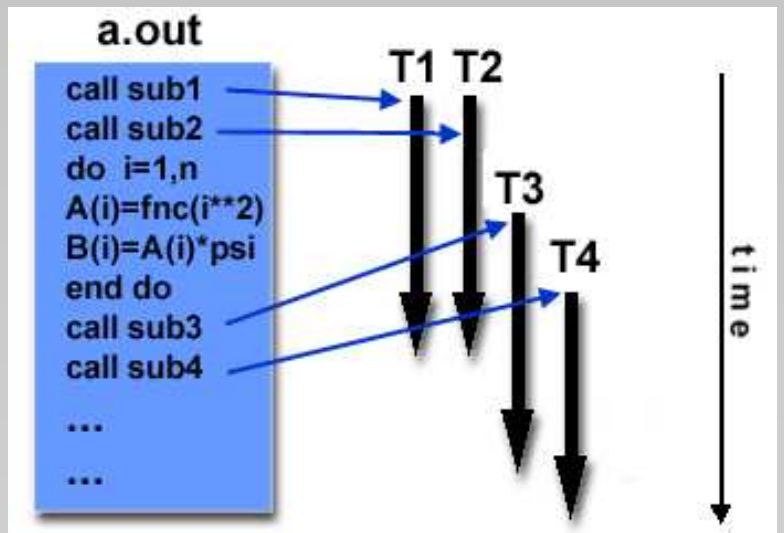

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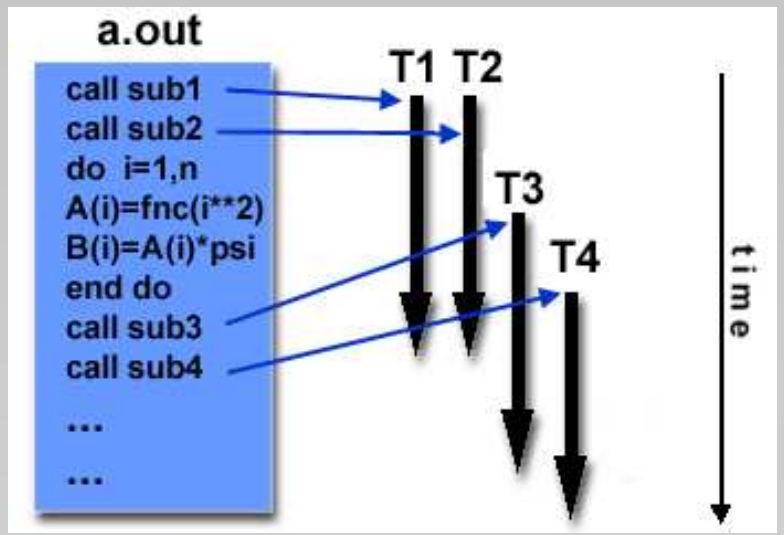

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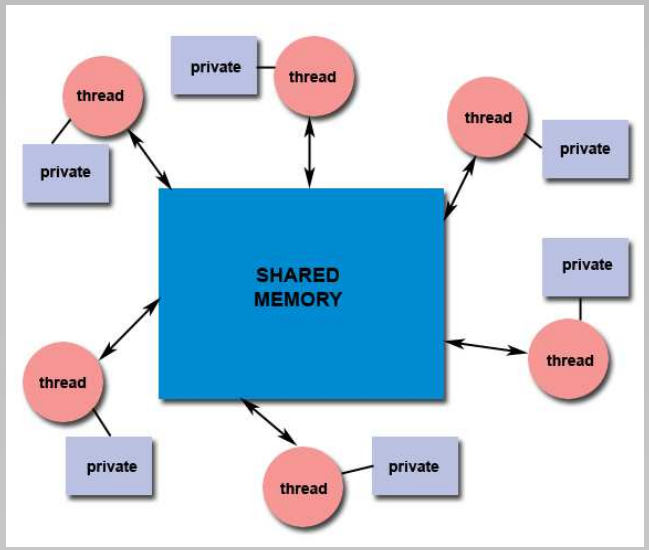
- a.out (*main program*) loads and acquires all of the necessary system and user resources to run.
- *Main program* performs some serial work,
- and then creates a number of tasks (threads) that can be scheduled and run by the OS concurrently.

Threads Model II

- Each thread has local data, but also, shares the entire resources of *main program*.



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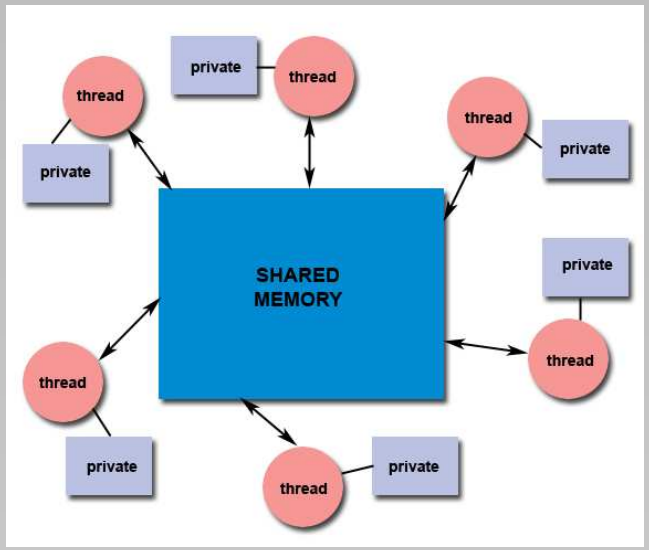

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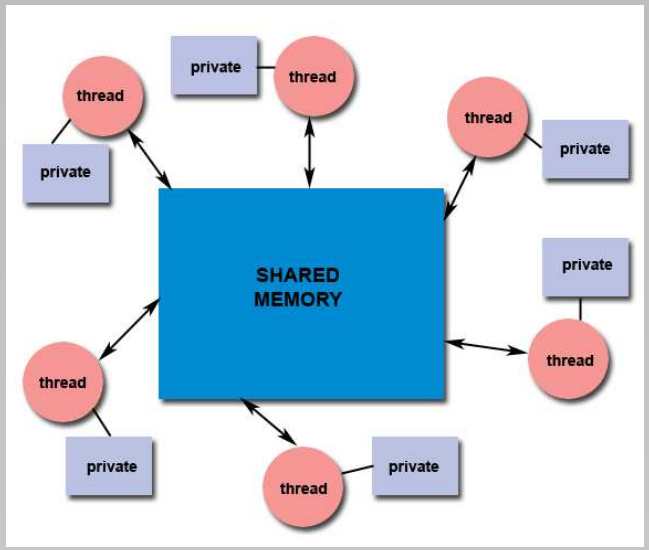

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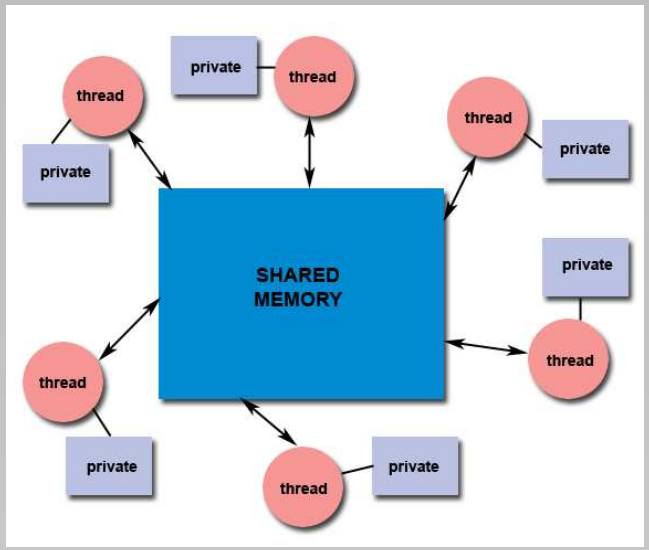

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- Any thread can execute any subroutine at the same time as other threads.

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- This requires **synchronization constructs** to insure that more than one thread is not updating the same global address at any time.

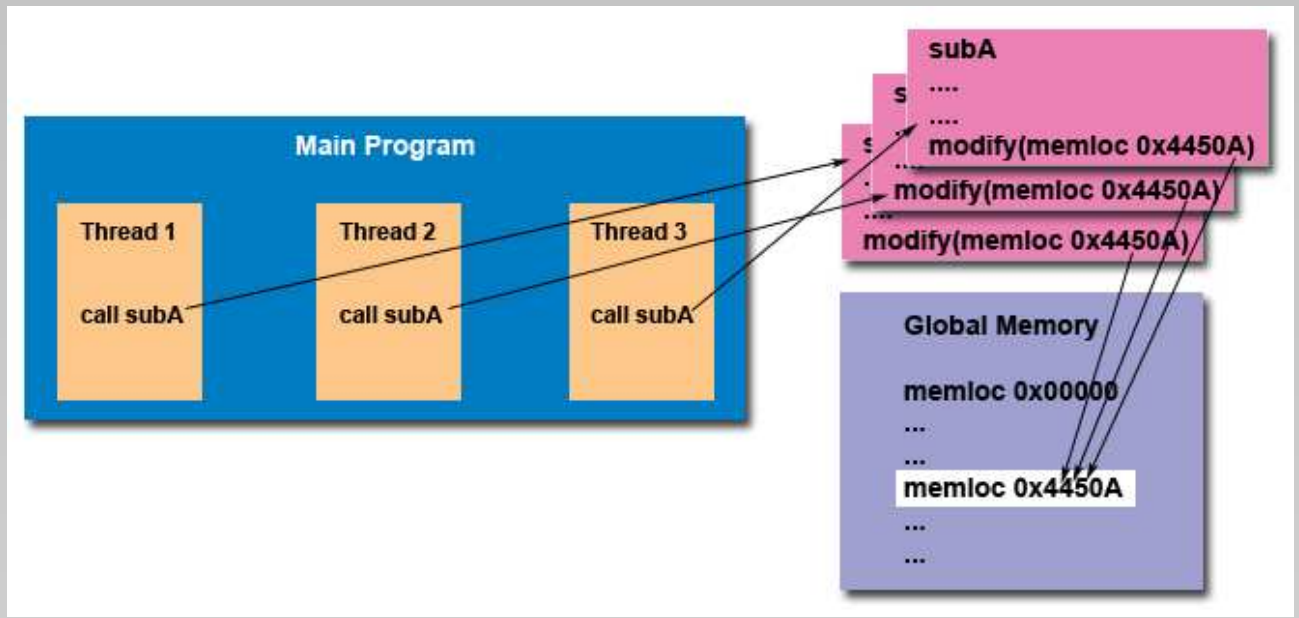

Figure: Threads Unsafe! Pointers having the same value point to the same data.

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- In both cases, the programmer is responsible for determining all parallelism.

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- Threaded programming models offer significant advantages over message-passing programming models along with some disadvantages as well.

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- In effect, while one thread is waiting for a communication operation, other threads can utilize the CPU, thus *masking associated overhead*.

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- With widespread acceptance of the POSIX thread API, development tools for POSIX threads are more widely available and stable.

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- **Priority/real-time scheduling:** tasks which are more important can be scheduled to supersede or interrupt lower priority tasks.
- **Asynchronous event handling:** tasks which service events of indeterminate frequency and duration can be interleaved. For example, a web server can both transfer data from previous requests and manage the arrival of new requests.

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   - POSIX has emerged as the standard threads API, supported by most vendors.

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- A number of vendors provide vendor-specific thread APIs.
- Standardization efforts have resulted in two very different implementations of threads.
- Microsoft has its own implementation for threads, which is not related to the UNIX POSIX standard or OpenMP.

1. **POSIX Threads**. *Library based; requires parallel coding.*
   - The IEEE specifies a standard 1003.1c-1995 (latest 1003.1, 2004), **POSIX API**.
   - C Language only. Very explicit parallelism; requires significant programmer attention to detail.
   - Commonly referred to as ***Pthreads***.
   - POSIX has emerged as the standard threads API, supported by most vendors.
   - The concepts themselves are largely independent of the API and can be used for programming with other thread APIs (NT threads, Solaris threads, Java threads, etc.) as well.

Why Threads? VI

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Why Threads? VII

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- Some work is more important than other work (priority interrupts).

Why Threads? IX

Common models for thread programming:

- **Manager/worker:** a single thread, the manager assigns work to other threads, the workers. Typically, the manager handles all input and distribute work to the other tasks. At least two forms of the manager/worker model are common:

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- **Pipeline:** a task is broken into a series of suboperations, each of which is handled in series, but concurrently, by a different thread. An automobile assembly line best describes this model.
- **Peer:** similar to the manager/worker model, but after the main thread creates other threads, it participates in the work.

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- The *arg* field specifies a pointer to the argument to function *thread_function*.
- This argument is typically used to pass the workspace and other *thread-specific* data to a thread.

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- Robust programs should not depend upon threads executing in a specific order.

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- *Cleanup:* the **pthread_exit()** routine does not close files; any files opened inside the thread will remain open after the thread is terminated.

Thread Basics: Creation and Termination VI

- **Example:** This example code creates 5 threads with the **pthread_create()** routine.

```
#include <pthread.h>
#include <stdio.h>
#define NUM_THREADS     5

void *PrintHello(void *threadid)
{
  long tid;
  tid = (long)threadid;
  printf("Hello World! It's me, thread #%ld!\n", tid);
  pthread_exit(NULL);
}
```


Thread Basics: Creation and Termination VI

- **Example:** This example code creates 5 threads with the **pthread_create()** routine.
- Each thread prints a ’Hello World!’ message, and then terminates with a call to **pthread_exit()**.

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Thread Basics: Creation and Termination VII

```
int main (int argc, char *argv[])
{
  pthread_t threads[NUM_THREADS];
  int rc;
  long t;
  for(t=0; t<NUM_THREADS; t++){
    printf("In main: creating thread %ld\n", t);
    rc = pthread_create(&threads[t], NULL, PrintHello,
                                                (void *)t);
    if (rc){
      printf("ERROR; return code from pthread_create() is
                                                %d\n", rc);
      exit(-1);
    }
  }
pthread_exit(NULL);
}
```