

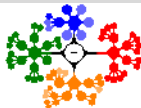
Lecture 7

Programming Shared Memory I

Why Threads?

Ceng471 *Parallel Computing* at December 09, 2010

Dr. Cem Özdoğan
Computer Engineering Department
Çankaya University



Programming Shared Memory

What is a Thread?

Threads Model

Why Threads?

Thread Basics: Creation
and Termination

Thread Creation

Thread Termination

1 Programming Shared Memory

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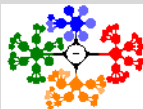
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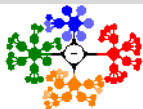
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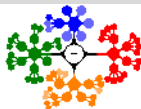


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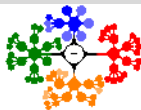


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- **Processes contain information about program resources and program execution state.**

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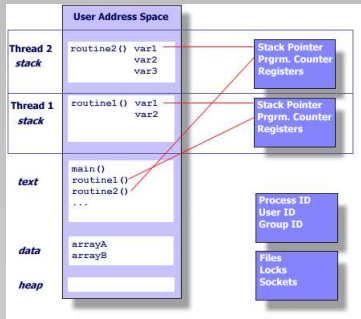
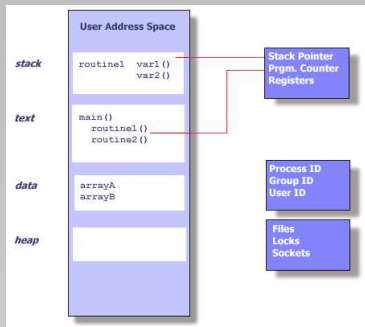


Figure: Left: Unix process. Right: Threads within a Unix process.

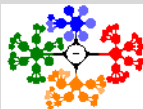
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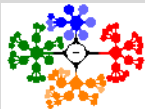
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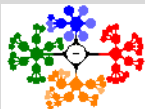
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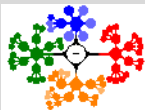
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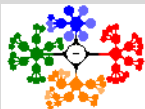
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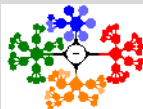
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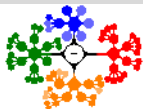
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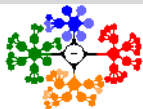
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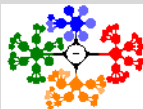
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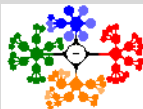
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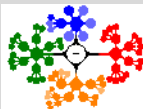
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- A thread is "lightweight" because most of the overhead has already been accomplished through the creation of its process.



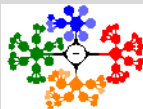
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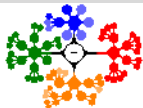
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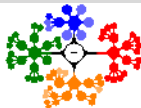
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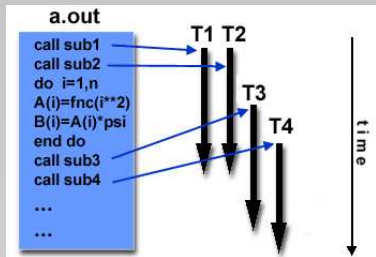
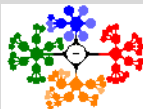


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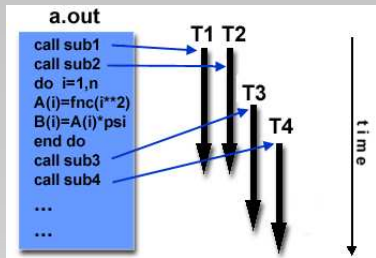
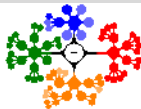
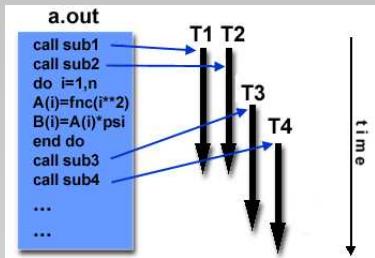


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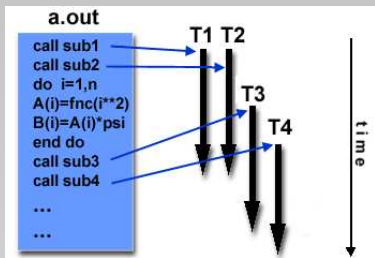
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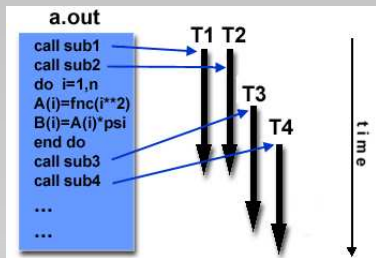


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- a.out (*main program*) loads and acquires all of the necessary system and user resources to run.
- *Main program* performs some serial work,
- and then creates a number of tasks (threads) that can be scheduled and run by the OS concurrently.

Threads Model II

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

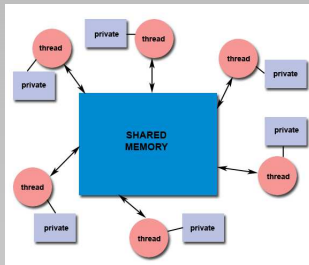
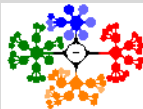


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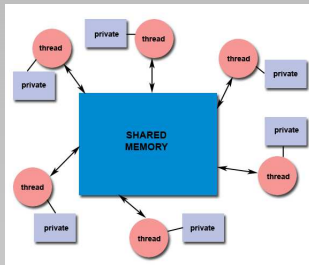
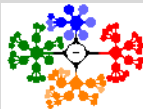


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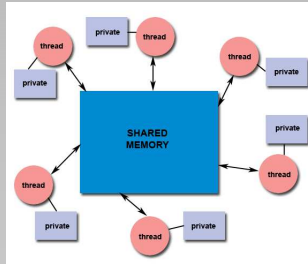


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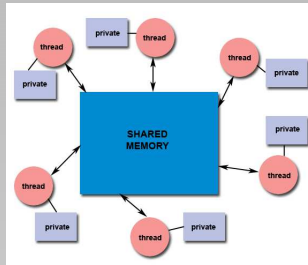


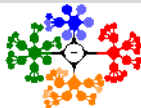
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- Each thread also benefits from a global memory view because it shares the memory space of program.
- Any thread can execute any subroutine at the same time as other threads.



Threads Model III

- Threads communicate with each other through global memory (updating address locations).



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- Changes made by one thread to shared system resources (such as closing a file) will be seen by all other threads.
- This requires **synchronization constructs** to insure that more than one thread is not updating the same global address at any time.

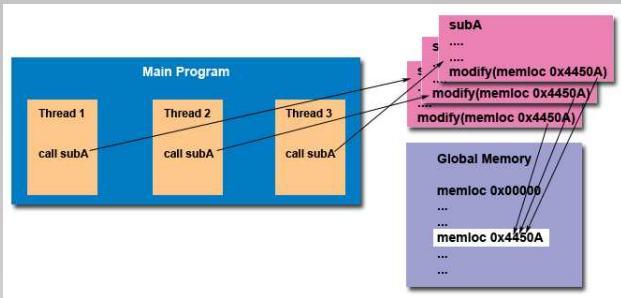
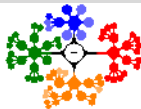
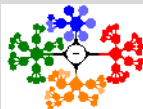


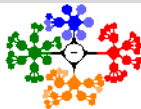
Figure: Threads Unsafe! Pointers having the same value point to the same data.

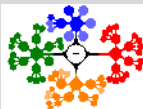


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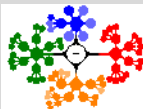


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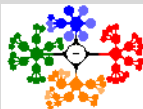




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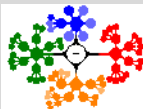
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- From a programming perspective, threads implementations commonly comprise:
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- In both cases, the programmer is responsible for determining all parallelism.

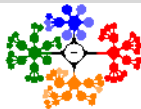
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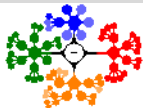
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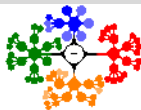


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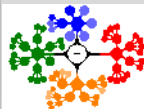
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- Managing threads requires fewer system resources than managing processes.
- Threaded programming models offer significant advantages over message-passing programming models along with some disadvantages as well.

Why Threads? II

- **Software Portability;**



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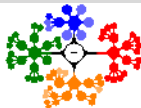
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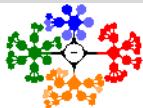
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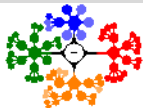
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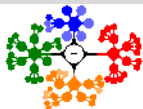


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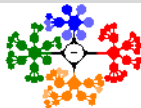


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- In effect, while one thread is waiting for a communication operation, other threads can utilize the CPU, thus *masking associated overhead*.



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- Scheduling and Load Balancing;



Programming Shared Memory

What is a Thread?

Threads Model

Why Threads?

Thread Basics: Creation
and Termination

Thread Creation

Thread Termination

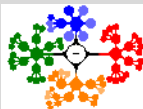
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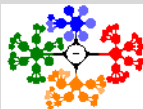
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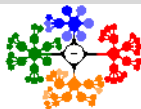
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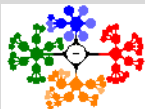
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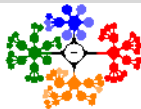
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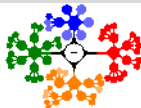
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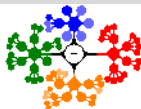
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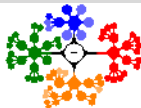
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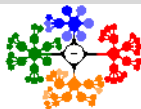
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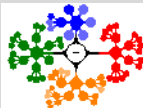


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- **Asynchronous event handling:** tasks which service events of indeterminate frequency and duration can be interleaved. For example, a web server can both transfer data from previous requests and manage the arrival of new requests.



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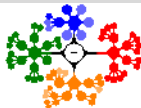


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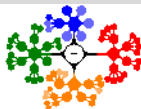


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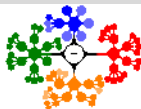


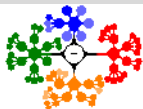
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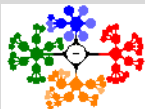




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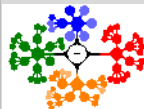
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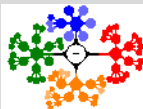
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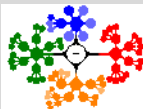
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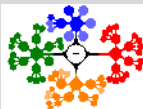




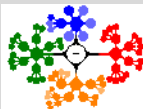
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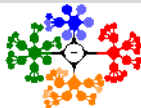
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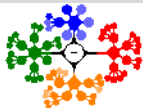
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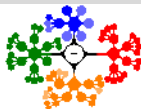
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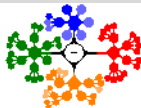
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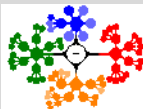
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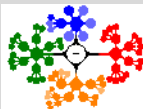
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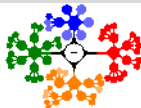
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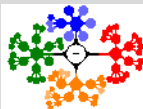
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Programming Shared Memory

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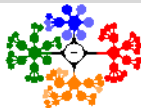
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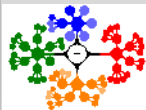
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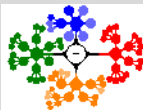
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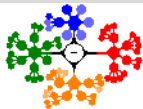
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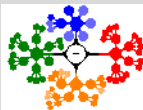
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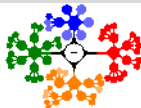


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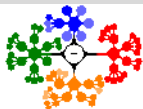
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- **Peer:** similar to the manager/worker model, but after the main thread creates other threads, it participates in the work.

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Programming Shared Memory

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Threads Model

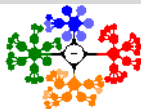
Why Threads?

Thread Basics: Creation
and Termination

Thread Creation

Thread Termination

Thread Basics: Creation and Termination I



- The *Pthreads* API subroutines can be informally grouped into four major groups:
 - 1 **Thread management:** Routines that work directly on threads - creating, detaching, joining, set/query thread attributes (joinable, scheduling etc.), etc.
 - 2 **Mutexes:** Routines that deal with synchronization. Mutex functions provide for creating, destroying, locking and unlocking mutexes, setting or modifying attributes associated with mutexes.

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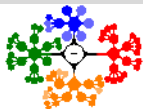
Thread Basics: Creation
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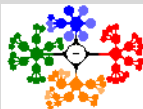
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 - 4 **Synchronization:** Routines that manage read/write locks and barriers.

Thread Basics: Creation and Termination II

- **Creating Threads:**



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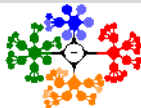
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Thread Basics: Creation and Termination II

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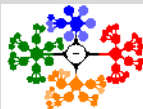
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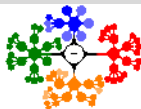


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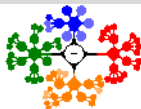


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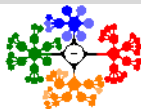
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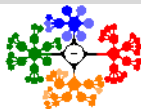
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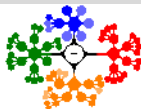
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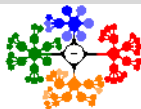
Thread Basics: Creation and Termination III

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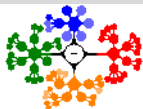
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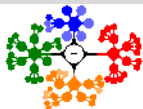
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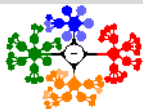
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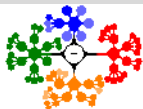


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Thread Basics: Creation and Termination III



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- This argument is typically used to pass the workspace and other thread-specific data to a thread.

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Thread Basics: Creation and Termination IV

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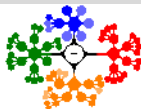
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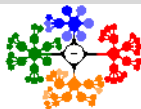
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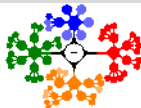
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- This is a very common class of errors caused by **race conditions** for data access that shows itself in some execution instances, but not in others.
- Robust programs should not depend upon threads executing in a specific order.



Thread Basics: Creation and Termination V

- **Terminating Threads.**



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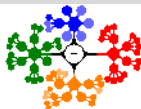
Thread Basics: Creation
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Thread Basics: Creation and Termination V

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- There are several ways in which a *Pthread* may be terminated:



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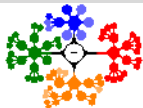
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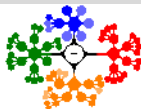
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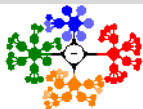
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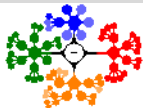
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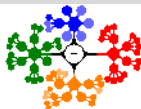
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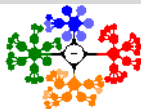
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 - If *main* finishes after the threads and exits, the threads will be automatically terminated.
- **Cleanup:** the **pthread_exit()** routine does not close files; any files opened inside the thread will remain open after the thread is terminated.





- **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);
}
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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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```
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);
}
```

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