Thread and Synchronization

pthread Programming
(Module 19)

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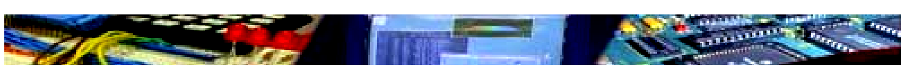
Summer 2014



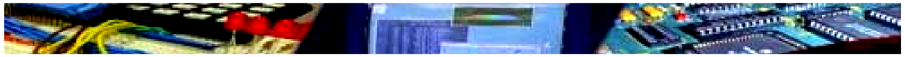
Pthread APIs

- *pthread_create( )*
- *pthread_detach( )*
- *pthread_equal( )*
- *pthread_exit( )*
- *pthread_join( )*
- *pthread_self( )*
- *pthread_cancel()*
- **pthread_mutex_init()**
- **pthread_mutex_destroy()**
- **pthread_mutex_lock()**
- **pthread_mutex_trylock()**
- **pthread_mutex_unlock()**
- *sched_yield( )*

```
int pthread_create(
        pthread_t *tid,                   // Thread ID returned by the system
        const pthread_attr_t  *attr,      // optional creation attributes
        void *(*start)(void *),           // start function of the new thread
        void *arg                         // Arguments to start function
   );
```

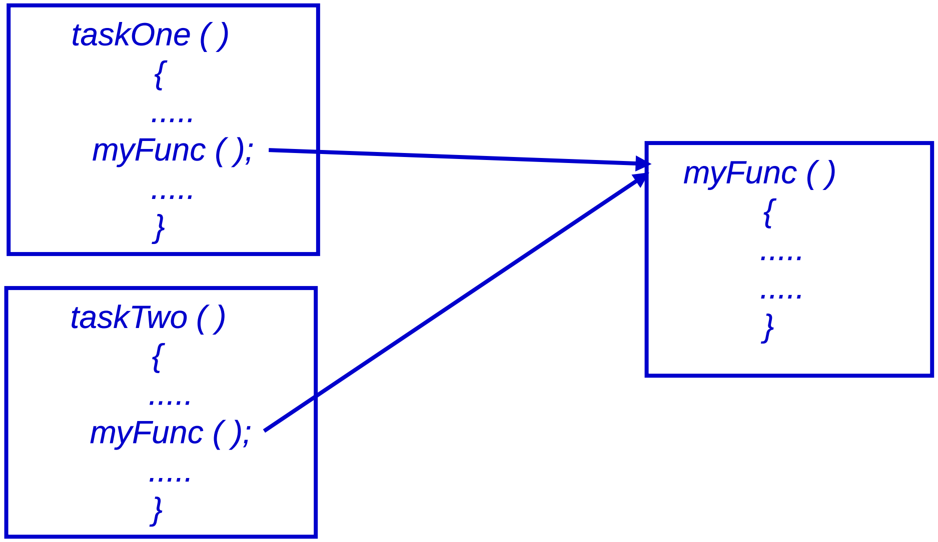
Example of Thread Creation

```
#include <pthread.h>
#include <stdio.h>

void *thread_routine(void* arg){
        printf("Inside newly created thread \n");
}

void main(){
        pthread_t    thread_id;                    // threat handle
        void   *thread_result;

        pthread_create( &thread_id, NULL, thread_routine, NULL );

        printf("Inside main thread \n");
        pthread_join( thread_id,  &thread_result );
}
```

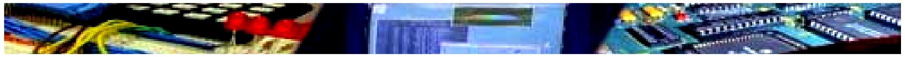


Shared Code and Reentrancy

- **A single copy of code is invoked by different concurrent tasks must reentrant**
  - pure code
  - variables in task stack guarded global and static variables (with semaphore or taskLock)
  - variables in task content

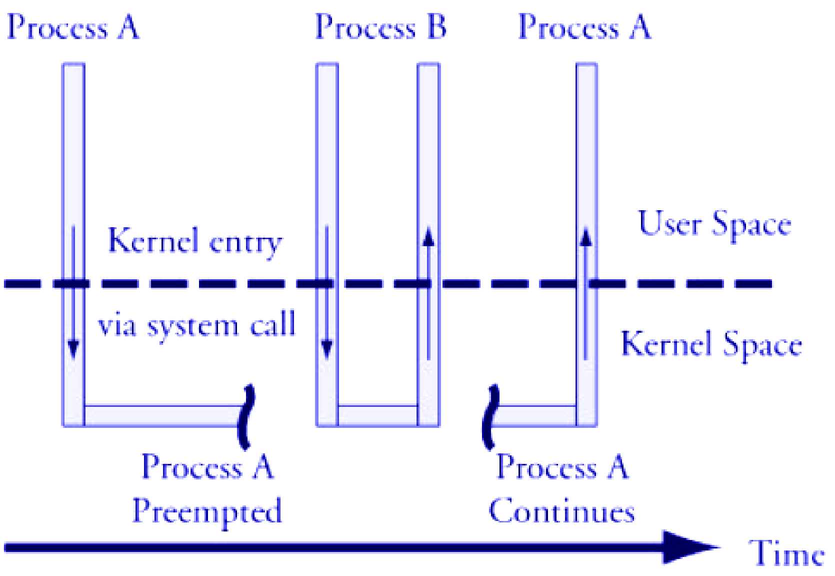


- **Can a driver manage multiple devices?**
- **Can multiple threads running in kernel space at the same time?**



Synchronization in Linux Kernel

- **The old Linux system ran all system services to completion or till they blocked (waiting for IO).**
  - When it was expanded to SMP, a lock was put on the kernel code to prevent more than one CPU at a time in the kernel.
- **Kernel preemption**
  - a process running in kernel mode can be replaced by another process while in the middle of a kernel function
  - In the example, process B may be waked up by a timer and with higher priority
  - Why – dispatch latency



(Christopher Hallinan,"Embedded Linux Primer: A Practical Real-World Approach".)

When Synchronization in Necessary

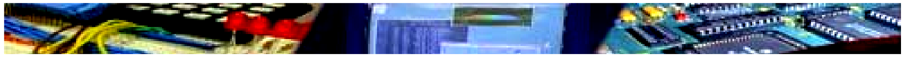
- **A race condition can occur when the outcome of a computation depends on how two or more interleaved kernel control paths are nested**
- **To identify and protect the critical regions in exception handlers, interrupt handlers, deferrable functions, and kernel threads**
  - On single CPU, critical region can be implemented by disabling interrupts while accessing shared data.
  - If data is shared among threads, critical region can be done by disabling preemption.
  - If the same data is shared only by the service routines of system calls, critical region can be implemented by disabling kernel preemption (interrupt is allowed) while accessing shared data
- **How about multiprocessor systems (SMP)**
  - Different synchronization techniques are necessary for data to be accessed by multiple CPUs

Thread Synchronization -- Mutex

- **Mutual exclusion (mutex):**
  - guard against multiple threads modifying the same shared data simultaneously
  - provides locking/unlocking critical code sections where shared data is modified
- **Basic Mutex Functions:**

```
int pthread_mutex_init(pthread_mutex_t   *mutex, const
                                 pthread_mutexattr_t *mutexattr);
int pthread_mutex_lock(pthread_mutex_t   *mutex);
int pthread_mutex_unlock(pthread_mutex_t   *mutex);
int pthread_mutex_destroy(pthread_mutex_t   *mutex);
```

  - data type named pthread_mutex_t is designated for mutexes
  - the attribute of a mutex can be controlled by using the pthread_mutex_init() function



Example: Mutex

```
#include <pthread.h>
pthread_mutex_t    my_mutex;                // should be of global scope
...
int main()
{
        int tmp;
        …
        tmp = pthread_mutex_init( &my_mutex, NULL );     // initialize the
        mutex
        ...
        // create threads
        ...
        pthread_mutex_lock( &my_mutex );
                    do_something_private();
        pthread_mutex_unlock( &my_mutex );
        ...
        return 0;
}
```