Preview

- Inter-process Communication
- The sigsuspend() System Call
- The abort() System Call
- Concept of Thread.
- Other View of Thread
- Summary of Thread
- Benefits with Multiple Threads
- What are Pthreads?
- The Thread ID
- The Thread Creation and Termination

Interprocess Communication

- Three issues in interprocess communication
  1. How one process can pass information to another
  2. How to make sure two or more processes do not get into the **critical region (critical section)-Mutual Exclusion**
  3. Proper sequencing when dependencies are present (ex. Producer-Consumer: a producer produce outputs and save into a buffer, a consumer consume outputs from the buffer)

Interprocess Communication

- **Critical section** (critical region) – The part of program where the shared memory is accessed.
- If we could arrange matters such that no two processes were ever in their critical regions at the same time (mutual exclusion), we can avoid races condition.

Interprocess Communication

- We can change the signal mask for a process to block and unblock selected signal by sequence of system calls.
- It might be possible to use this technique to protect critical region (critical section).

Interprocess Communication

```
sigset_t newmask, oldmask;
/* exclude all signal in signal set*/
sigemptyset(&newmask);
/* set SIGINT */
sigaddset(&newmask, SIGINT);
/*block SIGINT and save current signal mask */
if (sigprocmask(SIG_BLOCK, &newmask, &oldmask)<0)
   error_sys("SIG_BLOCK ERROR");

/**** Critical Region of code ********/

/*reset signal mask, which unblocks SIGINT */
if (sigprocmask(SIG_SETMASK,  &oldmask, NULL)<0)
   error_sys("SIG_SETMASK ERROR");
pause();
```


Interprocess Communication

- If a signal is sent to the process while it is blocked, the signal delivery will be differed until the signal is unblocked.
- If a signal does occur between the unblocking and the pause, the signal can be lost.
- The result is pause forever!!!
- The **sigsuspend**() system guarantee both reset and put a process to sleep.

The sigsuspend() System Call

```
#include <signal.h>
int sigsuspend(const sigset_t *sigmask);
```

- The **sigsuspend()** function replaces the current signal mask of a process with the signal set given by **sigmask* and then suspends processing of the calling process.
- The process does not resume running until a signal is delivered

The sigsuspend() System Call

```
sigset_t newmask, oldmask;
/* exclude all signal set */
sigemptyset(&newmask);
/* include SIGINT signal */
sigaddset(&newmask, SIGINT);
/*block SIGINT and save current signal mask */
if (sigprocmask(SIG_BLOCK, &newmask, &oldmask)<0)
   error_sys("SIG_BLOCK ERROR");

      /**** Critical Region of code ********/

/*reset signal mask, which unblocks SIGINT */
if (sigsuspend(&oldmask)<0)
   error_sys("SIG_SUSPEND ERROR");
```



```
/*sigsuspend.c */

#include <signal.h>
#include <unistd.h>
#include <stdio.h>
#include <time.h>
void catcher( int sig ) {
    printf( "inside catcher() function\n" );
}

void timestamp( char *str ) {

    time_t t;

    time( &t );
    printf( "%s the time is %s\n", str, ctime(&t) );
}

int main( int argc, char *argv[] )
{
    struct sigaction sigact; /* for sigaction call */
    sigset_t block_set;

    sigfillset( &block_set ); /*set all signals  are included */
    sigdelset( &block_set, SIGALRM ); /* exclude SIGALRM  from  signal set*/
    sigact.sa_handler = catcher;      /* set signal hadler*/
    sigaction( SIGALRM, &sigact, NULL ); /* set sigaction for SIGALRM signal */
    timestamp( "before sigsuspend()" );
    alarm( 5 );
    sigsuspend( &block_set ); /* replaces the current signal mask  with block_set */
    timestamp( "after sigsuspend()" );

    return( 0 );
}
```


The abort() System Call

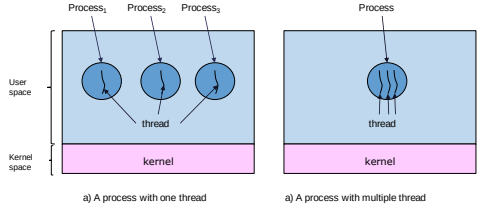
- The abort() system call cause abnormal program termination.
- The abort() system call send SIGABRT signal to caller process

```
#include <stdlib.h>
void abort(void);
```


Concept of Threads

- In a traditional OS, each process has an address space and a single thread of control.
- But in modern software, there are multiple threads of control in the same addresses space.
- Each threads inside a process need its independent spaces for running but sharing the same address space of program.

Concepts of Threads



a) A process with one thread a) A process with multiple thread

Concept of Threads

Threads

- Threads are processes in a process!!! – multiple execution in the same process environment.
- It is made up with a thread ID, a program counter, a register set, and a stack.
- Different threads are not quite as independent as different processes since they share same address space
- It shares with other threads belonging to the same process its code section, data section and other operating system resources such as files and signals.

Concept of Threads

- **Multiple process running on a computer** –Process are share physical memory, disks, printers and other resources
- **Multiple threads running on a process** – the threads are share an address space, open files, and other recourses
- With thread – the ability for multiple threads of execution to share a set of resources so they can work together closely to perform some task.

Concepts of Threads

- The CPU switches rapidly back and forth among the threads in the single CPU system (Same idea as multiprogramming)
- No protection between threads – using same address space (share the global variables)
- A thread can be in any one of several states: running, blocked, ready

Concepts of Threads

Per process items	Per thread items
Address space	Program counter
Global variables	Registers
Open files	Stack
Child processes	State
Pending alarms	
Signals and signal handlers	
Accounting information	

Concept of Threads

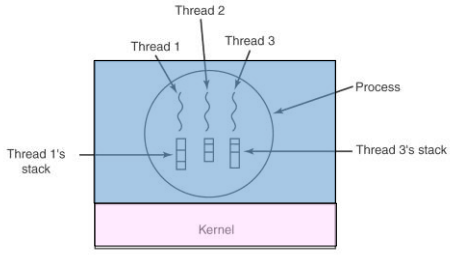
- Since each thread usually call different functions from the same address space (each thread executing different part of program), each thread need its own stack.
- A multithread software start with single thread.
- The thread has ability to create new threads by calling a library procedure (i.e. thread_create)
- When a thread has finish its work, it can exit by calling a library procedure (i.e. thread_exit)

Concept of Threads

- pthread functions for POSIX

Thread call	Description
Pthread_create	Create a new thread
Pthread_exit	Terminate the calling thread
Pthread_join	Wait for a specific thread to exit
Pthread_yield	Release the CPU to let another thread run
Pthread_attr_init	Create and initialize a thread's attribute structure
Pthread_attr_destroy	Remove a thread's attribute structure

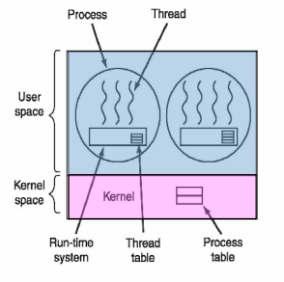
Concepts of Threads



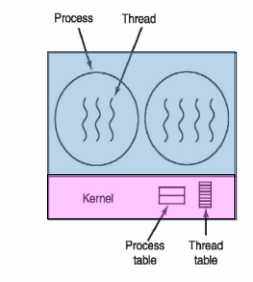
Threads Implementation

- Implementing thread in user space
  - Threads are handled by the run-time system
  - OS does not know the existence of threads
- Implementing thread in the kernel
  - Thread are handled by OS

Implementing Threads in User's space



Implementing Threads in Kernel's Space



Other View of Thread

1. A thread is defined as **an independent stream of instructions** that can be scheduled to run by the operating system.
2. **A function that runs independently** from its main program: can be scheduled by Operating System.

Motivation of Threads

Ex) A web browser

1. A thread for displaying images or text
2. A thread for retrieving data from network

Ex) Word processor

1. A thread for displaying graphics
2. A thread for reading input from keyboard
3. A thread for performing spelling and grammar checking in the background

Summary of Thread

- Exists within a process and uses the process resources
- Has its own independent flow of control as long as its parent process exists and the OS supports it
- Duplicates only the essential resources it needs to be independently schedulable
- Share the process resources with other threads that act equally independently
- Dies if the parent process dies
- Is "lightweight" because most of the overhead has already been accomplished through the creation of its process

Benefits with Multiple Threads.

- With multiple thread, we can design a program to do more than one thing at a time within a single process, with each thread handling a separate task.
- We can simplify code that deal with asynchronous events by assigning a separate thread to handle each event type.
- In multi processor system, it is easy to apply parallel processing with multiple threads. Each thread can working with a processor.

What are Pthreads?

- Hardware vendors had implemented their own proprietary versions of threads.
- For a requirement of standardized programming interface, this interface has been specified by the IEEE POSIX 1003.1c standard (1995) (POSIX thread).
- Pthreads are defined as a set of C language programming types and procedure calls, implemented with a header file <pthread.h>

The Thread ID

- A Process ID (**pid_t**) for a process is unique in the system.
- But a thread ID (**pthread_t**) has significance only within the context of the process where it belongs.
- Even though unsigned long (Linux), unsigned integer (Solaries 9) is used represent a pthread_t, a function **ptread_equal**() must be used to compare thread ID.

The Thread ID

```
#include <phread.h>

/*returns non-zero if equal, return 0 otherwise */
int pthread_equal(pthread_t t1, pthread_t t2);
```

```
#include <phread.h>
/*returns thread ID of the calling thread */
pthread_t prhread_self(void);
```


The thread Creation

- Initially, your main() program comprises a single, default thread.
- All other threads must be explicitly created by the programmer
- **pthread_create()** function creates a new thread and makes it executable. This routine can be called any number of times from anywhere within your code.
- Once created, threads are peers, and may create other threads. **There is no implied hierarchy or dependency between threads**

The thread Creation

```
#include <pthread.h>
int pthread_create (pthread_t *thread,
                    const pthread_attr_t *att,
                    void *(*start_routine)(void*), void *arg);
```

- att point to structure of pthread atribute. If att is NULL, a default attribute will be used
- start_routing point to address of a void function with no parameter or
- We can save parameters to typeless pointer arg and be able to pass to the function.
- If successful, return 0; otherwise return an error number
  - [EAGAIN]: The system lacked the necessary resources to create another thread,
  - [EPERM]: The caller does not have appropriate permission to set the required scheduling parameters or scheduling policy.
  - [EINVAL]The attributes specified by *attr* are invalid

The thread Creation

```
struct  pthread_attr_t{
{
    int         flags
    int         stacksize
    int         contentionscope
    int         inheritsched
    int         detachstate
    int         sched
    struct sched_param        param
    struct timespec starttime deadline       period
};
```


The thread Creation

- When multiple threads are created, there is **no guarantee which runs first**. It is depends on the thread scheduler.


```
/*********************************************
  CreatTh.c: Demonstrate creation of threads
*********************************************/
#include <stdio.h>
#include <stdlib.h>
#include <pthread.h>
#define NUM_THREADS 5

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

int main(int argc, char *argv[])
{
   pthread_t threads[NUM_THREADS];
   int rc, t;
   for(t=0;t<NUM_THREADS;t++)
   {
      printf("In main: creating thread %d\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);
   exit (0);
}
```


The thread Termination

- If any thread within a process call exit or _exit system call, then the entire process terminate.
- A single thread inside a process can terminate three ways.
  - The thread can simply return from the start routine
  - The thread can be cancelled by another thread with **pthread_cancel**() in the same process.
  - The thread can call phread_exit

The thread Termination

```
#include <pthread>
void pthread_exit(void *rval_ptr);
```

- The rval_ptr: typeless pointer. This pointer is available to other threads in the process by calling the pthread_join() system call.