

# Threads

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# Threads

# What is a Threads

我们知道可以通过多个进程来执行多任务，但是考虑到进程的资源占用等问题，本章讲解线程来实现多任务操作。  
线程是一个程序的多个不同的执行部分，它们共享全局变量。

# 线程和进程

- ① 进程是操作系统进行资源（包括 cpu、内存、磁盘 IO 等）分配的最小单位
- ② 线程是 cpu 调度的基本单位
- ③ 我们打开的微信，浏览器都是一个进程。进程可能有多个子任务，比如微信要接受消息，发送消息，这些子任务就是线程。资源分配给进程，线程共享进程资源。
- ④ 线程的调度比进程的调度所需要的系统开销要小得多。

# How to create threads

# 线程相关的函数 I

## 函数原型

```
#include <pthread.h>

int pthread_create(pthread_t *thread, pthread_attr_t *attr,
    void *(*start_routine)(void *), void *arg);
```

- ❶ 第一个参数是事先声明的一个 pthread 类型的指针，新创建的线程通过这个指针来引用。
- ❷ 第二个参数用来设置线程的属性，一般情况下可以设置为 NULL。
- ❸ 第三个参数是本线程要执行的具体方法（函数）的指针。
- ❹ 最后一个参数是本线程执行第三个参数指定的方法时，需要使用的参数。
- ❺ 如果创建线程成功会返回 0 。



# 线程相关的函数 II

## 函数原型

```
#include <pthread.h>
void pthread_exit(void *retval);
int pthread_join(pthread_t th, void **thread_return);
```

- ❶ pthread\_exit 会结束调用它的线程。
- ❷ pthread\_join 是主程序用来等待子线程结束的方法，和进程里的 wait 类似。
  - ❶ 第一个参数用来指定是哪个线程。
  - ❷ 第二个参数用来存储线程的返回值。
  - ❸ 如果成功会返回 0 。

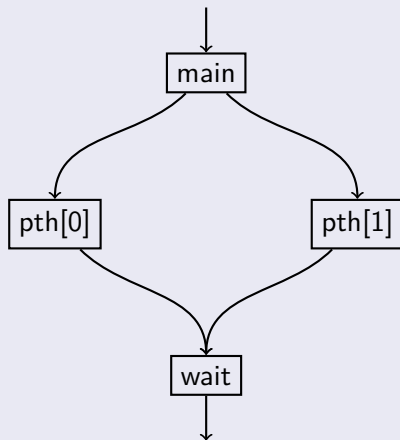
# 多线程例子

```
void *fmt(void * g);
int main(){
    pthread_t  pth[2]; void * rz;
    char  ch='a'; char  chA='A';
    int ra=pthread_create(&pth[0],NULL,fmt,&ch);
    int rA=pthread_create(&pth[1],NULL,fmt,&chA);
    pthread_join(pth[0],&rz);
    pthread_join(pth[1],&rz);
    printf("two threads has finished.\n");
}

void *fmt(void * arg){
    char c=*(char *)arg; int i=0;
    for(char a=c;i<3;a++,i++){
        printf("%c\n",a); sleep(1);}
    return NULL;
    //pthread_exit("a thread finished.\n");}
```

# 执行过程

## 执行示意图



Question: 如果没有 wait 会如何执行？

# Synchronization

# 为什么需要线程同步

上一个多线程的例子是两个线程各自使用自己的参数去执行一段代码。但是如果**两个线程**去操作**一个共同资源**的时候采取上一个多线程类似的代码就会出现**问题**。

这个时候就需要线程同步，以免多个线程去争抢同一个资源，在这里线程同步的概念就是要让线程有个先来后到进行排队，同一个资源同一时刻只能由一个线程进行操作。

线程同步有多种方法，此处介绍两种基本的方法：

- ① semaphore  
act as gatekeepers around a piece of code
- ② mutex  
act as a mutual exclusion (hence the name mutex) device to protect sections of code

这两种方式都可实现类似的功能，但是也存在哪一种方法更适用的问题。请回答以下情况中，哪种机制更适合：

- ① 修改一个共享变量
- ② 总共有 5 个资源，比如客服电话线路，一个线程想使用其中一个

- ① **Dijkstra**, a Dutch computer scientist, first conceived the concept of semaphores.
- ② A semaphore is **a special type of variable** that can be incremented or decremented, but **crucial access** to the variable is guaranteed to **be atomic**, even in a multithreaded program.

*This means that if two (or more) threads in a program attempt to change the value of a semaphore, **the system guarantees that all the operations will in fact take place in sequence**. With normal variables the result of conflicting operations from different threads within the same program is undefined.*

# semaphore functions I

The semaphore functions do not start with *pthread\_*, as most thread-specific functions do, but with *sem\_*.

A semaphore is created with the *sem\_init* function:

## create a semaphore

```
#include <semaphore.h>
int sem_init(sem_t *sem, int pshared, unsigned int value);
```

- 1 initializes a semaphore object pointed to by *sem*
- 2 The *pshared* parameter controls the type of semaphore. If 0, the semaphore is local to the current process. Otherwise, the semaphore may be shared between processes.
- 3 the initial integer *value* of the semaphore
- 4 returns 0 on success; on error, -1 is returned, and *errno* is set to indicate the error.



# semaphore functions II

A pair of functions controls the value of the semaphore and is declared as follows:

## control the value of a semaphore

```
#include <semaphore.h>
int sem_wait(sem_t * sem);
int sem_post(sem_t * sem);
```

- 1 The `sem_post` function atomically increases the value of the semaphore by 1.
- 2 The `sem_wait` function atomically decreases the value of the semaphore by 1, but always waits until the semaphore has a nonzero count first.
- 3 return 0 on success; on error, the value of the semaphore is left unchanged, -1 is returned, and `errno` is set to indicate the error.

# semaphore functions III

This function tidies up the semaphore when you have finished with it. It is declared as follows:

## destroy a semaphore

```
#include <semaphore.h>
int sem_destroy(sem_t * sem);
```

- 1 this function takes a pointer to a semaphore and tidies up any resources that it may have. If you attempt to destroy a semaphore for which some thread is waiting, you will get an error.
- 2 returns 0 on success; on error, -1 is returned, and `errno` is set to indicate the error.

# 生产者消费者 (threadPC.c) 示例 I

## 生产者消费者函数

```
void * consumer(void * args){
    while(1){
        sem_wait(&sem);
        printf("consumer: the  buf is:%s.\n",buf);
    }
    pthread_exit(NULL);
}

void * productor(void * args){
    while(1){
        printf("productor: input something:\n");
        fgets(buf,100,stdin);
        sem_post(&sem);
    }
    pthread_exit(NULL);
}
```

# 生产者消费者示例 II

## 主程序

```
sem_t sem; char * buf;
int main(){
    pthread_t thC;
    pthread_t thP;
    void * th_rz;
    buf = (char *) malloc(100);
    res = sem_init(&sem,0,0);
    res=pthread_create(&thC,NULL,consumer,NULL);
    res=pthread_create(&thP,NULL,productor,NULL);
    pthread_join(thC,&th_rz);
    pthread_join(thP,&th_rz);
    sem_destroy(&sem);
    exit(EXIT_SUCCESS);
}
```

## 不理想和理想的生产者消费者程序

- ① 我们的生产者会一直提示用户输入数据（写入 buf），不管消费者是否取走了 buf 里的数据。
- ② 理想的生产者应该先查看 buf 里的数据是否被取走，然后再生产。（作业）

The other way of synchronizing access in multithreaded programs is with mutexes (short for mutual exclusions), which act by allowing the programmer to “lock” an object so that only one thread can access it. To control access to a critical section of code you **lock** a mutex before entering the code section and then **unlock** it when you have finished.

```
#include <pthread.h>
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);
```

*mutexattr* 参数是用来控制 mutex 的属性的，此处先设置为 NULL，有兴趣的同学可以自行学习。这些函数如果操作成功会返回 0。

# 多窗口售票 (threadMutex.c) 程序 I

## 售票函数

```
void * sellTicket(void *args){
    int i= *(int *)args;
    while(1){
        pthread_mutex_lock(&mut);
        if(ticket<1){
            pthread_mutex_unlock(&mut);
            break;
        }
        printf("thread %d is selling ticket %d.\n",i,ticket);
        ticket--;
        pthread_mutex_unlock(&mut);
        sleep(1);
    }
    pthread_exit(NULL);
}
```



# 多窗口售票 (threadMutex.c) 程序 II

## 主程序

```
int ticket=10;
int main(){
    int res; pthread_t th[3]; void * th_rz;
    res = pthread_mutex_init(&mut,NULL);
    int arg=0;
    res=pthread_create(&th[0],NULL,sellTicket,&arg);
    int arg1=1;
    res=pthread_create(&th[1],NULL,sellTicket,&arg1);
    int arg2=2;
    res=pthread_create(&th[2],NULL,sellTicket,&arg2);
    pthread_join(th[0],&th_rz);
    pthread_join(th[1],&th_rz); pthread_join(th[2],&th_rz);
    pthread_mutex_destroy(&mut);
    exit(EXIT_SUCCESS);
}
```

# 多窗口售票 (threadMutex.c) 程序 III

## 运行结果

```
$ gcc -o threadMutex threadMutex.c -lpthread
$ ./threadMutex
thread 0 is selling ticket 10.
thread 1 is selling ticket 9.
thread 2 is selling ticket 8.
thread 0 is selling ticket 7.
thread 1 is selling ticket 6.
thread 2 is selling ticket 5.
thread 2 is selling ticket 4.
thread 1 is selling ticket 3.
thread 0 is selling ticket 2.
thread 2 is selling ticket 1.
```

编写一个程序，要求如下：

- ① 在一个进程中创建两个线程
- ② 在父进程中，每 1 秒输出一个大写字母：A~Z
- ③ 在子进程中，每 1 秒输出一个小写字母：a~z

# The End

# Appendix

# 本课程相关资源下载

## ① ppt

<https://github.com/gmsft/ppt/tree/master/linux>

## ② 实验指导书

<https://github.com/gmsft/ppt/tree/master/book/linux>

# about man page

The manual is generally split into eight numbered sections, organized as follows (on Research Unix, BSD, macOS and Linux):

section	description
1	General commands
2	System calls
3	Library function(C standard library)
4	Special files(devices) and drivers
5	File formats and conventions
6	Games and screensavers
7	Miscellanea
8	System administration commands and daemons

Table: man page

在终端中运行 `man read` 与 `man 2 read`，观察其输出的区别。