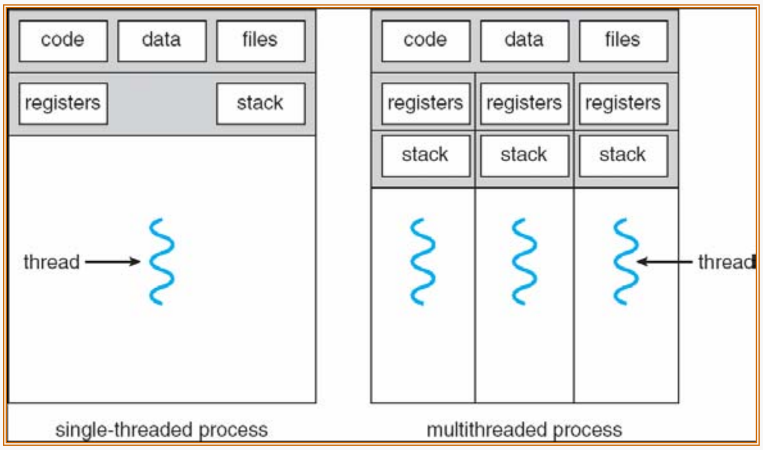
Single and Multithreaded Processes



Benefits

Responsiveness

Resource Sharing

Economy

Utilization of MP Architectures

User Threads vs Kernel Threads

Thread management done by user-level threads library

Three primary thread libraries:

- POSIX Pthreads
- Win32 threads
- Java threads

Supported by the Kernel

Examples

- Windows XP/2000
- Solaris
- Linux
- Tru64 UNIX
- Mac OS X

Multithreading Models

Many-to-One

One-to-One

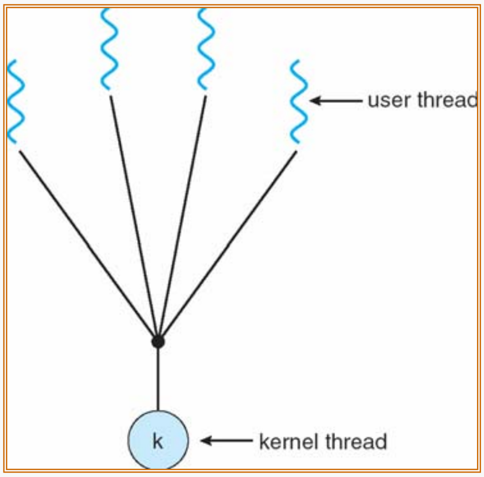
Many-to-Many

Many-to-One

Many user-level threads mapped to single kernel thread

Examples:

- Solaris Green Threads
- GNU Portable Threads

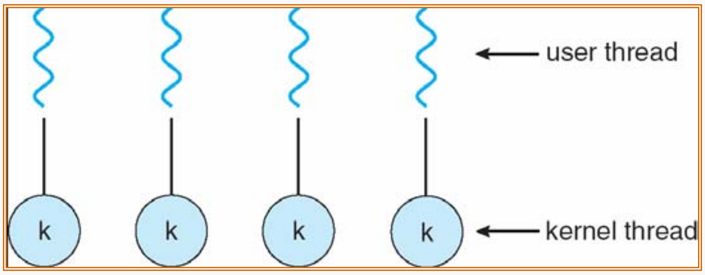


One-to-One

Each user-level thread maps to kernel thread

Examples

- Windows NT/XP/2000
- Linux
- Solaris 9 and later

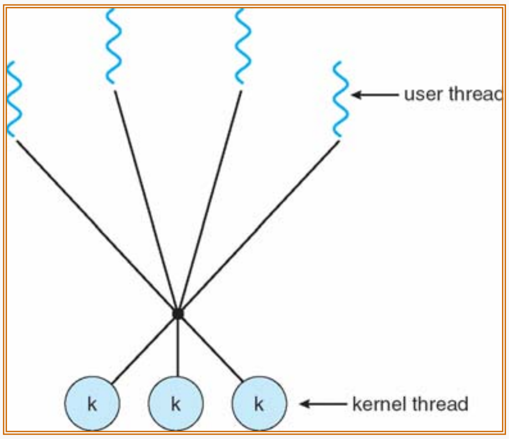


Many-to-Many Model

Allows many user level threads to be mapped to many kernel threads

Allows the operating system to create a sufficient number of kernel threads

- Solaris prior to version 9
- Windows NT/2000 with the *ThreadFiber* package



Threading Issues

Semantics of **fork()** and **exec()** system calls

Thread cancellation

Signal handling

Thread pools

Thread specific data

Scheduler activations

Semantics of fork() and exec()

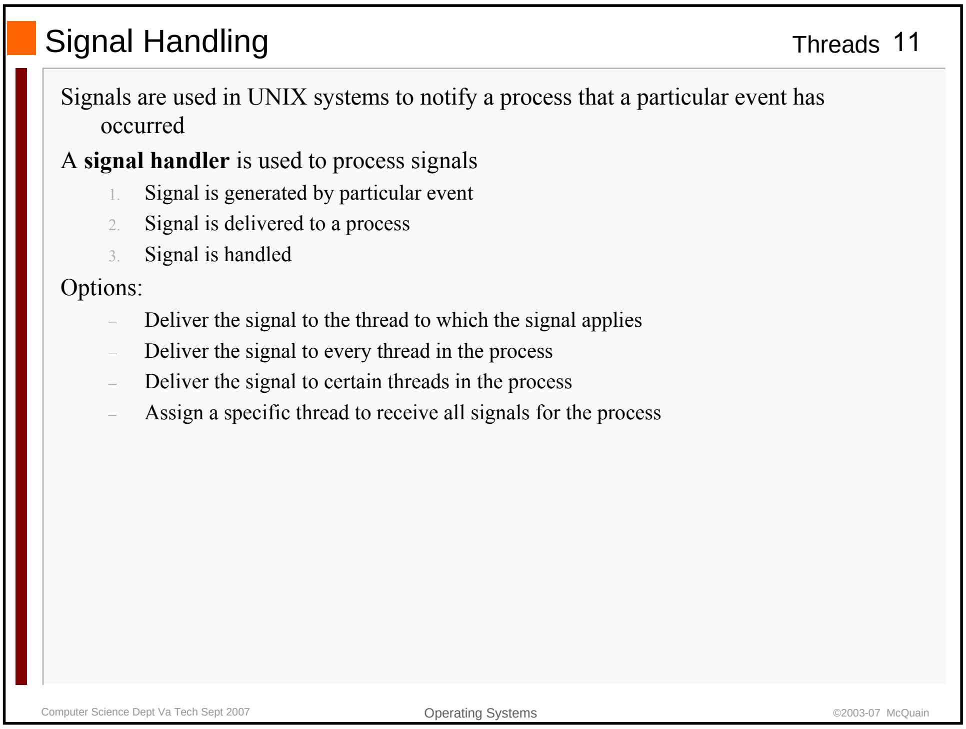
Does **fork()** duplicate only the calling thread or all threads?

Thread Cancellation

Terminating a thread before it has finished

Two general approaches:

- **Asynchronous cancellation** terminates the target thread immediately
- **Deferred cancellation** allows the target thread to periodically check if it should be cancelled



Signal Handling

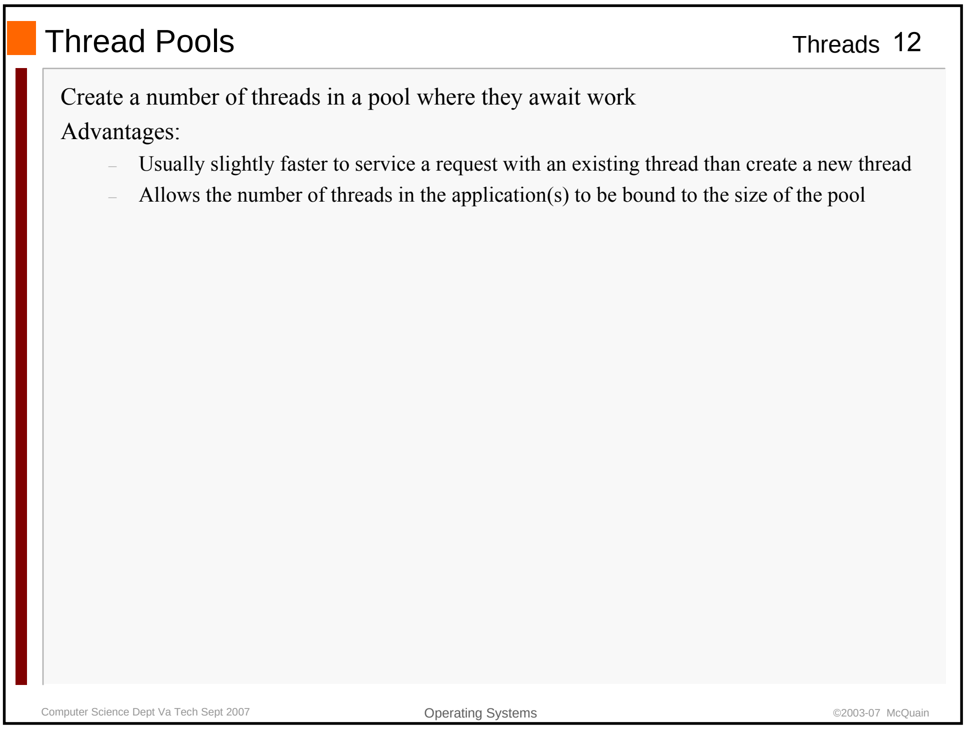
Signals are used in UNIX systems to notify a process that a particular event has occurred

A **signal handler** is used to process signals

1. Signal is generated by particular event
2. Signal is delivered to a process
3. Signal is handled

Options:

- Deliver the signal to the thread to which the signal applies
- Deliver the signal to every thread in the process
- Deliver the signal to certain threads in the process
- Assign a specific thread to receive all signals for the process



Thread Pools

Create a number of threads in a pool where they await work

Advantages:

- Usually slightly faster to service a request with an existing thread than create a new thread
- Allows the number of threads in the application(s) to be bound to the size of the pool

Thread Specific Data

- Allows each thread to have its own copy of data
- Useful when you do not have control over the thread creation process (i.e., when using a thread pool)

Scheduler Activations

- Both M:M and Two-level models require communication to maintain the appropriate number of kernel threads allocated to the application
- Scheduler activations provide **upcalls** - a communication mechanism from the kernel to the thread library
- This communication allows an application to maintain the correct number kernel threads

Pthreads

A POSIX standard (IEEE 1003.1c) API for thread creation and synchronization

API specifies behavior of the thread library, implementation is up to development of the library

Common in UNIX operating systems (Solaris, Linux, Mac OS X)

Windows XP Threads

Implements the one-to-one mapping

Each thread contains

- A thread id
- Register set
- Separate user and kernel stacks
- Private data storage area

The register set, stacks, and private storage area are known as the **context** of the threads

The primary data structures of a thread include:

- ETHREAD (executive thread block)
- KTHREAD (kernel thread block)
- TEB (thread environment block)

Linux Threads

Linux refers to them as *tasks* rather than *threads*

Thread creation is done through **clone()** system call

clone() allows a child task to share the address space of the parent task (process)

Java Threads

Java threads are managed by the JVM

Java threads may be created by:

- Extending Thread class
- Implementing the Runnable interface