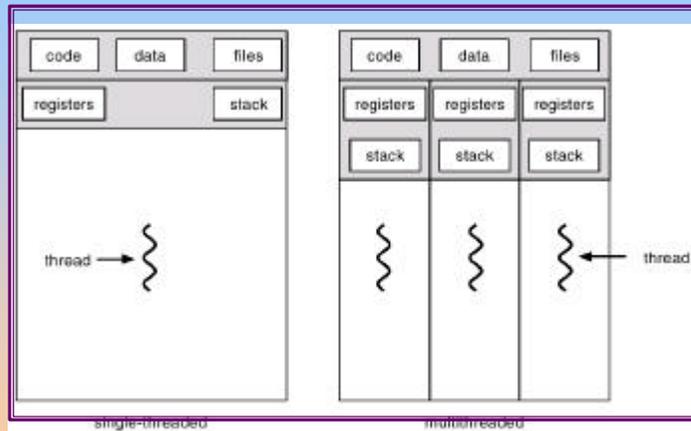


# Chapter 5: Threads

- Overview
- Multithreading Models
- Threading Issues
- Pthreads
- Solaris 2 Threads
- Windows 2000 Threads
- Linux Threads
- Java Threads

# Single and Multithreaded Processes





## Benefits



- Responsiveness
- Resource Sharing
- Economy
- Utilization of MP Architectures



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## User Threads



- Thread management done by user-level threads library
- Examples
  - POSIX *Pthreads*
  - Mach *C-threads*
  - Solaris *threads*



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## Kernel Threads



- Supported by the Kernel
- Examples
  - Windows 95/98/NT/2000
  - Solaris
  - Tru64 UNIX
  - BeOS
  - Linux



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## Multithreading Models



- Many-to-One
- One-to-One
- Many-to-Many



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## Many-to-One

- Many user-level threads mapped to single kernel thread.
- Used on systems that do not support kernel threads.

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## Many-to-One Model

The diagram illustrates the Many-to-One Model. It features a central point where four wavy lines, representing user threads, converge. These lines then connect to a single circle labeled 'k', which represents the kernel thread. An arrow points from the text 'user thread' to one of the wavy lines, and another arrow points from the text 'kernel thread' to the circle 'k'.

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## One-to-One

- Each user-level thread maps to kernel thread.
- Examples
  - Windows 95/98/NT/2000
  - OS/2

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## One-to-one Model

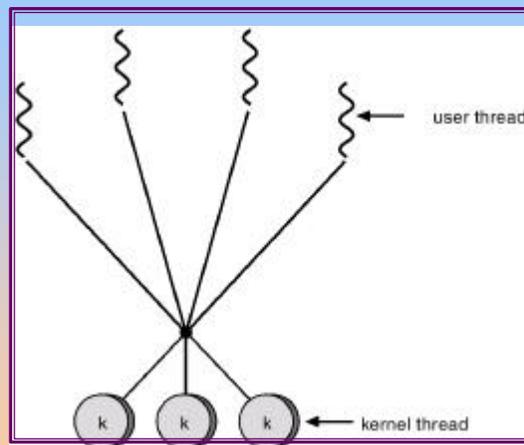
The diagram illustrates the one-to-one model of thread execution. It features a white rectangular box containing four vertical columns. Each column consists of a wavy line at the top, representing a user thread, connected by a solid vertical line to a circular node at the bottom, representing a kernel thread. The circular nodes are labeled with the letter 'k'. To the right of the box, an arrow points to the top wavy line with the label 'user thread', and another arrow points to the bottom circular node with the label 'kernel thread'.

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## 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 2
- Windows NT/2000 with the *ThreadFiber* package

## Many-to-Many Model





## Threading Issues



- Semantics of fork() and exec() system calls.
- Thread cancellation.
- Signal handling
- Thread pools
- Thread specific data



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## 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.



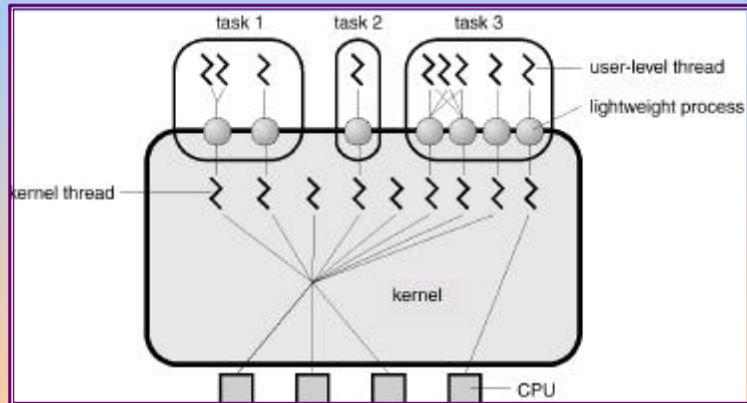
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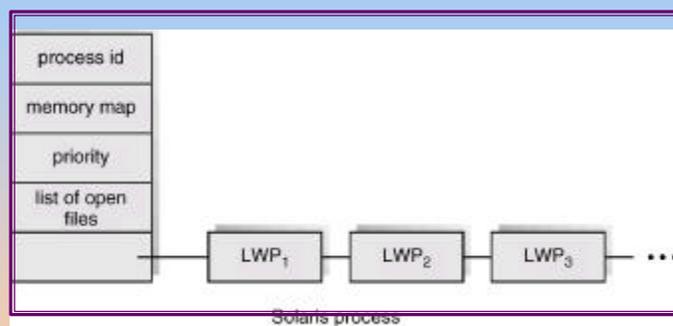
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## Solaris 2 Threads



## Solaris Process





## Windows 2000 Threads



- Implements the one-to-one mapping.
- Each thread contains
  - a thread id
  - register set
  - separate user and kernel stacks
  - private data storage area



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## 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)



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# Java Threads

- Java threads may be created by:
  - ✦ Extending Thread class
  - ✦ Implementing the Runnable interface
- Java threads are managed by the JVM.

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