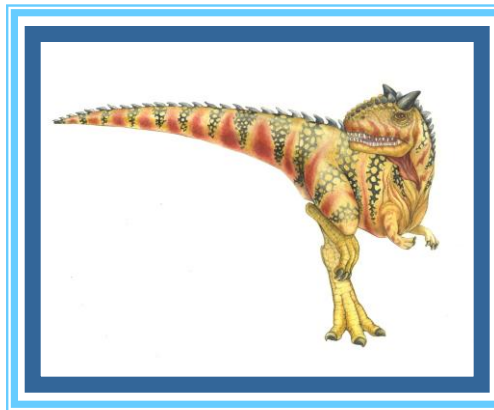


Chapter 4: Threads





Chapter 4: Threads

- Overview
- Multicore Programming
- Multithreading Models
- Thread Libraries
- Implicit Threading
- Threading Issues
- Operating System Examples





Objectives

- To introduce the notion of a thread—a fundamental unit of CPU utilization that forms the basis of multithreaded computer systems
- To discuss the APIs for the Pthreads, Windows, and Java thread libraries
- To explore several strategies that provide implicit threading
- To examine issues related to multithreaded programming
- To cover operating system support for threads in Windows and Linux





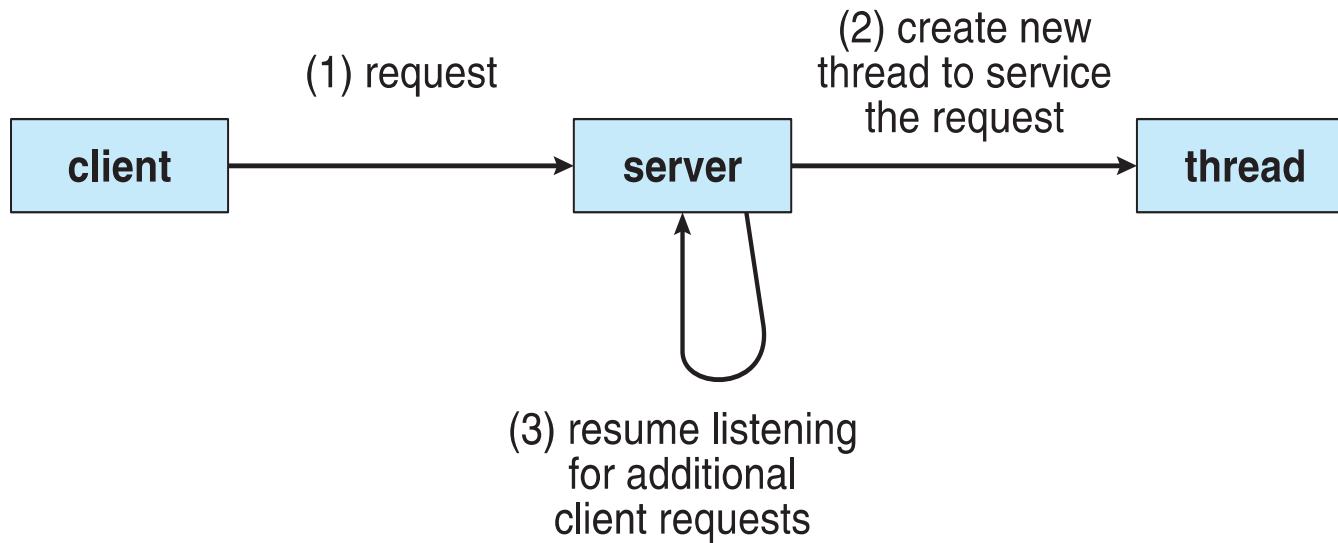
Motivation

- Most modern applications are multithreaded
- Threads run within application
- Multiple tasks with the application can be implemented by separate threads
 - Update display
 - Fetch data
 - Spell checking
 - Answer a network request
- Process creation is heavy-weight while thread creation is light-weight
- Can simplify code, increase efficiency
- Kernels are generally multithreaded





Multithreaded Server Architecture





Benefits

- ❑ **Responsiveness** – may allow continued execution if part of process is blocked, especially important for user interfaces
- ❑ **Resource Sharing** – threads share resources of process, easier than shared memory or message passing
- ❑ **Economy** – cheaper than process creation, thread switching lower overhead than context switching
- ❑ **Scalability** – process can take advantage of multiprocessor architectures





Multicore Programming

- **Multicore** or **multiprocessor** systems putting pressure on programmers, challenges include:
 - **Dividing activities**
 - **Balance**
 - **Data splitting**
 - **Data dependency**
 - **Testing and debugging**
- **Parallelism** implies a system can perform more than one task simultaneously
- **Concurrency** supports more than one task making progress
 - Single processor / core, scheduler providing concurrency





Multicore Programming (Cont.)

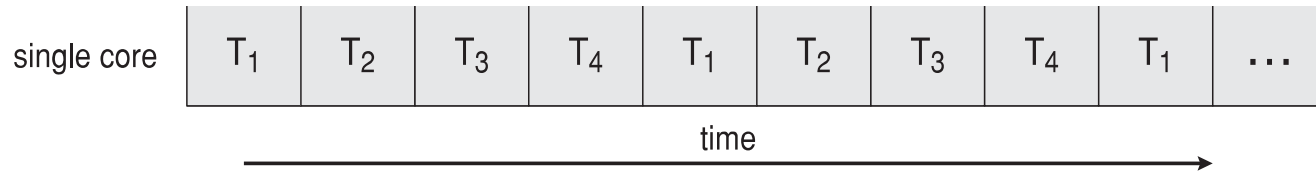
- Types of parallelism
 - **Data parallelism** – distributes subsets of the same data across multiple cores, same operation on each
 - **Task parallelism** – distributing threads across cores, each thread performing unique operation
- As # of threads grows, so does architectural support for threading
 - CPUs have cores as well as ***hardware threads***
 - Consider Oracle SPARC T4 with 8 cores, and 8 hardware threads per core



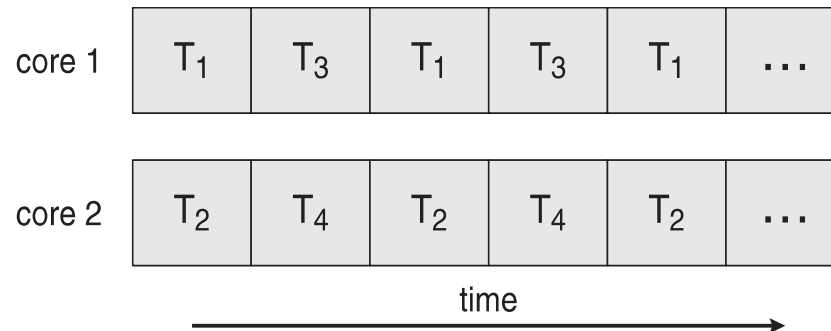


Concurrency vs. Parallelism

□ Concurrent execution on single-core system:

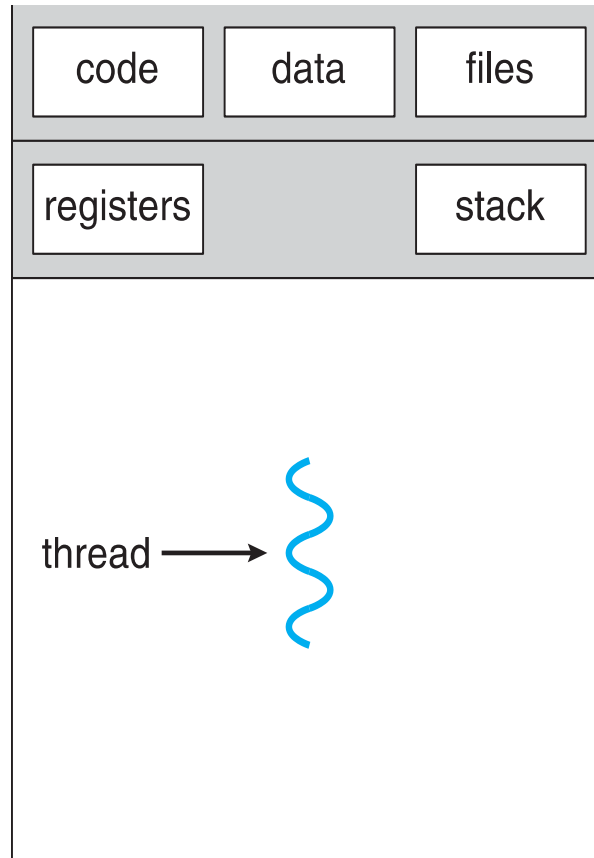


□ Parallelism on a multi-core system:

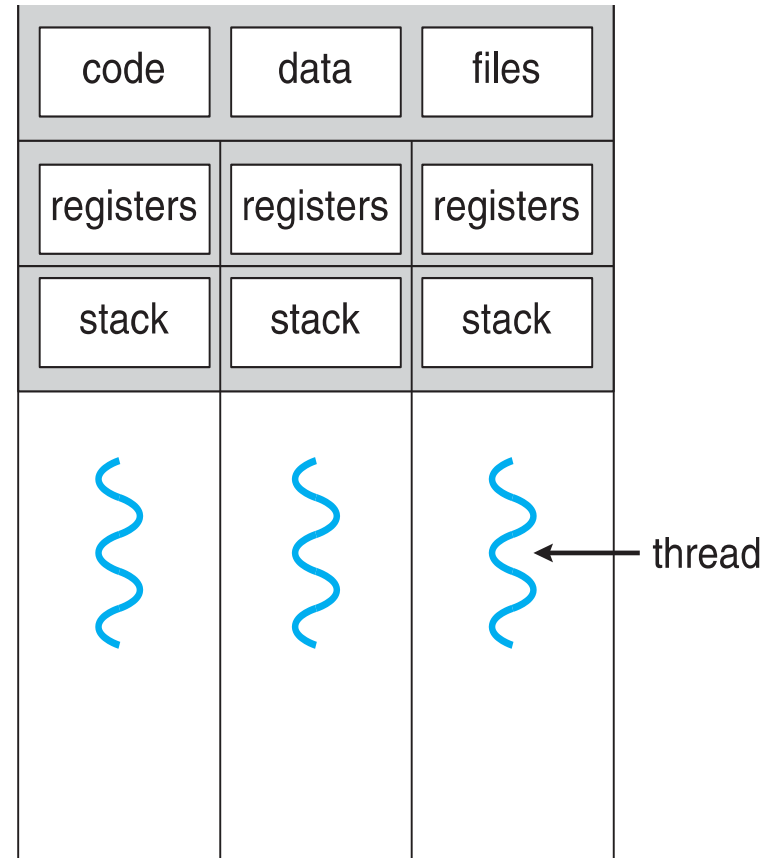




Single and Multithreaded Processes



single-threaded process



multithreaded process





Amdahl's Law

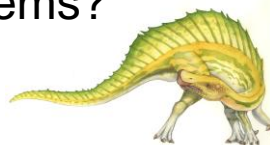
- Identifies performance gains from adding additional cores to an application that has both serial and parallel components
- S is serial portion
- N processing cores

$$speedup \leq \frac{1}{S + \frac{(1-S)}{N}}$$

- That is, if application is 75% parallel / 25% serial, moving from 1 to 2 cores results in speedup of 1.6 times
- As N approaches infinity, speedup approaches $1 / S$

Serial portion of an application has disproportionate effect on performance gained by adding additional cores

- But does the law take into account contemporary multicore systems?





User Threads and Kernel Threads

- **User threads** - management done by user-level threads library
- Three primary thread libraries:
 - POSIX **Pthreads**
 - Windows threads
 - Java threads
- **Kernel threads** - Supported by the Kernel
- Examples – virtually all general purpose operating systems, including:
 - Windows
 - Solaris
 - Linux
 - Tru64 UNIX
 - Mac OS X





Multithreading Models

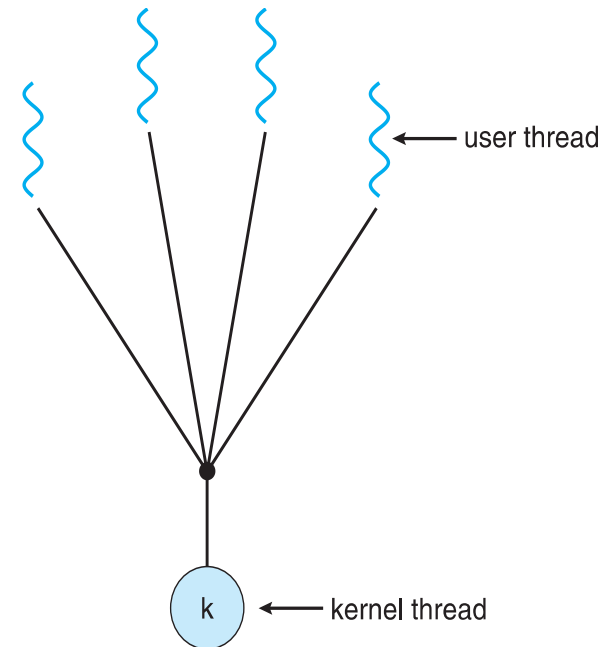
- Many-to-One
- One-to-One
- Many-to-Many





Many-to-One

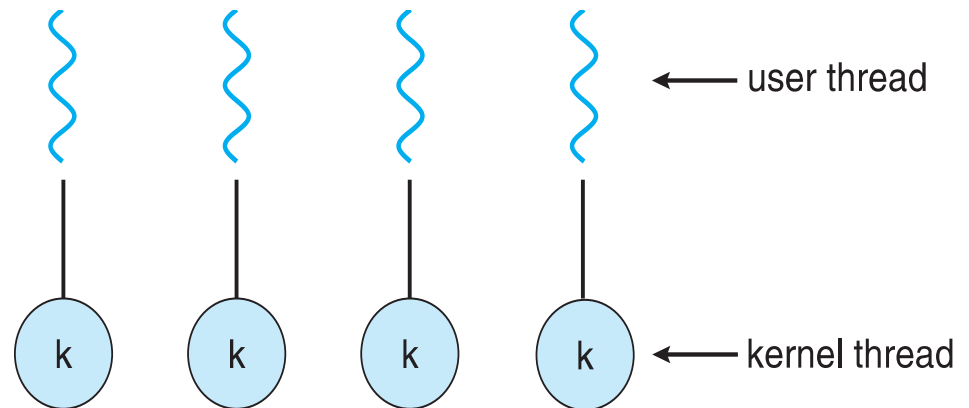
- ❑ Many user-level threads mapped to single kernel thread
- ❑ One thread blocking causes all to block
- ❑ Multiple threads may not run in parallel on multicore system because only one may be in kernel at a time
- ❑ Few systems currently use this model
- ❑ Examples:
 - ❑ **Solaris Green Threads**
 - ❑ **GNU Portable Threads**





One-to-One

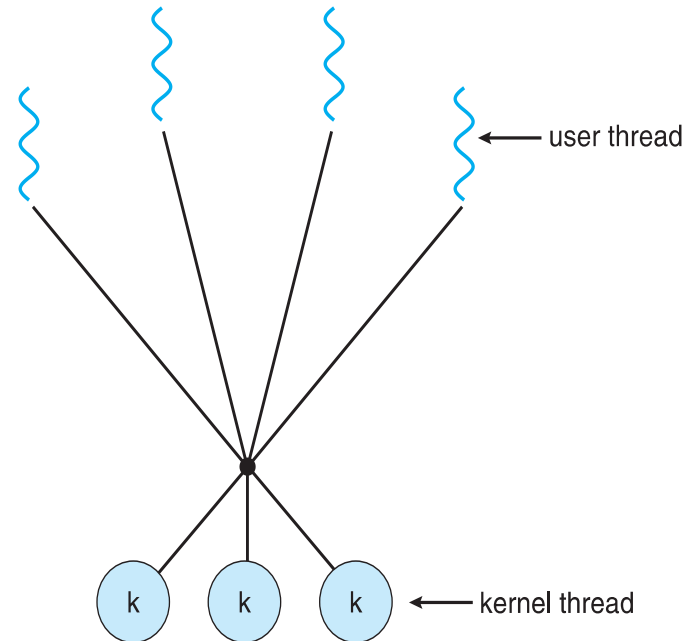
- Each user-level thread maps to kernel thread
- Creating a user-level thread creates a kernel thread
- More concurrency than many-to-one
- Number of threads per process sometimes restricted due to overhead
- Examples
 - Windows
 - Linux
 - Solaris 9 and later





Many-to-Many Model

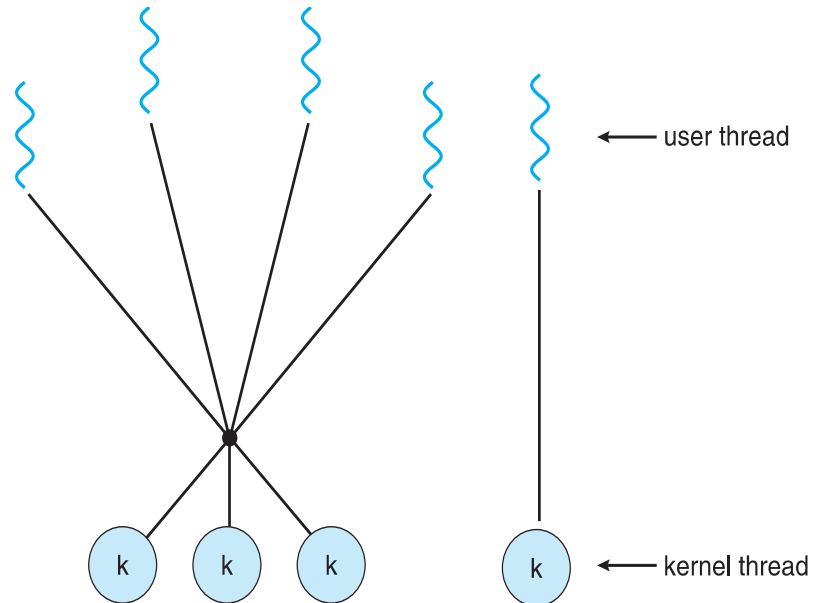
- Allows many user level threads to be mapped to many kernel threads
- Allows the operating system to create a sufficient number of kernel threads
- Solaris prior to version 9
- Windows with the *ThreadFiber* package





Two-level Model

- Similar to M:M, except that it allows a user thread to be **bound** to kernel thread
- Examples
 - IRIX
 - HP-UX
 - Tru64 UNIX
 - Solaris 8 and earlier



End of Chapter 4

