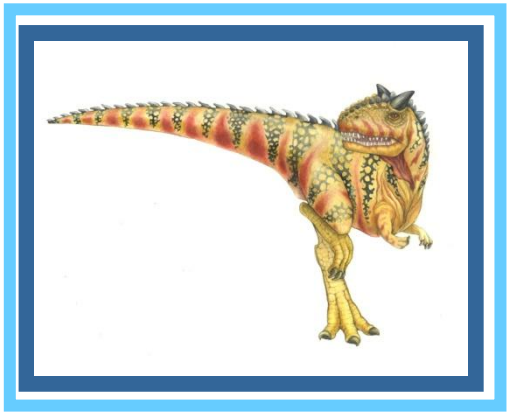
Chapter 4: Threads



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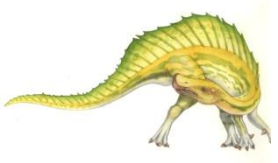
Administrivia

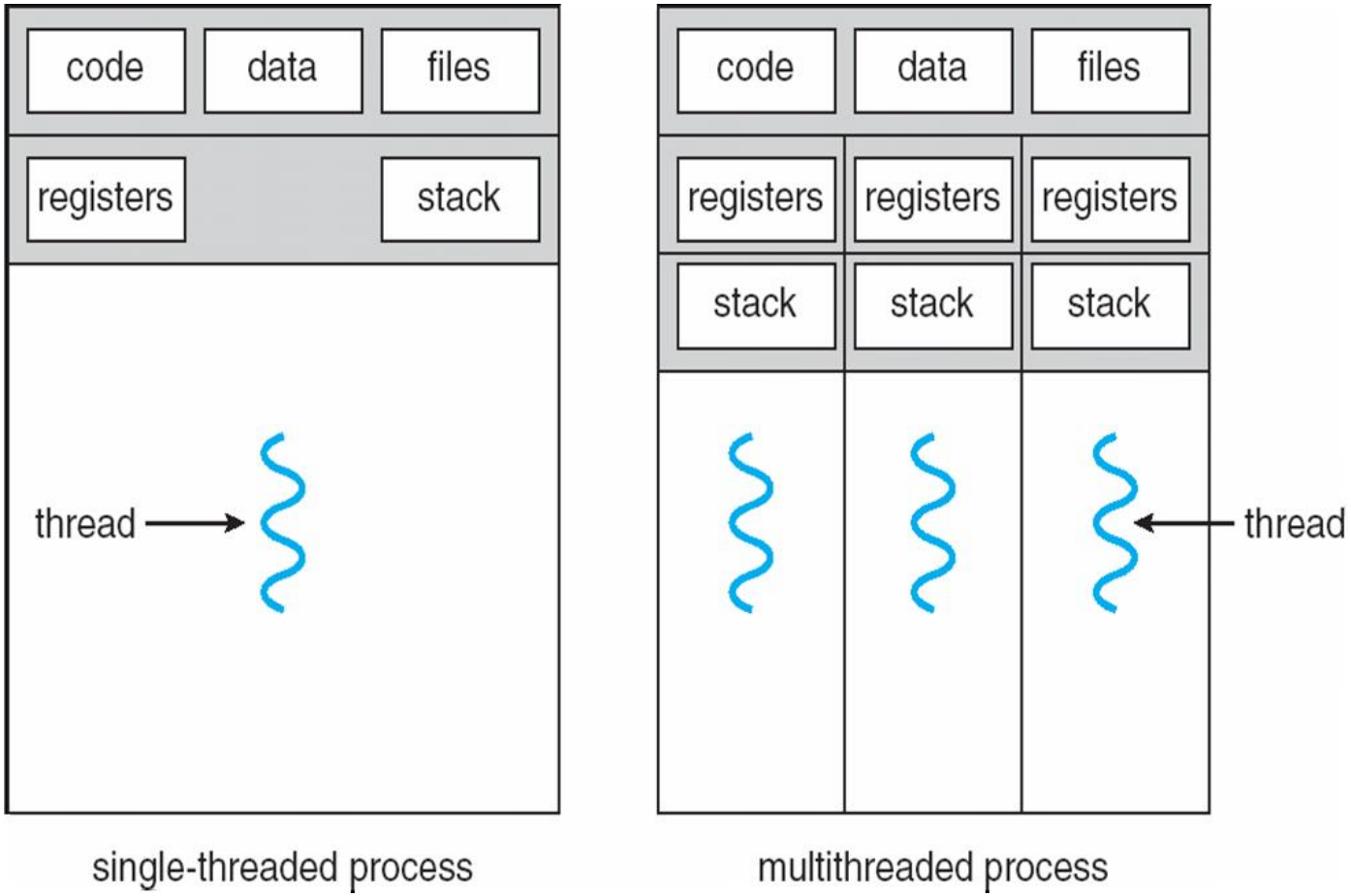
- System calls project.
- Exam next Friday, Chapters 1—4.



Outline

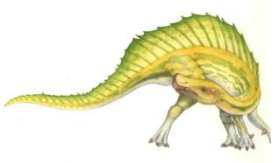
- What are threads?
- Threads and multi-processing.
- User, kernel thread models.
- Thread semantics and details.
- Threads in XP and Linux.

Single and Multithreaded Processes

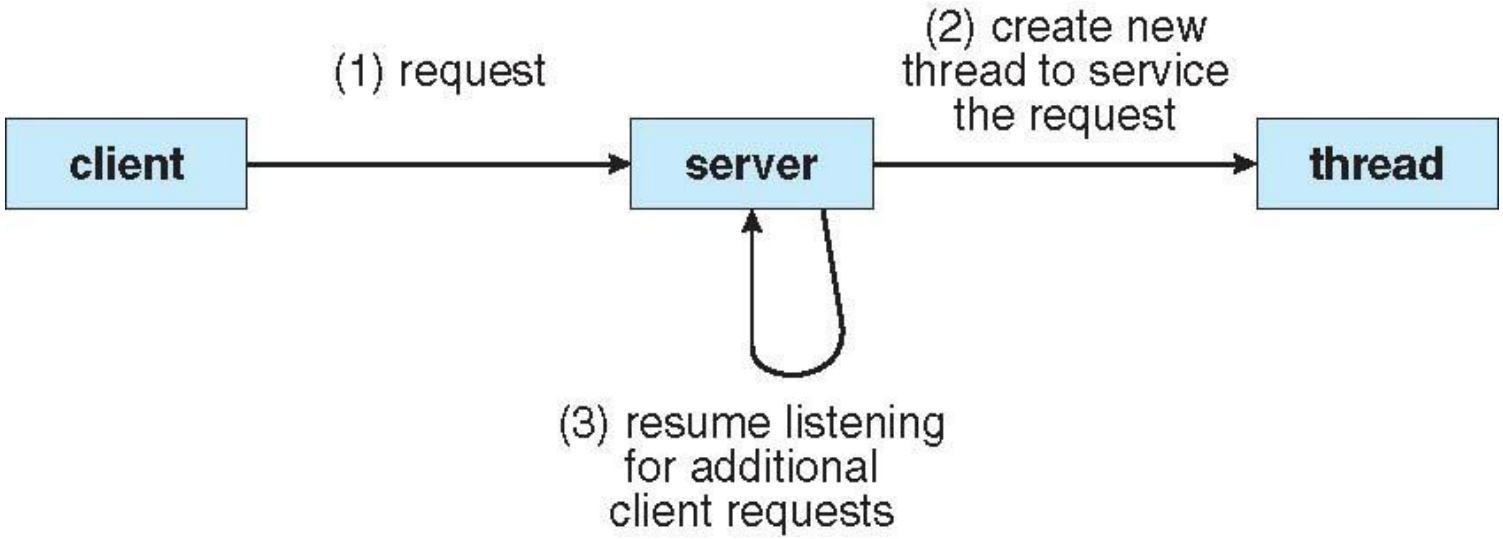


Multicore Programming

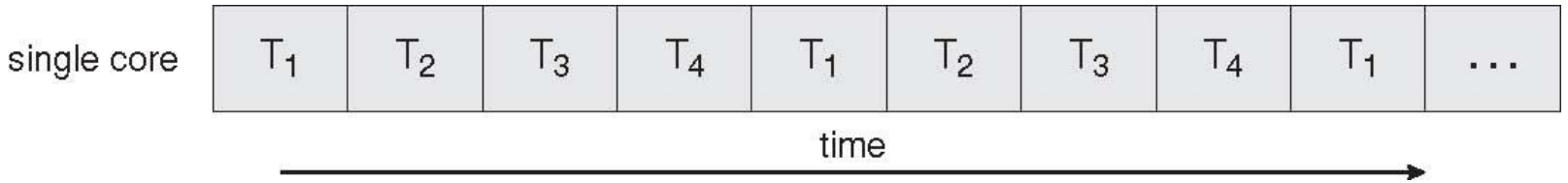
- Multicore systems putting pressure on programmers, challenges include
  - **Dividing activities**
  - **Balance**
  - **Data splitting**
  - **Data dependency**
  - **Testing and debugging**



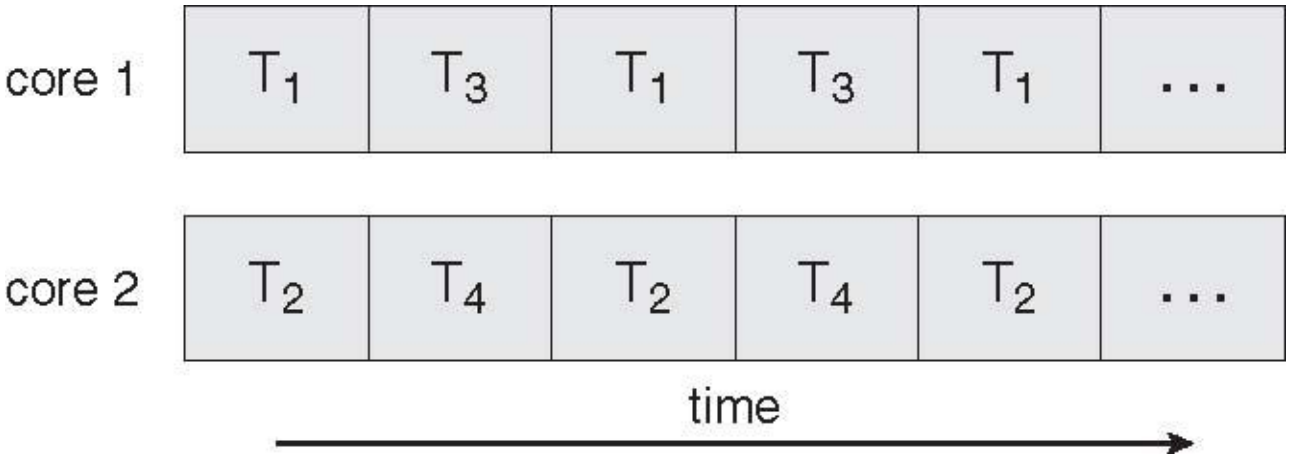
Multithreaded Server Architecture

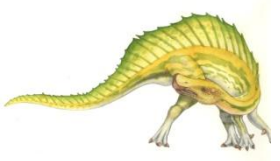


Concurrent Execution on a Single-core System



Parallel Execution on a Multicore System



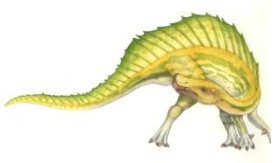


User Threads

- Thread management done by user-level threads library
- Three primary thread libraries:
  - POSIX Pthreads
  - Win32 threads
  - Java threads

Kernel Threads

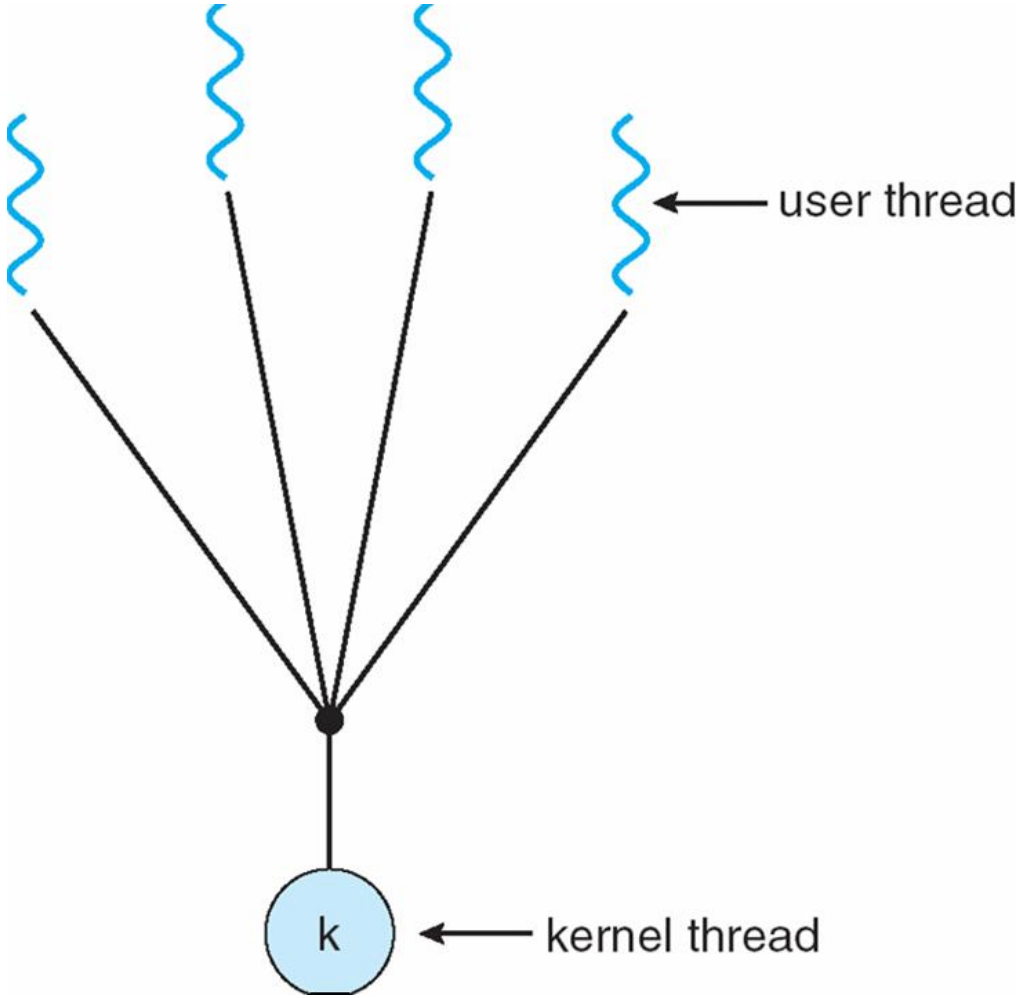
- Supported by the Kernel
- Examples
  - Windows XP/2000
  - Solaris
  - Linux
  - Tru64 UNIX
  - Mac OS X



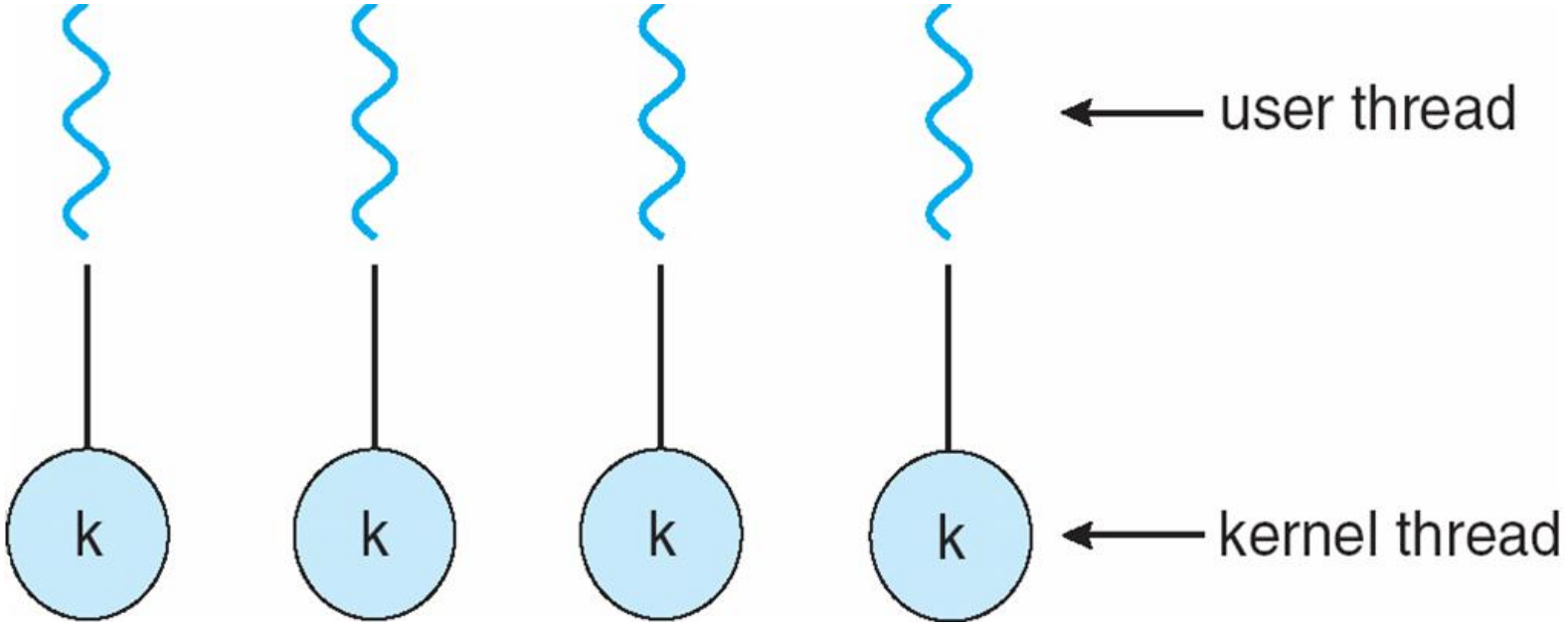
Multithreading Models

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

Many-to-One Model



One-to-one Model

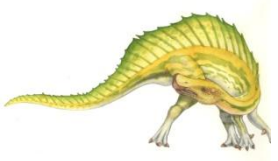


Thread Libraries

- Thread library provides programmer with API for creating and managing threads
- Two primary ways of implementing
  - Library entirely in user space
  - Kernel-level library supported by the OS

Pthreads

- May be provided either as user-level or kernel-level
- 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)



Java Threads

- Java threads are managed by the JVM
- Typically implemented using the threads model provided by underlying OS
- Java threads may be created by:
  - Extending Thread class
  - Implementing the Runnable interface

Threading Issues

- Semantics of **fork()** and **exec()** system calls
- Thread cancellation of target thread
  - Asynchronous or deferred
- Signal handling
- Thread pools
- Thread-specific data
- Scheduler activations

Semantics of fork() and exec()

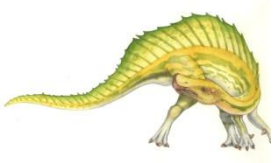
- Does **fork()** duplicate only the calling thread or all threads?

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 threa 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)

Operating System Examples

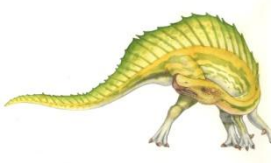
- Windows XP Threads
- Linux Thread

Windows XP Threads

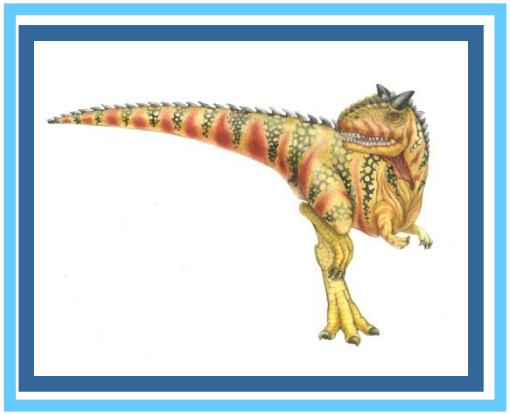
- Implements the one-to-one mapping, kernel-level
- Each thread contains
  - A thread id
  - Register set
  - Separate user and kernel stacks
  - Private data storage area
- The register set, stacks, and private storage area are known as the context of the threads
- The primary data structures of a thread 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)



End of Chapter 4



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