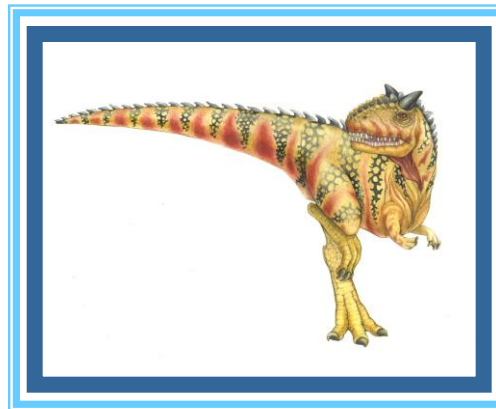


# Chapter 4: Threads

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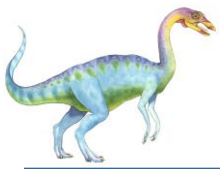


# Chapter 4: Threads

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- Overview
- Multicore Programming



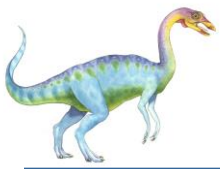


# Objectives

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- To introduce the notion of a thread—a fundamental unit of CPU utilization that forms the basis of multithreaded computer systems



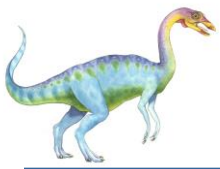


# Motivation

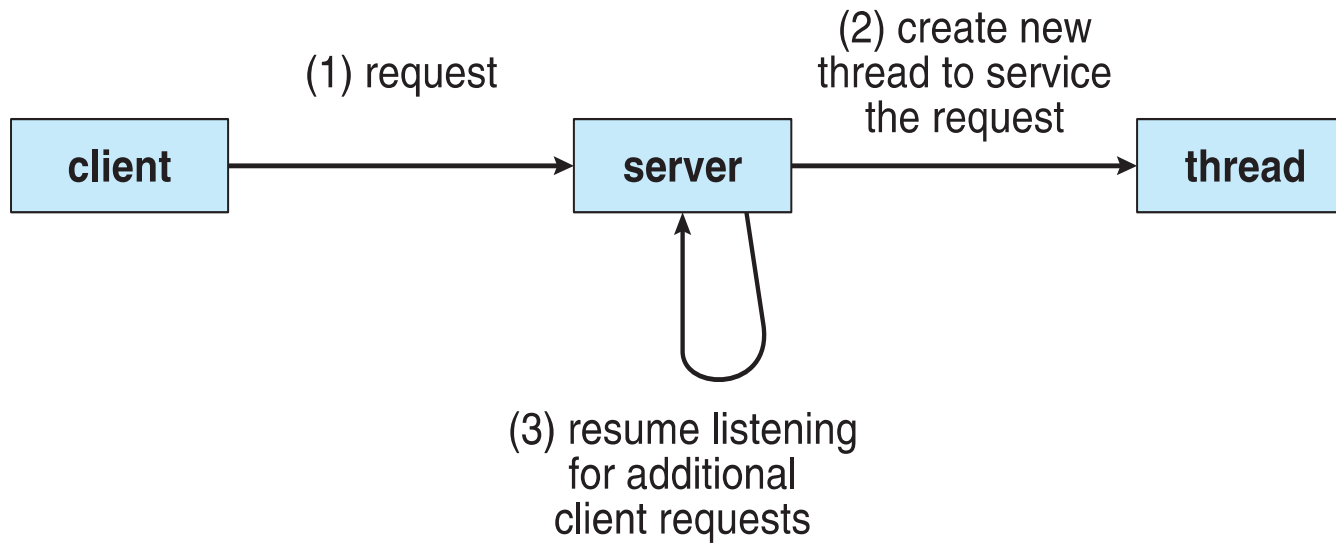
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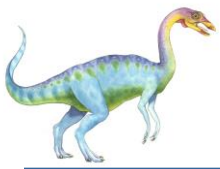
- Most modern applications are multithreaded
- Threads run within application
- Multiple tasks with the application can be implemented by separate threads
  - Update display
  - Fetch data
  - Spell checking
  - Answer a network request
- Process creation is heavy-weight while thread creation is light-weight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





# Multithreaded Server Architecture



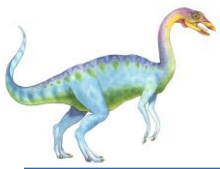


# Benefits

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- **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



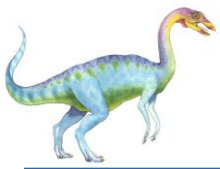


# Multicore Programming

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- **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.)

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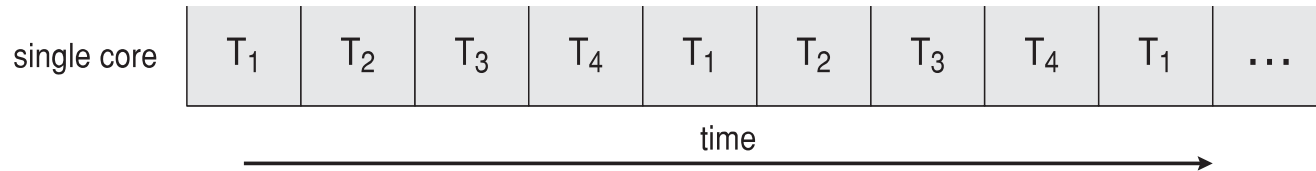
- Types of parallelism
  - **Data parallelism** – distributes subsets of the same data across multiple cores, same operation on each
  - **Task parallelism** – distributing threads across cores, each thread performing unique operation
- As # of threads grows, so does architectural support for threading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



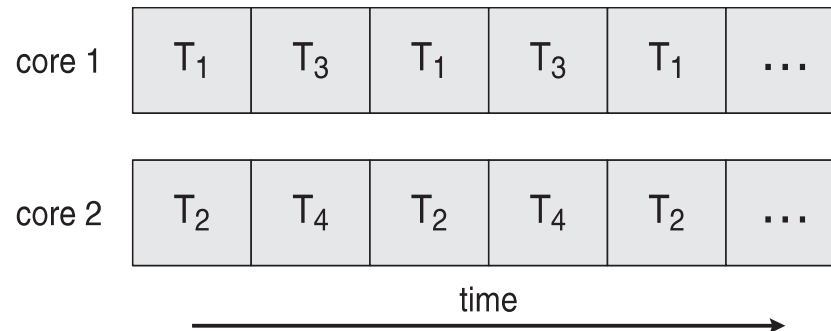


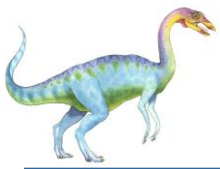
# Concurrency vs. Parallelism

## □ Concurrent execution on single-core system:

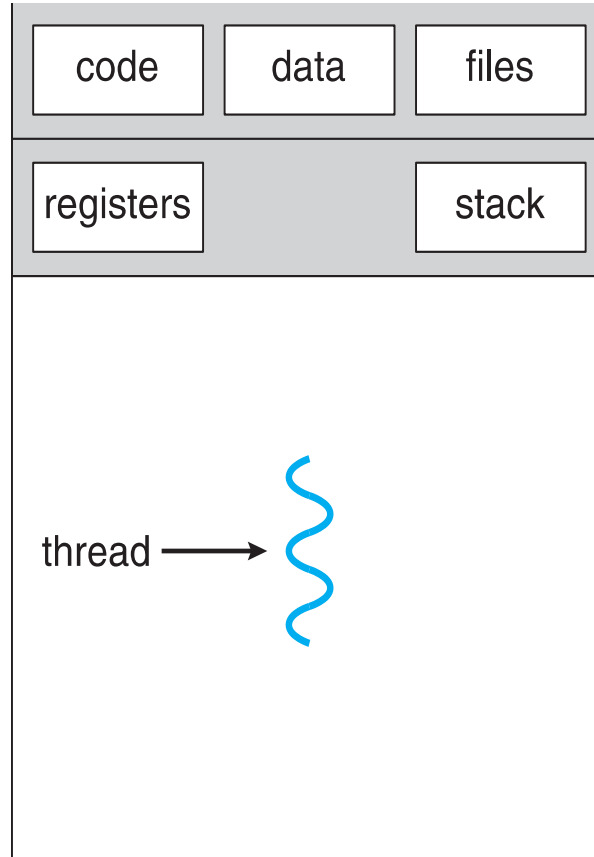


## □ Parallelism on a multi-core system:

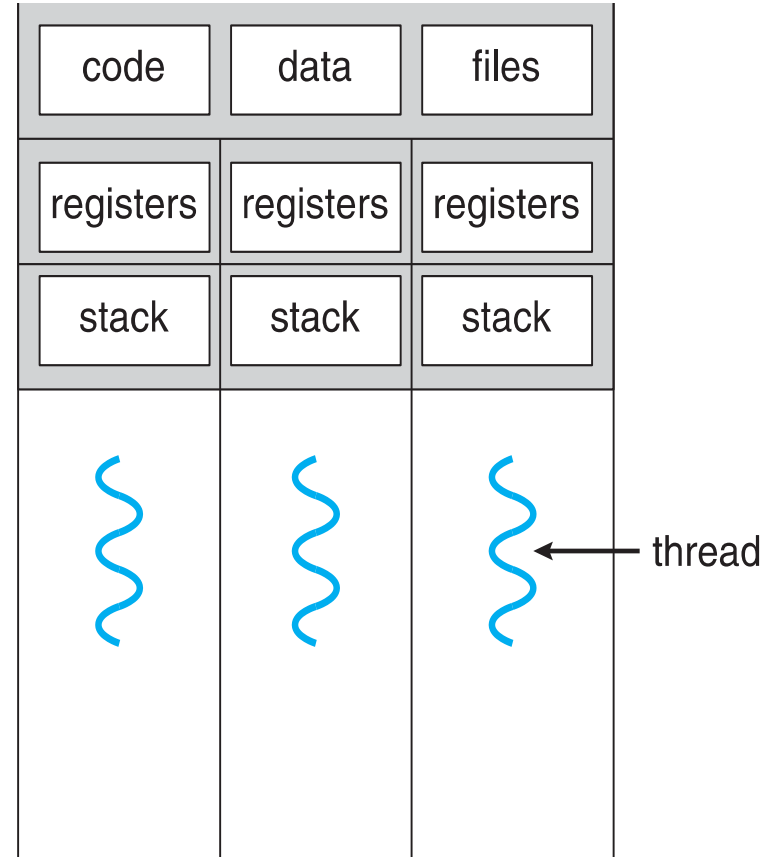




# Single and Multithreaded Processes



single-threaded process



multithreaded process



# End of Chapter 4

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