Threads

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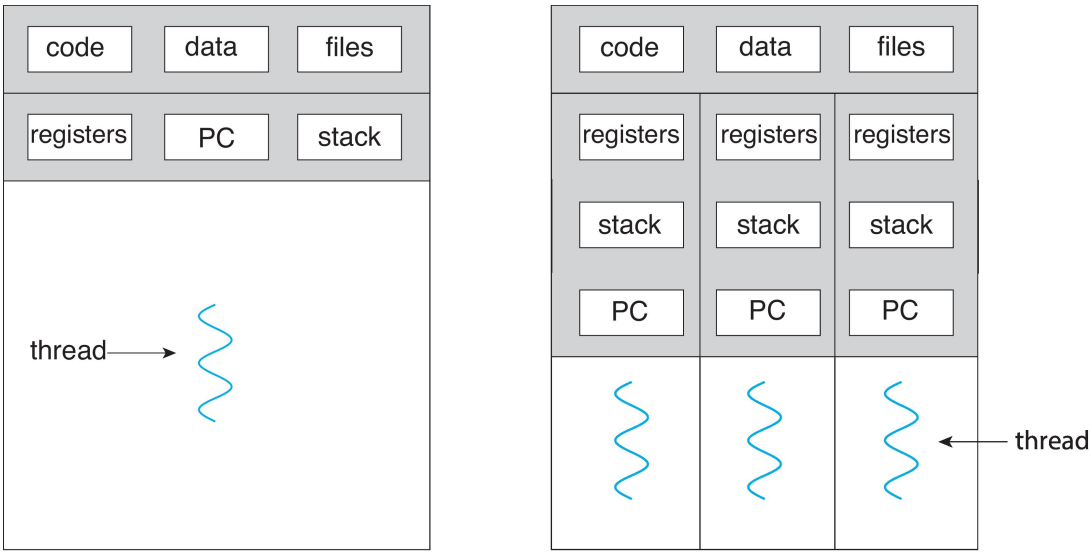
- A **thread** is a **single sequential flow of control within a program**.
- **Threads** are the **smallest unit of processing** that can be performed in an **operating system**.
- A **single process** can have **more than one thread**; each thread having a unique **program counter, stack, thread id, and set of registers**.
- **All threads** running under a **single** process have **shared memory (instructions, data, heap)**. They also can **communicate with each other directly**; there is no need for IPC.
- The **amount of time** it takes to **switch between threads** is less than the **amount of time** it takes to **switch between processes**.
- On **computer systems** that have **multiple cores**, **threads can run in parallel**.



single-threaded process multithreaded process

Threads vs Processes

- **Threads** have **no data segment or heap**.
- A **process has code, data, heap, and stack segmetns**.
- A **thread cannot live on it's own**; it needs to be attached to a process.
- **Processes** must have **atleast one thread**.
- There can be **more than one thread in a single process**.
- **Threads** in a **process** share data.
- If a **thread dies**, it's **stack is reclaimed**.
- If a **process dies**, all of it's **threads die**.

POSIX Threads

- To **create a thread** you use the **pcreate_thread(thread, attr, start_routine, arg) function**.
  - **thread** — An opaque, unique identifier for the new thread returned by the subroutine.
  - **attr** — An opaque attribute object that may be used to set thread attributes.
  - **start_routine** — The routine that the thread will execute one it has been created.
  - **arg** — A single argument that may be passed to the **start_routine**.
- To **destroy a thread** you use the **pthread_exit(status) function**. This will **terminate the calling thread**, and **make the status available** to any **successful join with the terminating thread**.
- To **wait for a thread to terminate**, you use the **pthread_join(threadid, status) function**. This will **suspend the execution** of the **calling thread** until the **target thread terminates**.

User Threads and Kernel Threads

- **User threads** are **threads** that are **managed** at the **user-level**.
- **Kernel threads** are **threads** that are **managed by the kernel**.
- **User threads** and **kernel threads** have the same capabilities.

Multithreading Models

- There are three multithreading models:
  1. **Many-to-One**.
  2. **One-to-One**.
  3. **Many-to-Many**.

Thread Issues

- One **issue** with multiple threads is the behaviour of the **fork** system call. **Should fork duplicate the calling thread, or all threads?**.
  - In practice, both variations are used.
- Another **issue** with multiple threads is **where signals should be delivered to**.
  - We could deliver the signal to the thread it corresponds to.
  - We could deliver the signal to all threads in the process.
  - We could deliver the signal to certain threads in the process.
  - We could assign a specific thread to receive all signals for the process.
- Another **issue** is **thread cancellation**, i.e. terminaing a thread before it is finished.
  - There are two general approaches:
    1. **Asynchronous cancellation** terminates the target thread **immediately**.
    2. **Deferred cancellation** allows the target thread to **periodically check** if it should be cancelled.
  - The **state of the thread** also affects cancellation.
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