# Scheduling basics

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- Disk-Scheduler: Why have one? Multiplexing but also efficiency!
- Network I/O: When to send packets, which packets to drop, QoL,...

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- LTS: Decide which processes to put in the *run queue*
- STS: Decide which process runs on the *CPU*
- MTS: Temporarily removes processes from main memory (and e.g. writes them out to disk)

$\Rightarrow$ Reduce degree of multiprogramming, make room in memory (and a few other reasons)

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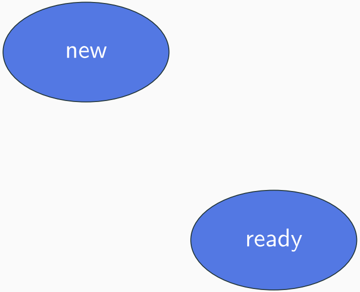

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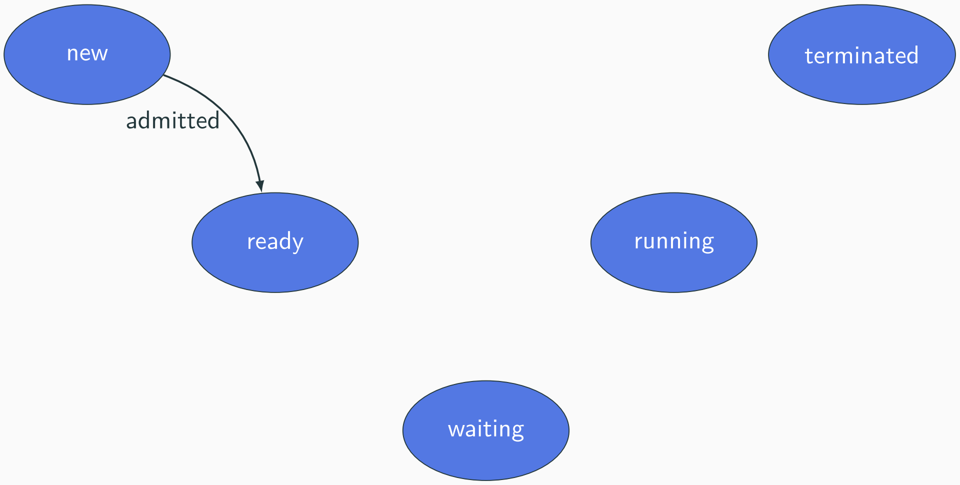

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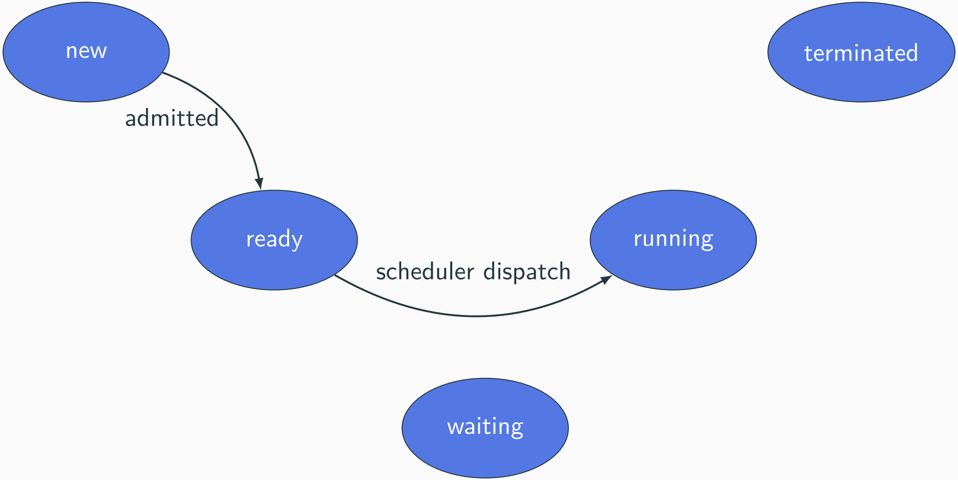

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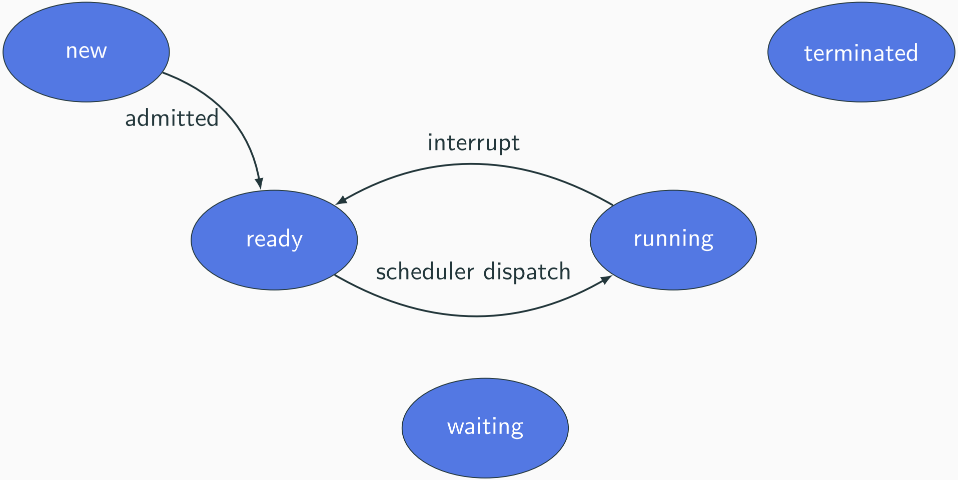

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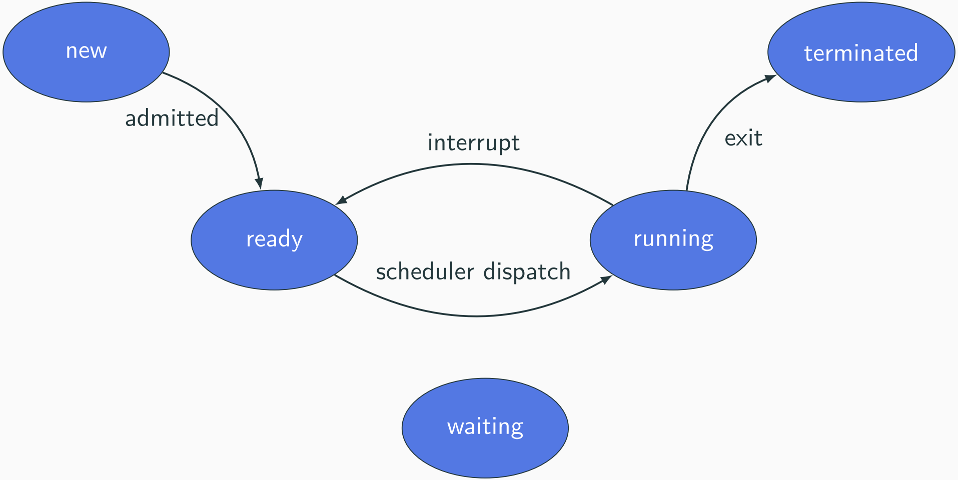

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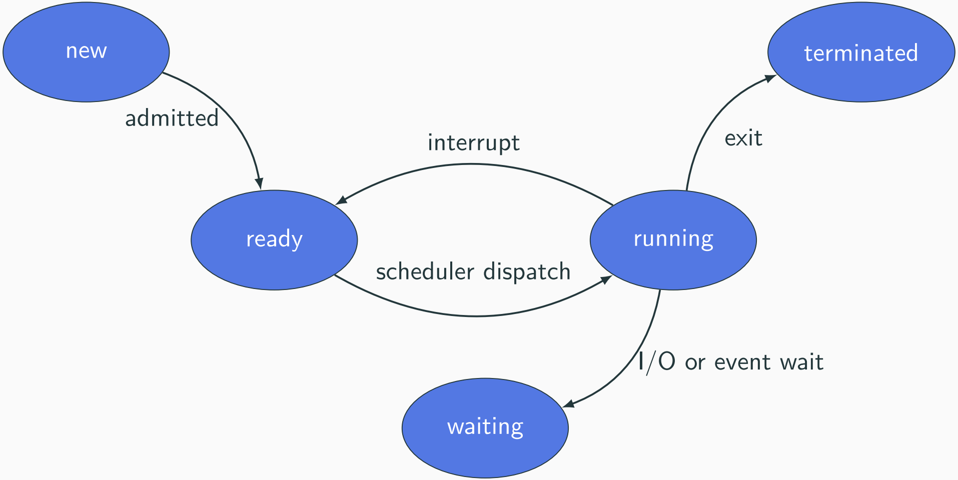

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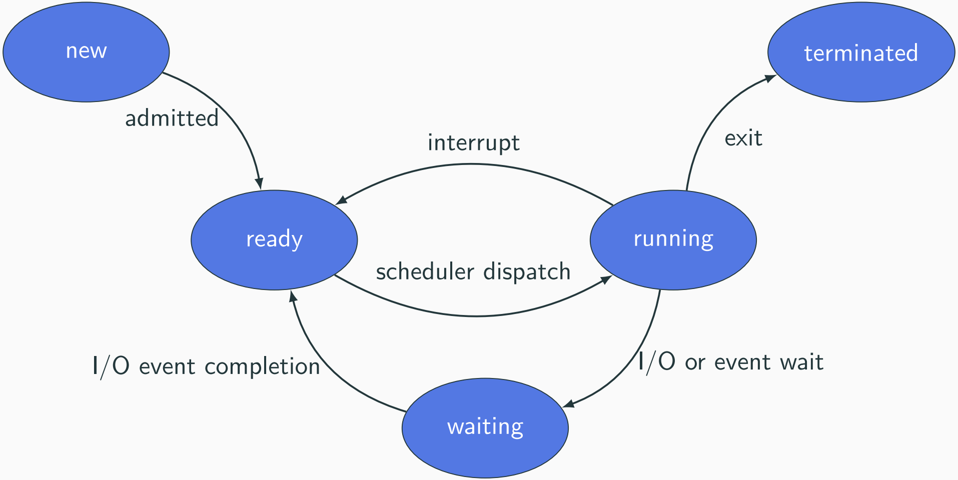

# Scheduling - Scheduler Worldcup

**What makes a good Scheduler good?**

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**Some metrics**

- Processor utilization: Percentage of working time
- Throughput: How many jobs do you finish?
- Turnaround time: Wallclock-time from submission to finish
- Waiting time: How long did it spend in the ready queue
- Response time: Time between submission of a request and first response (e.g. key press to echo on screen)

# Scheduling - Preemption the third

**What does your hardware need to support to allow non-cooperative scheduling?**

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Timer Interrupts! Waiting for a cosmic ray to hit, a network package to arrive, a system call or any other random interrupt gets old fast :)

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- Short: High interactivity, higher overhead
- Long: Lower interactivity, smaller overhead

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  Interrupt the process after the estimated time is over.

# Priorities

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- Each process is assigned a priority
- The process with the highest priority is chosen

# Multi-Level Feedback Queues

| | | | | |
|---|---|---|---|---|
| Short time slice | A | B | C | D |
| Medium time slice | | | | |
| Long time slice | | | | |

**How it works**

- All processes start in the highest queue
- When they use up their timeslice and are preempted, they descend
- If they block before, they stay in the level (optionally: Are moved up)

$\Rightarrow$ I/O bound processes rise to the top and react quickly, CPU bound processes get longer timeslices but less often


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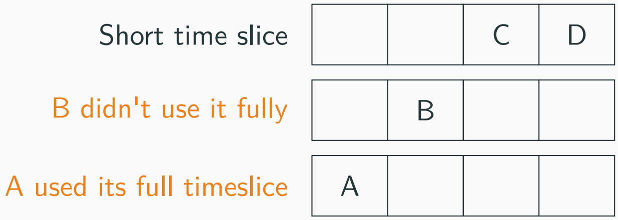


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- Prefer I/O bound, prefer short jobs, group the rest based on their needs

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- Kernel space! Users shouldn't be able to modify them

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They are saved when it is switched out.

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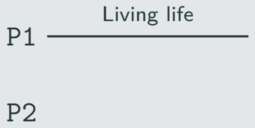
## In pictures



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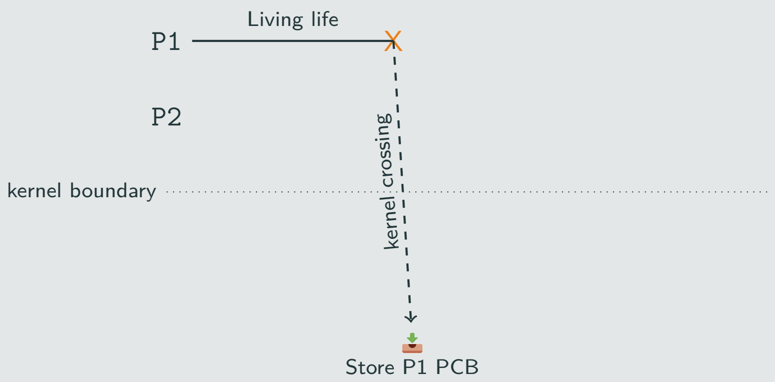

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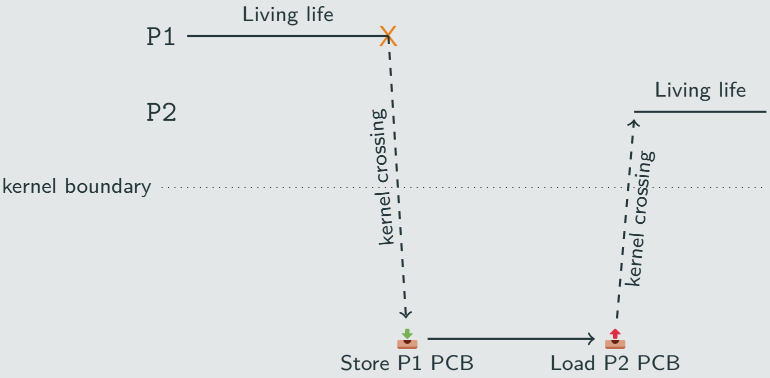

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5. Leave kernel mode and transfer control to the PC of the next process

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- A thread lives in an address space, i.e. all the addresses that it can can access and the data that is stored there
- Thread + Address Space = Process

**Spawn a few threads using pthreads!**

Write a small program that creates five threads using the pthread library. Each thread should print its number (e.g., `Hello, I am 4`) and the main program should wait for each thread to exit.

# Thread models — One To One

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## Problems?

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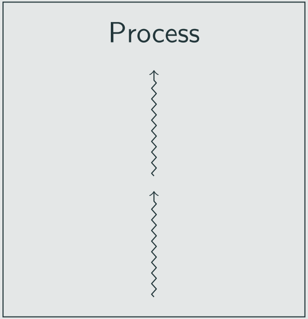


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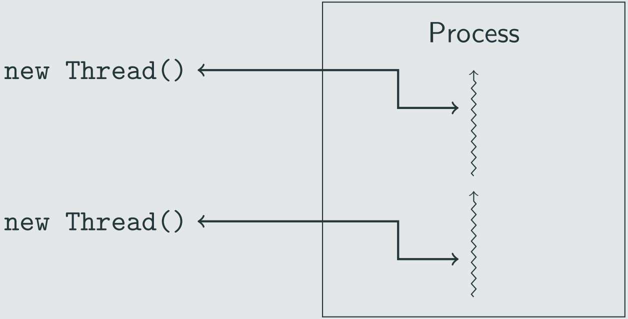


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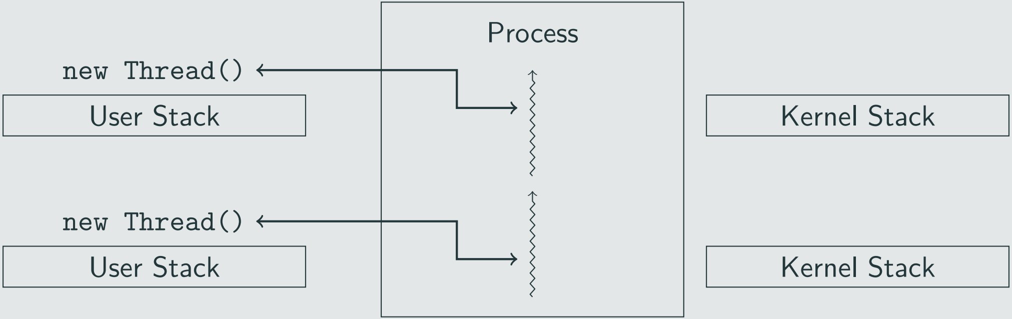

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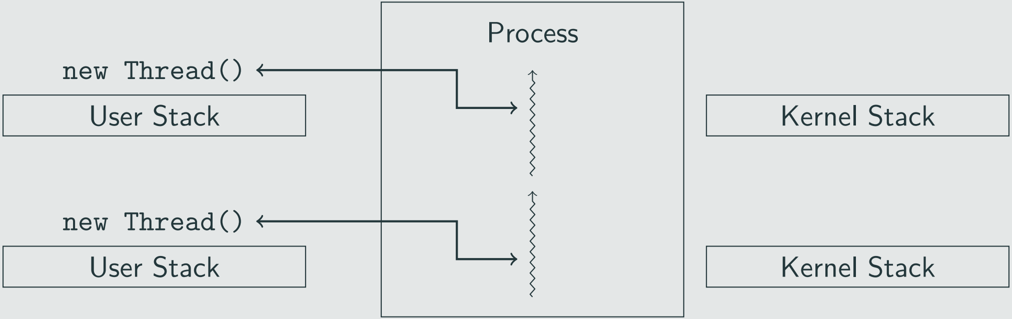


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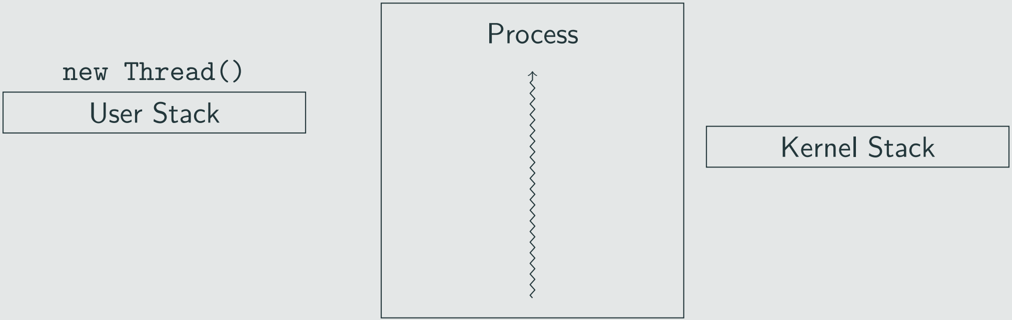

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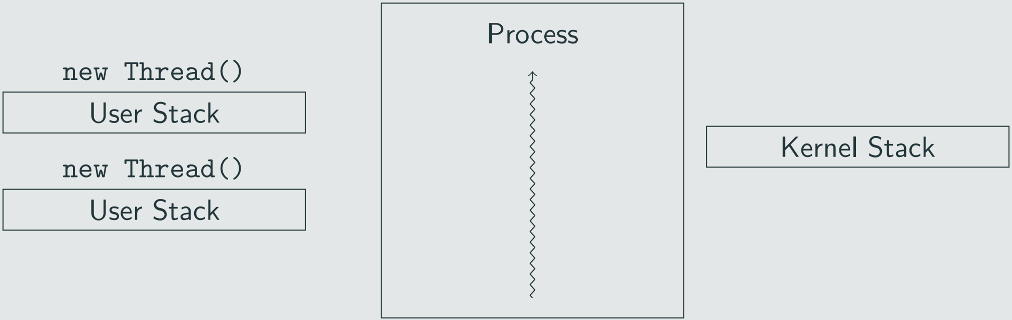

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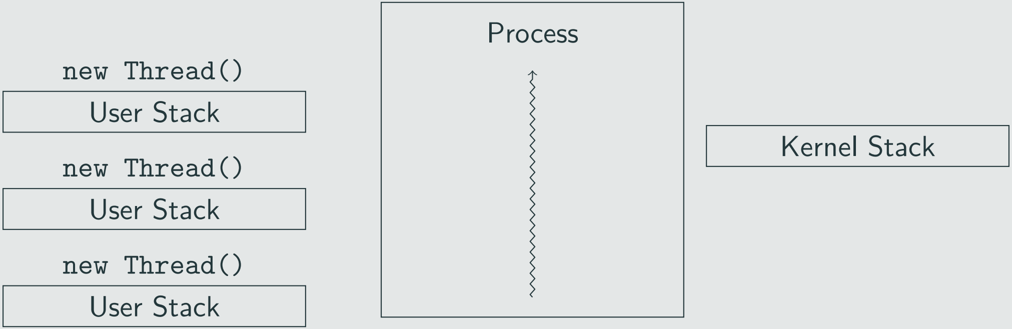

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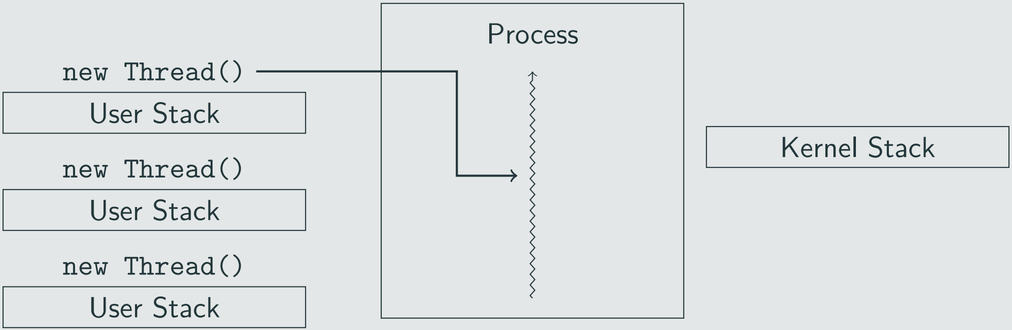

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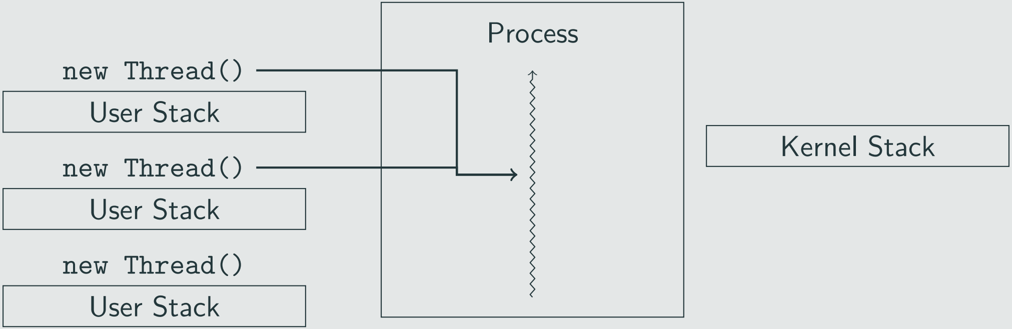

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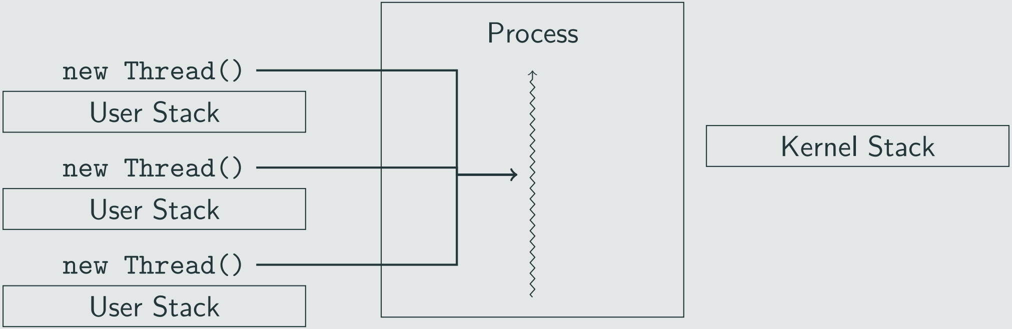

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Famous paper by a proponent of Structured Programming:
„*Go To Statement Considered Harmful*“ by Edsger W. Dijkstra

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So that might sound familiar...

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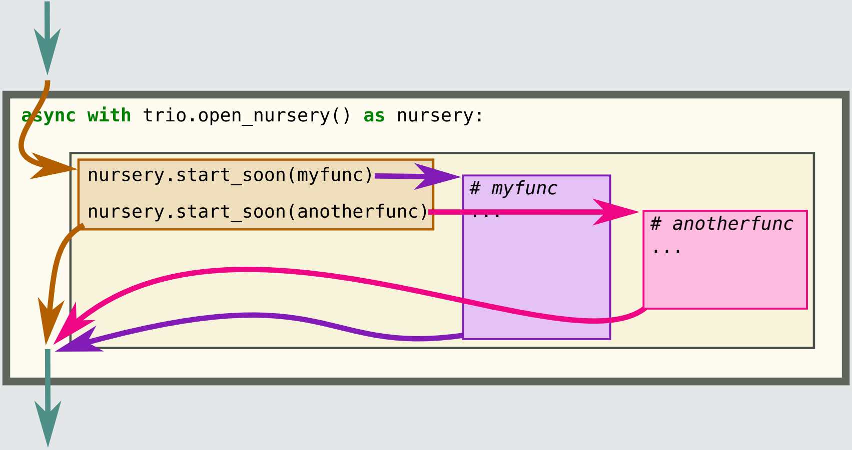
## Structured Concurrency




Taken from vorpus.org

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**Nice, but what does this have to do with ULTs?**

- Spawning lots of threads for small operations *is too slow otherwise*

Further reading:

Notes on Structured Concurrency

ULTs and Structured concurrency in Java - Project Loom

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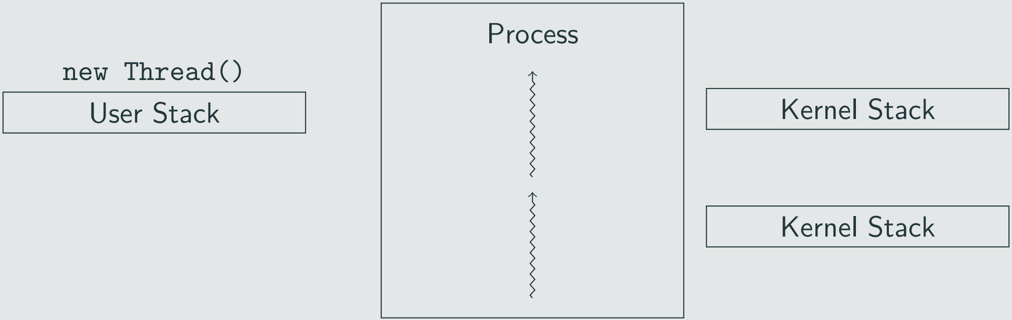

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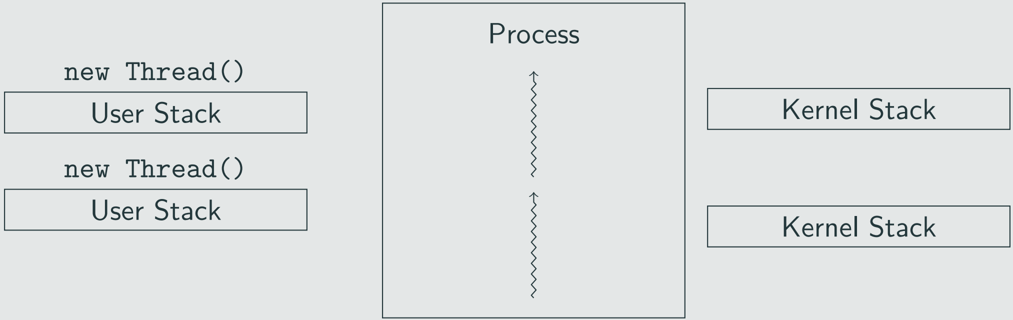

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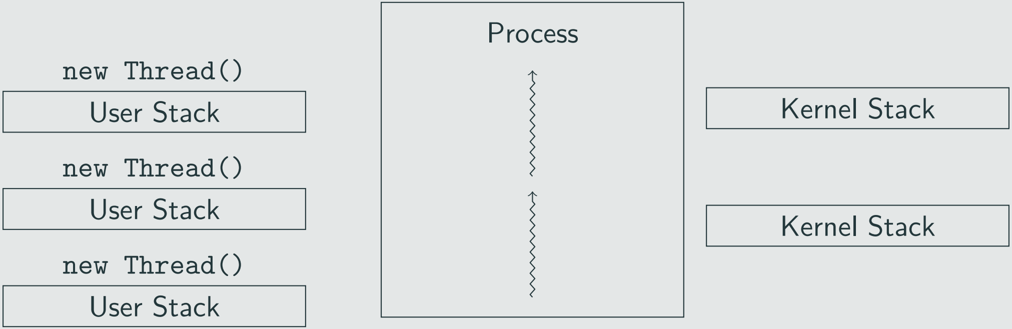

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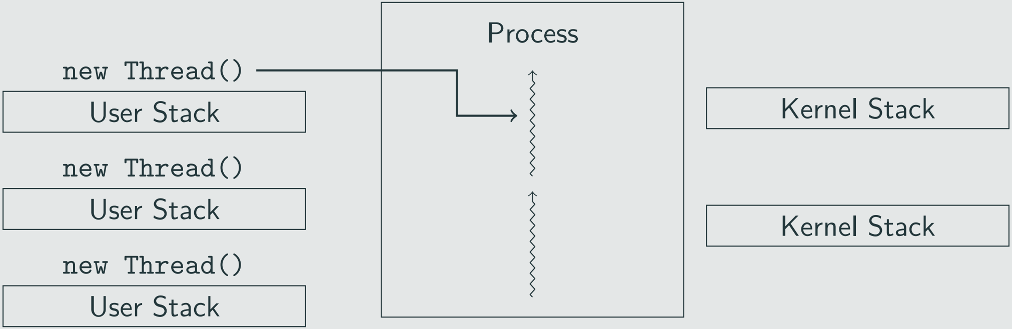

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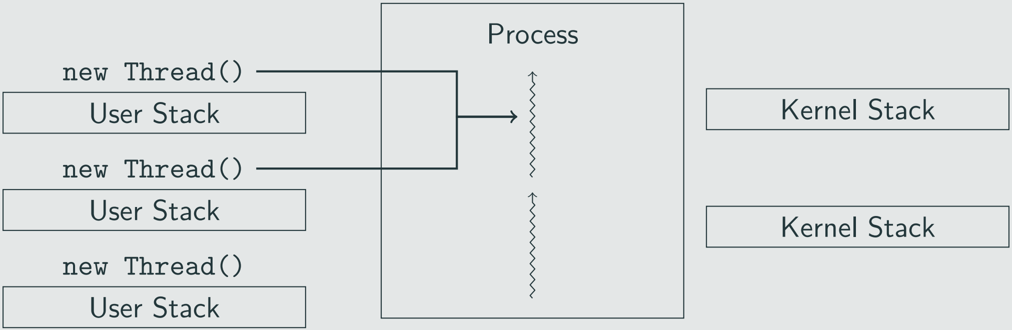

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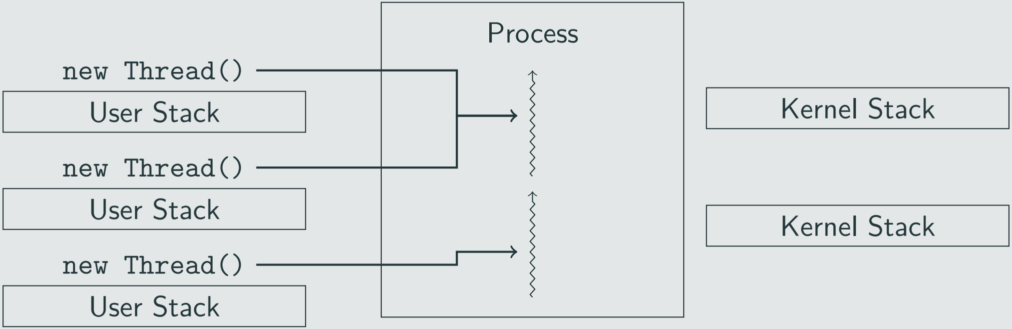

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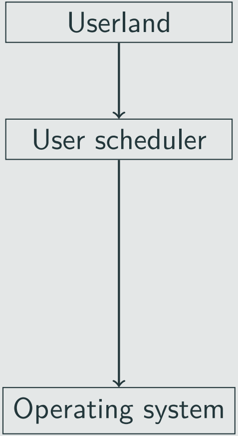


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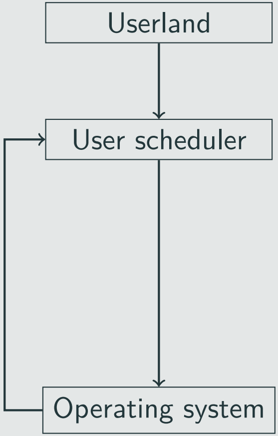

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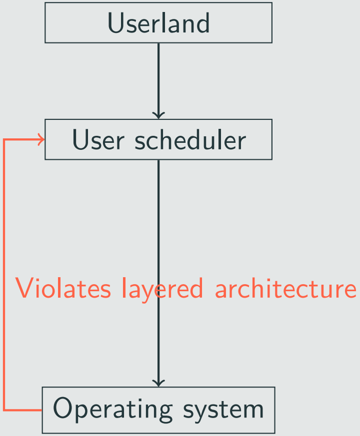

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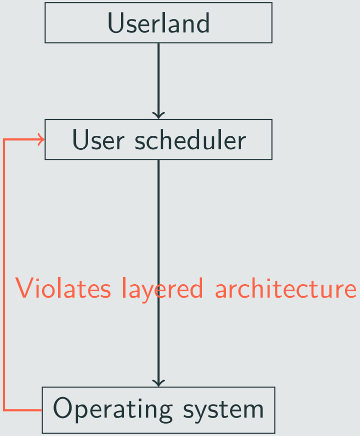


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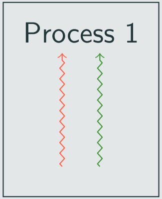

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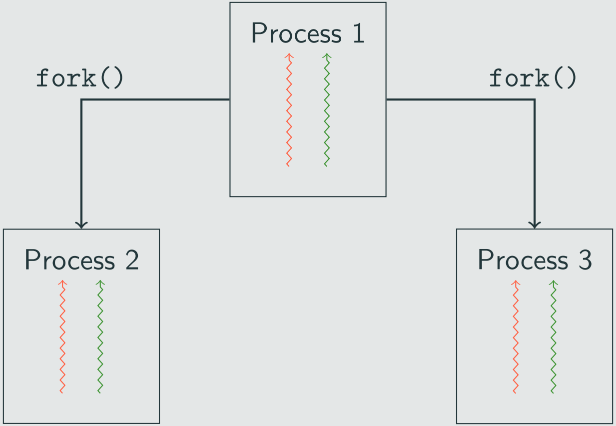

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**Summary**

`fork` is not as simple as it once was. Is it still a good abstraction?

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