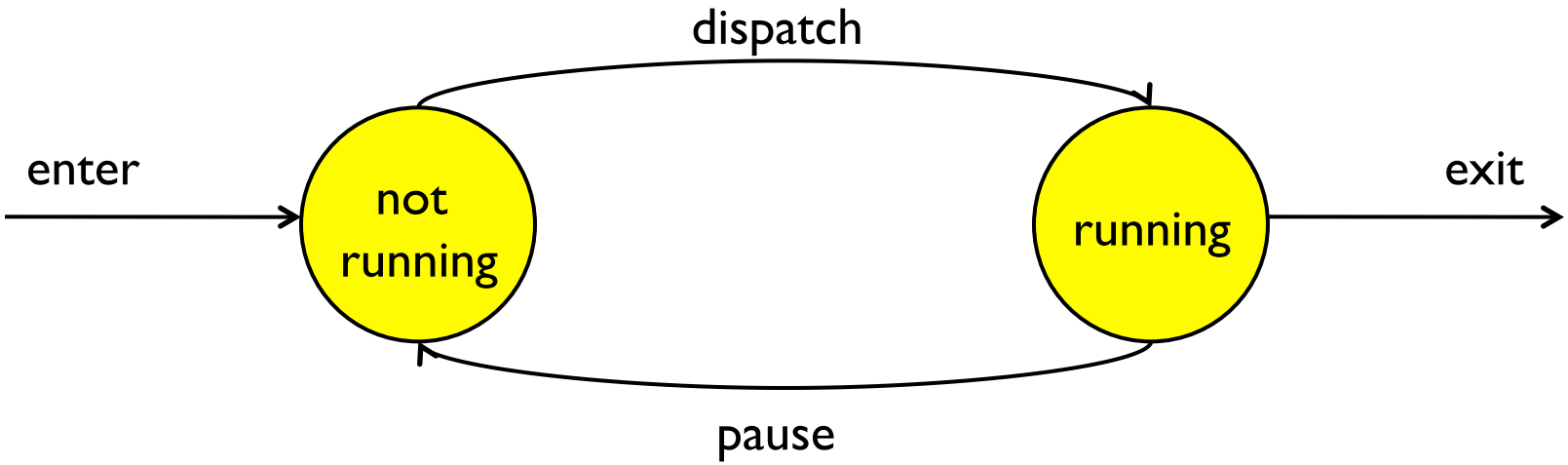
# Processes: A System View

CS 241

February 17, 2012

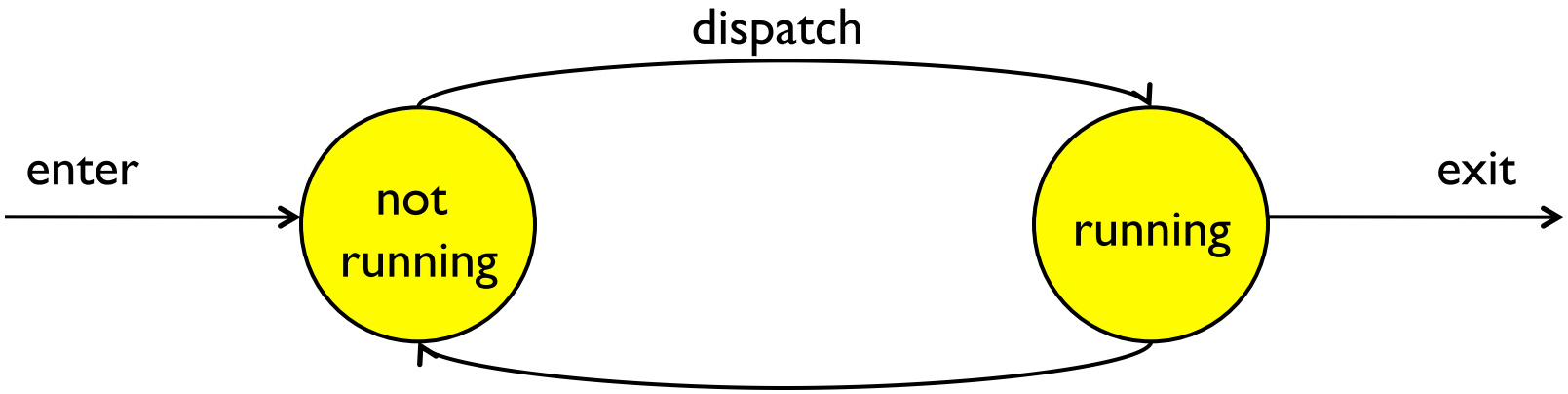
# What the OS does: 2 State Model

Processes

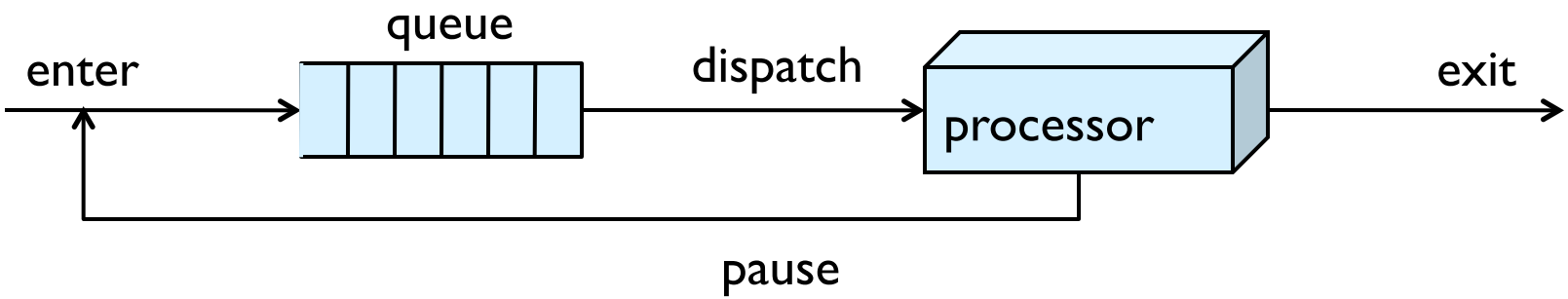


# What the OS does: 2 State Model

Processes

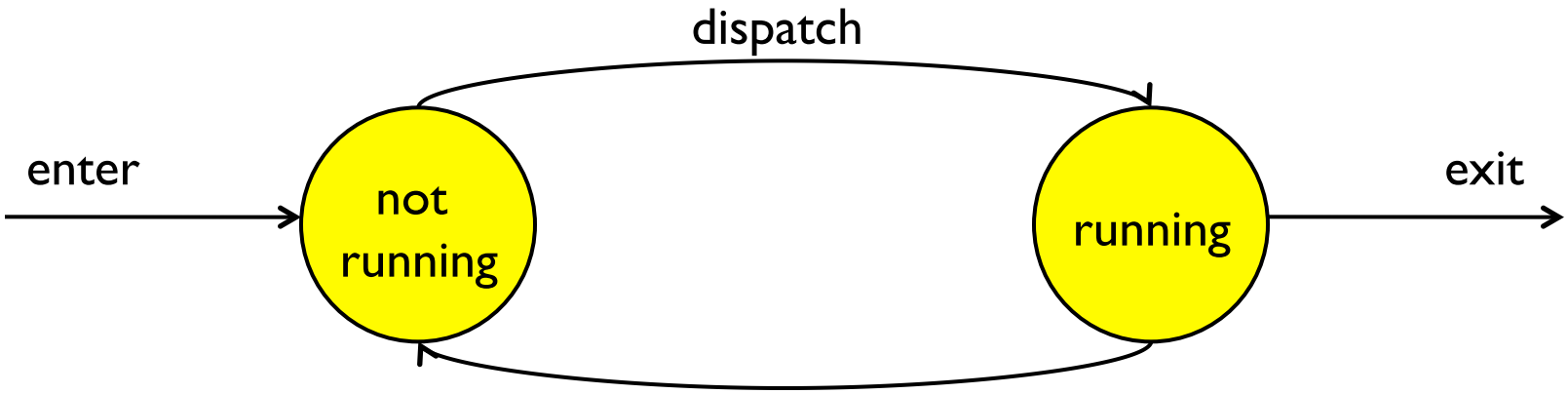



System



# 2 State Model

Processes

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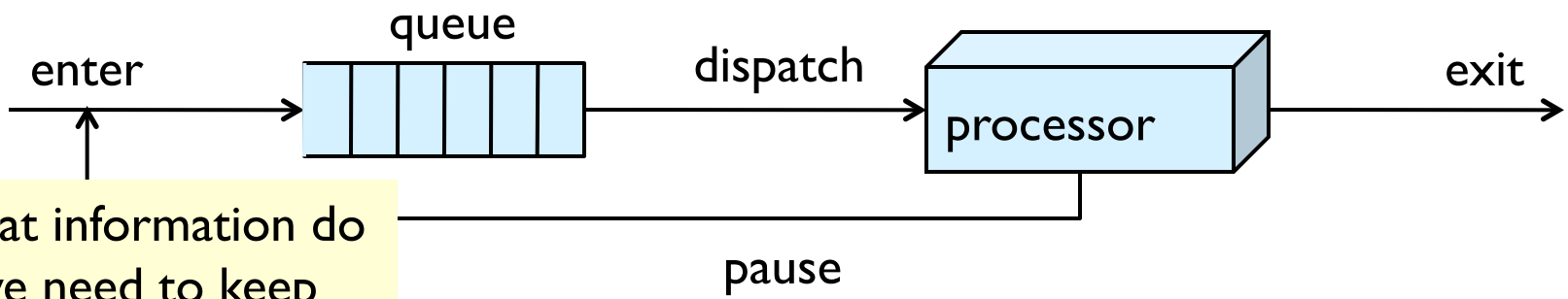



What information do we need to keep while in the queue?

# What the OS stores: PCB

OS stores Process Control Block (PCB) for each process

- In-memory OS structure
- User processes cannot access it

Contents:

- Identifiers
  - pid & ppid (process ID & parent process ID)
- Processor state information
  - User-visible registers, control and status, stack
- Scheduling information
  - Process state, priority, what event the process is waiting for, ...

# What the OS stores: PCB

Contents (cont'd):

- Inter-process communication
  - Signals
- Privileges
  - CPU instructions, memory
- Memory Management
  - e.g., Page tables
- Resource ownership and utilization

# Five State Process Model

"All models are wrong. Some Models are Useful"

- George Box, statistician

2 state model

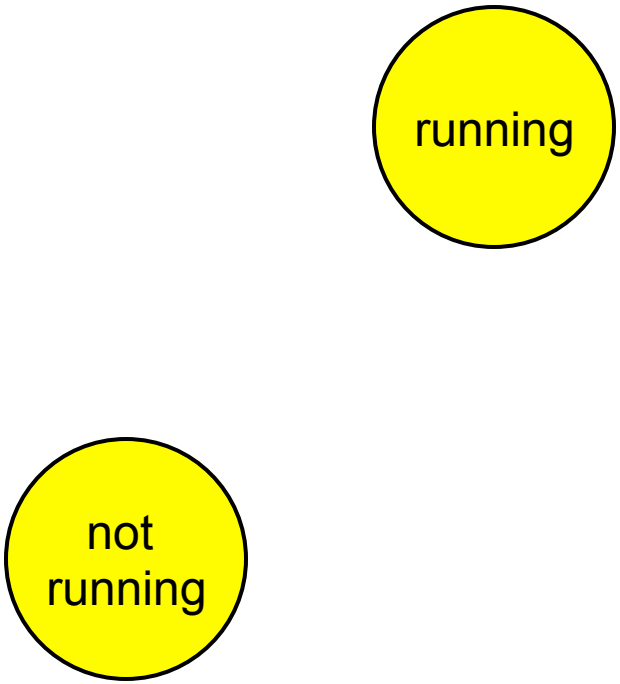
- Too simplistic
- What does "Not Running" mean?

7 state model

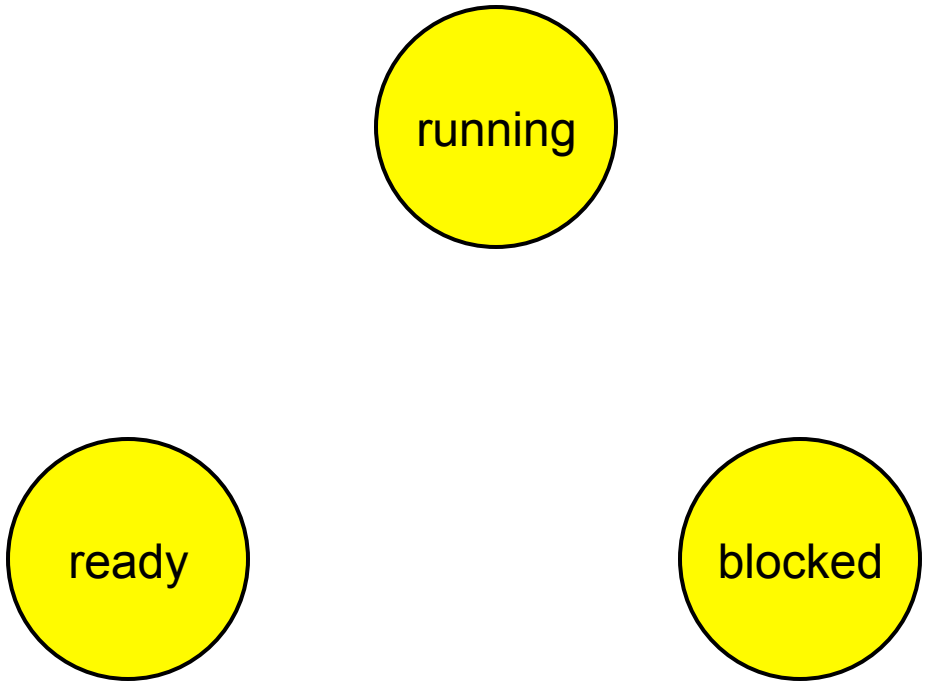
- Considers suspending process to disk
- See Stallings book, section 3.2

Next: 5 state model

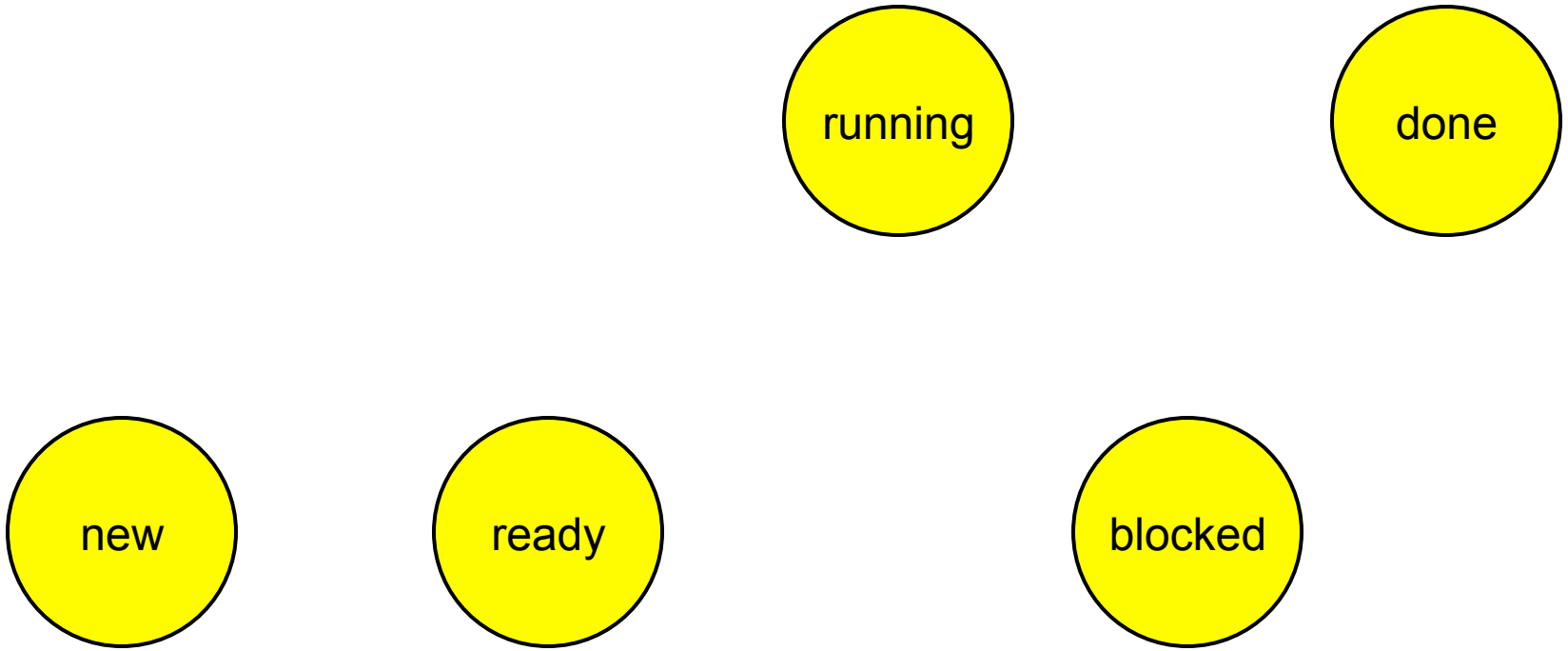
# 5 State Model: States



# 5 State Model: States



# 5 State Model: States



# 5 State Model: Summary

Running

- Currently executing
- On a single processor machine, at most one process in the "running" state

Ready

- Prepared to execute

Blocked

- Waiting on some event

New

- Created, but not loaded into memory

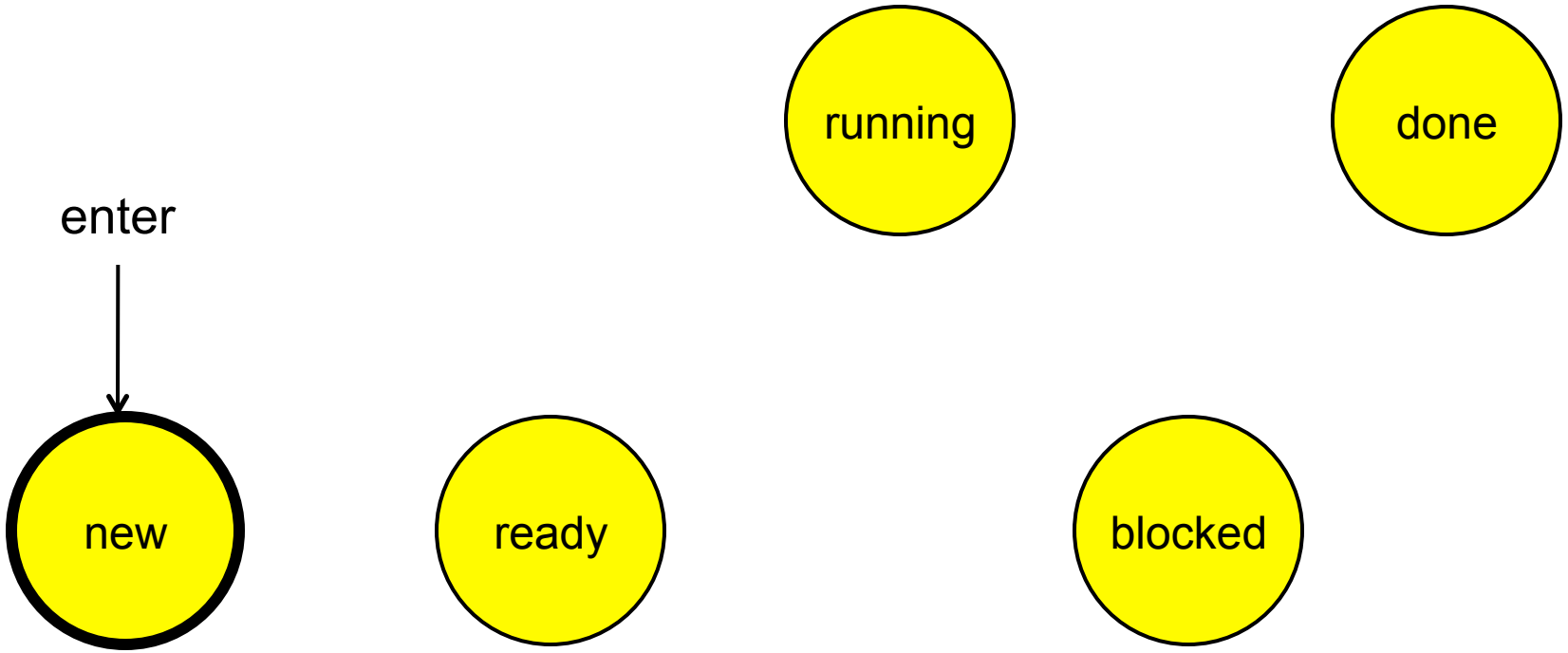
Done

- Released from pool of executing processes

# 5 State Model: Transitions

Null (nothing) to New

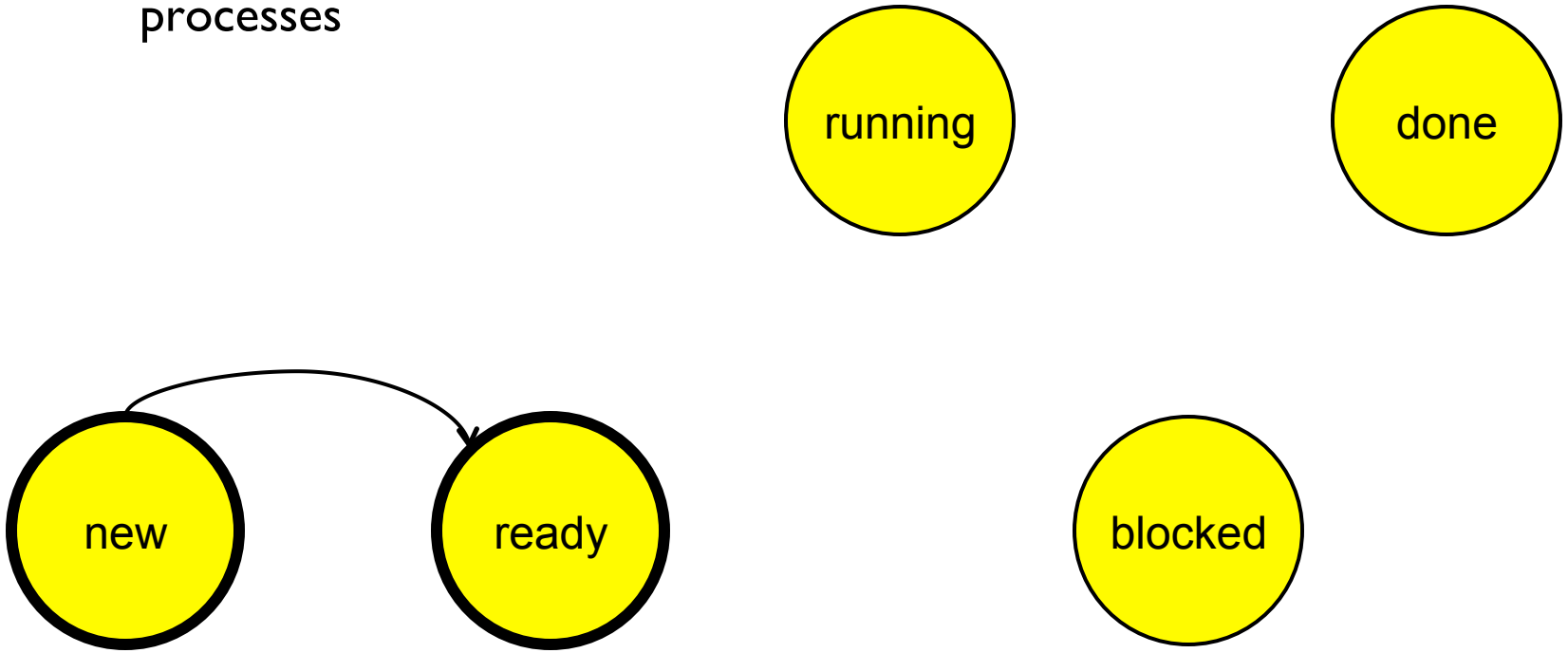
- New process creation



# 5 State Model: Transitions

New to Ready

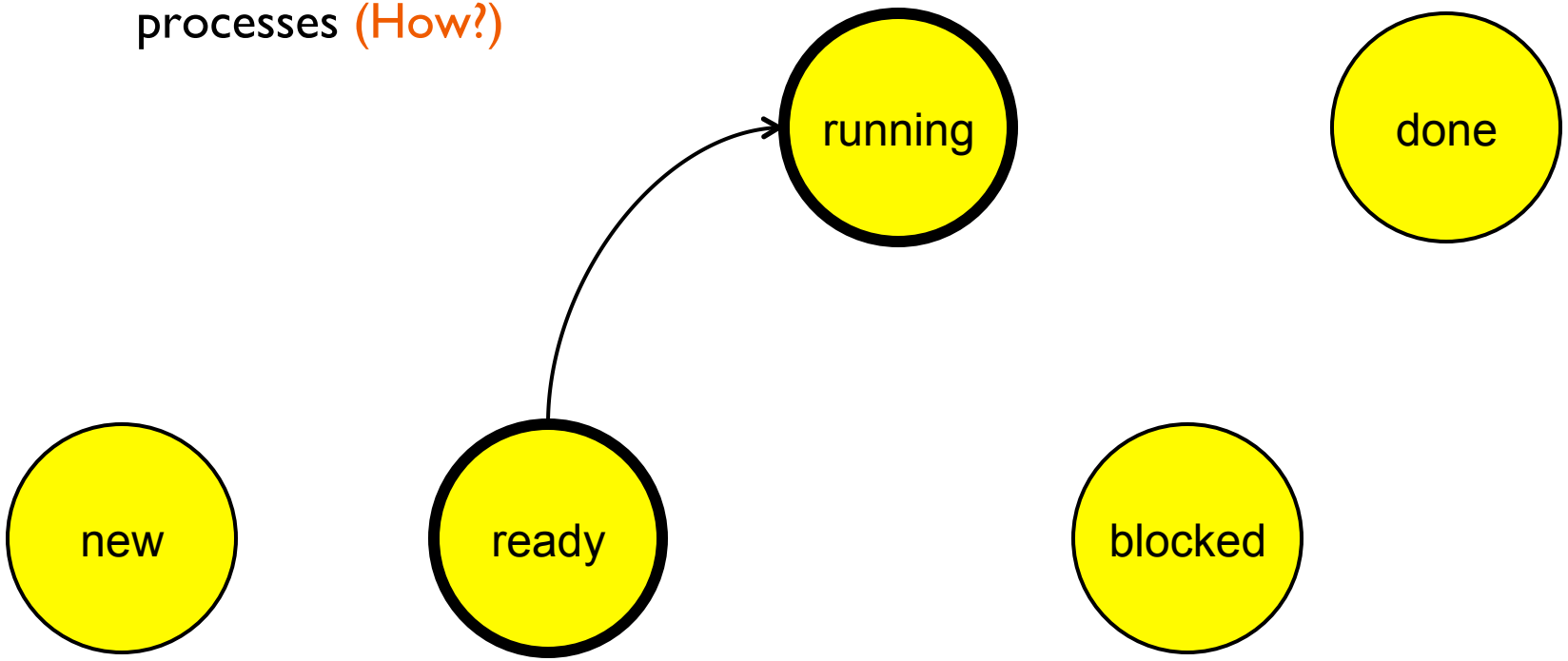
- Move to pool of executable processes



# 5 State Model: Transitions

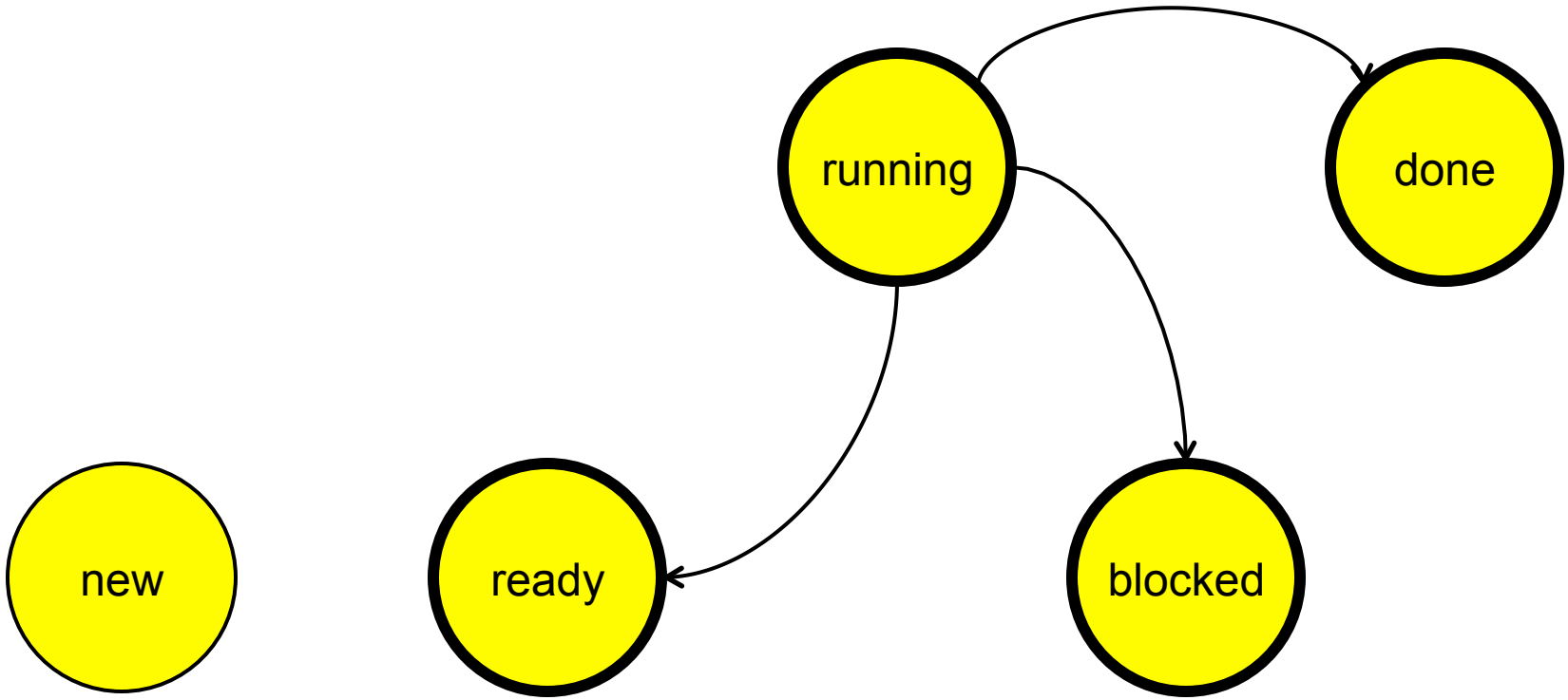
Ready to Running

- Chosen to run from the pool of processes (How?)



# 5 State Model: Transitions

What events cause these transitions?



# 5 State Model: Transitions

Running to Ready

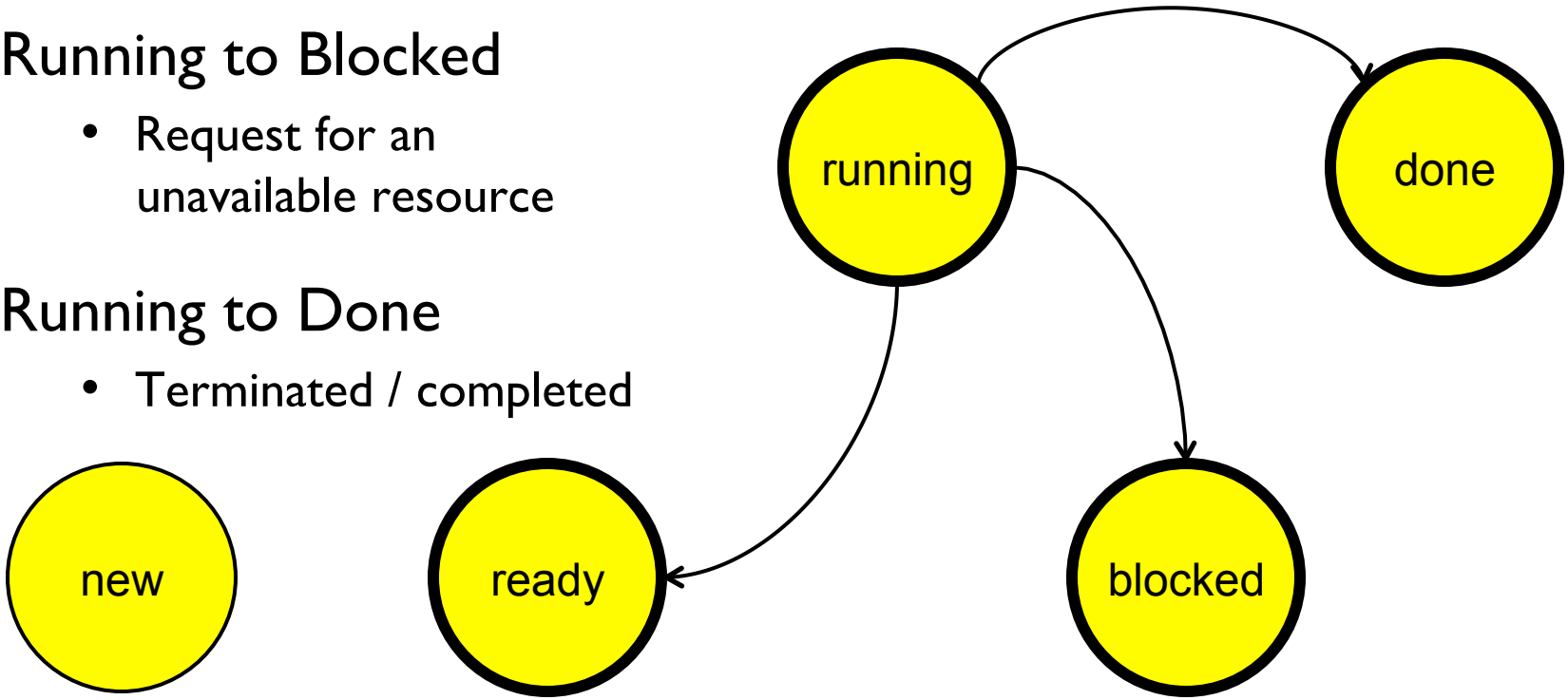
- Preempted by OS

Running to Blocked

- Request for an unavailable resource

Running to Done

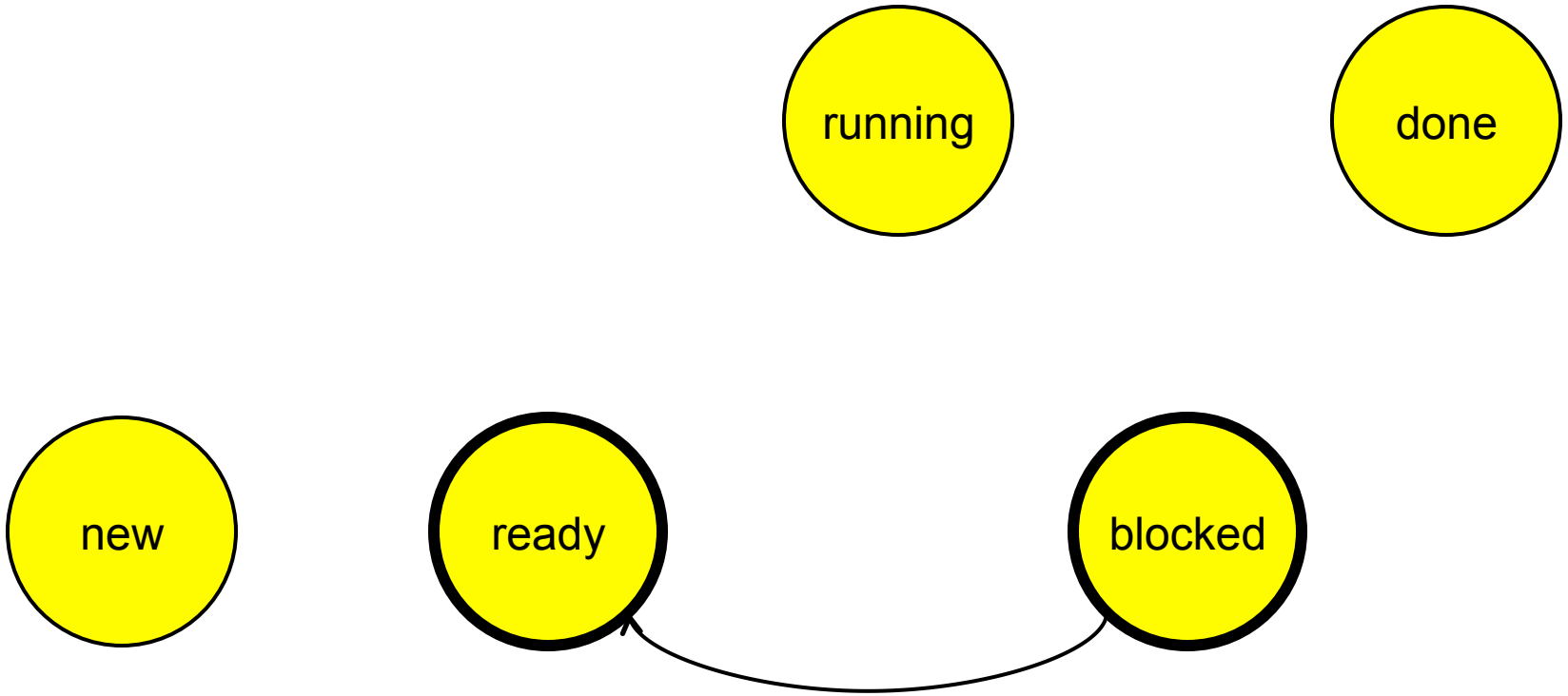
- Terminated / completed



# 5 State Model: Transitions

Blocked to Ready

- Resource is now available



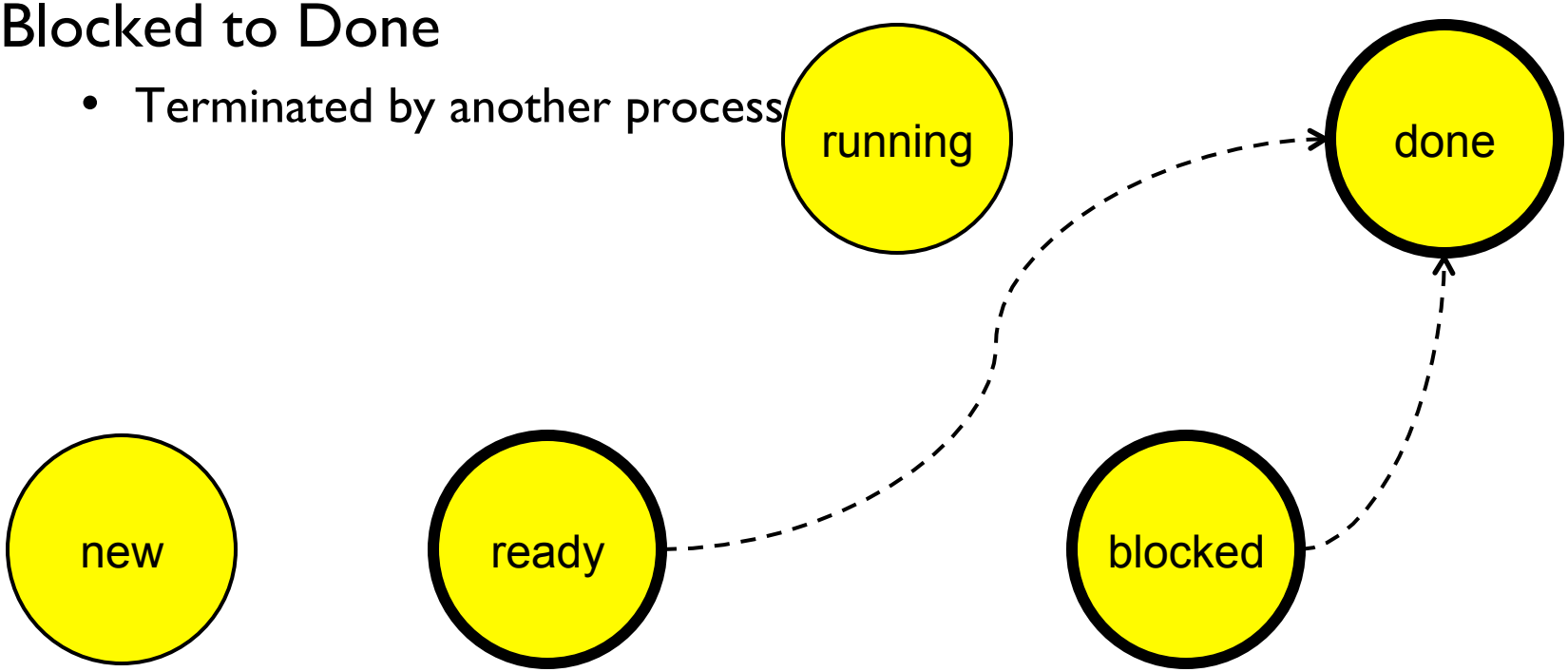
# 5 State Model: Transitions

Ready to Done

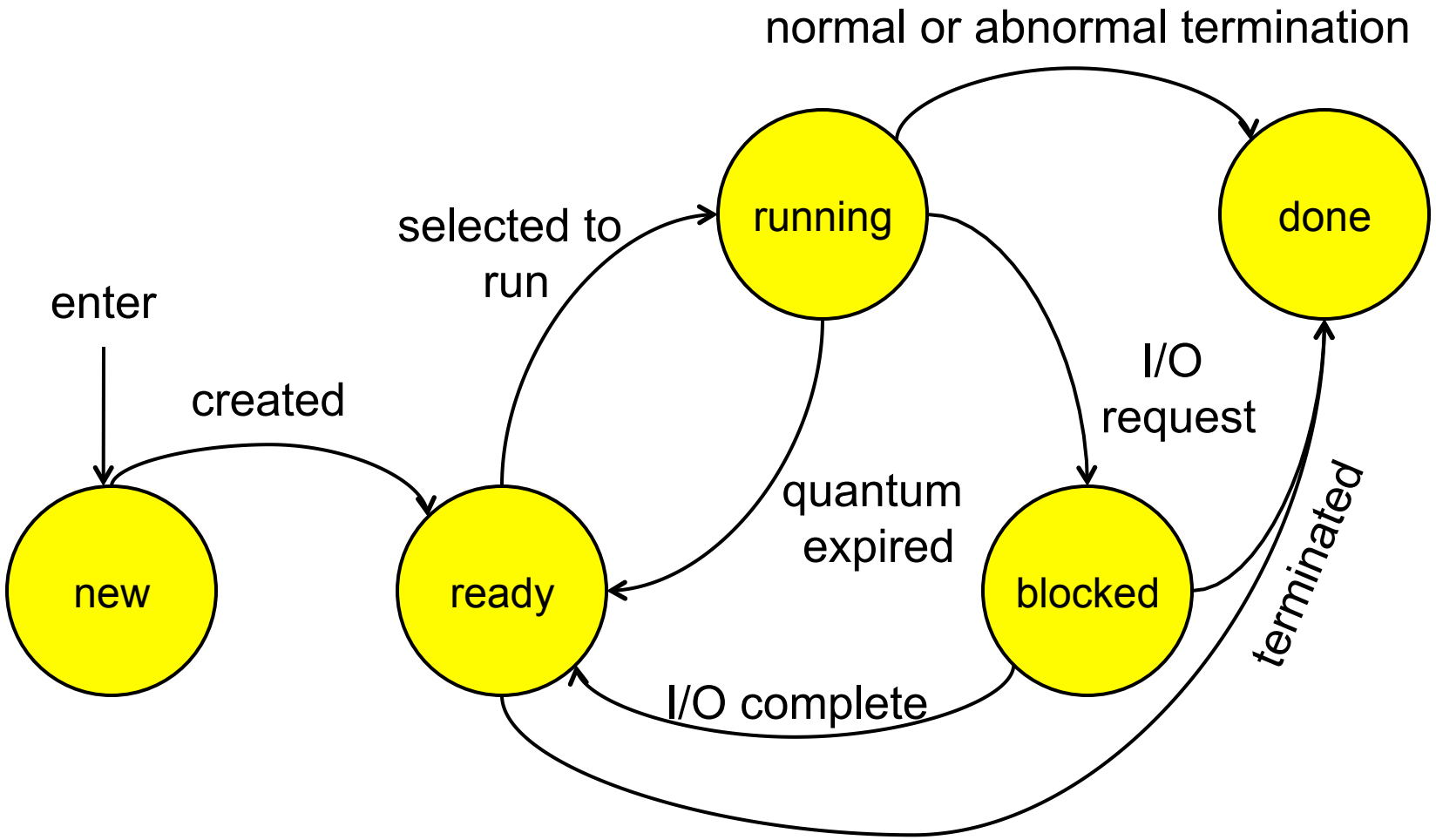
- Terminated by another process

Blocked to Done

- Terminated by another process

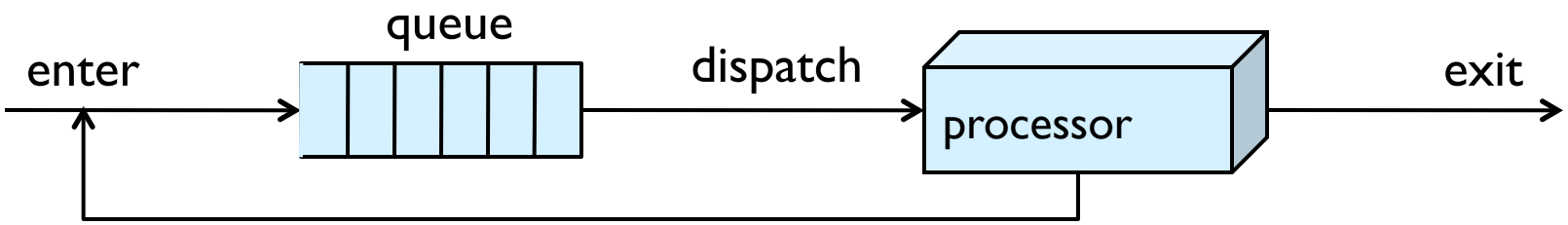


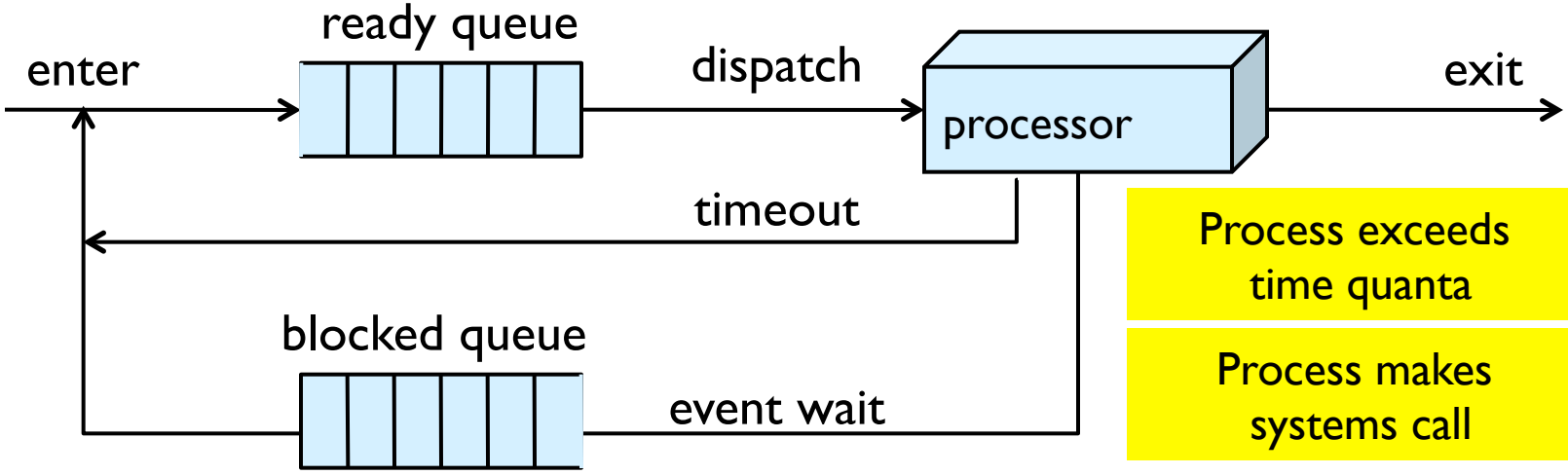
# 5 State Model: Transitions



# Process Queue Model

2 State Model: What is missing?

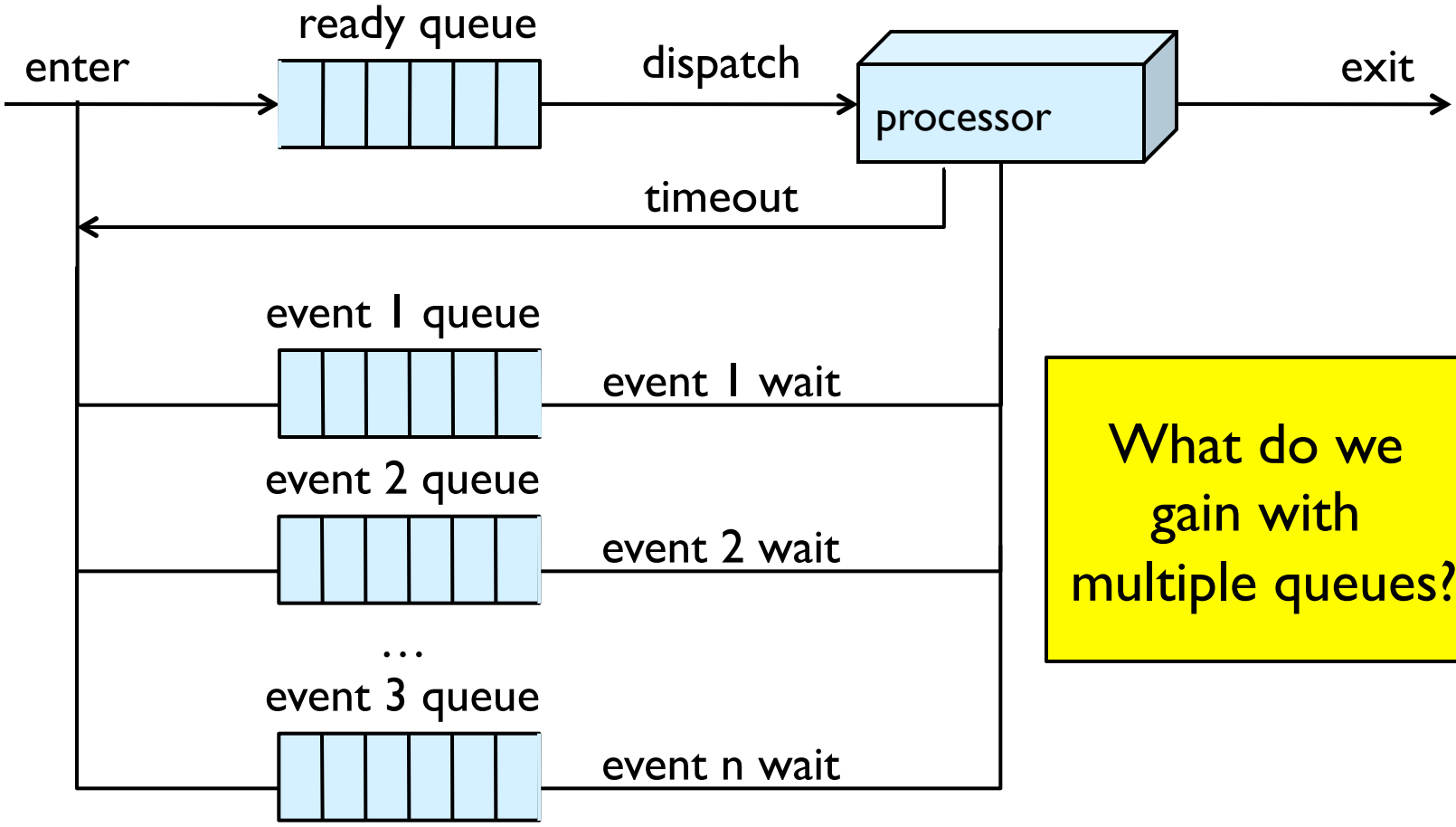



Process exceeds time quanta

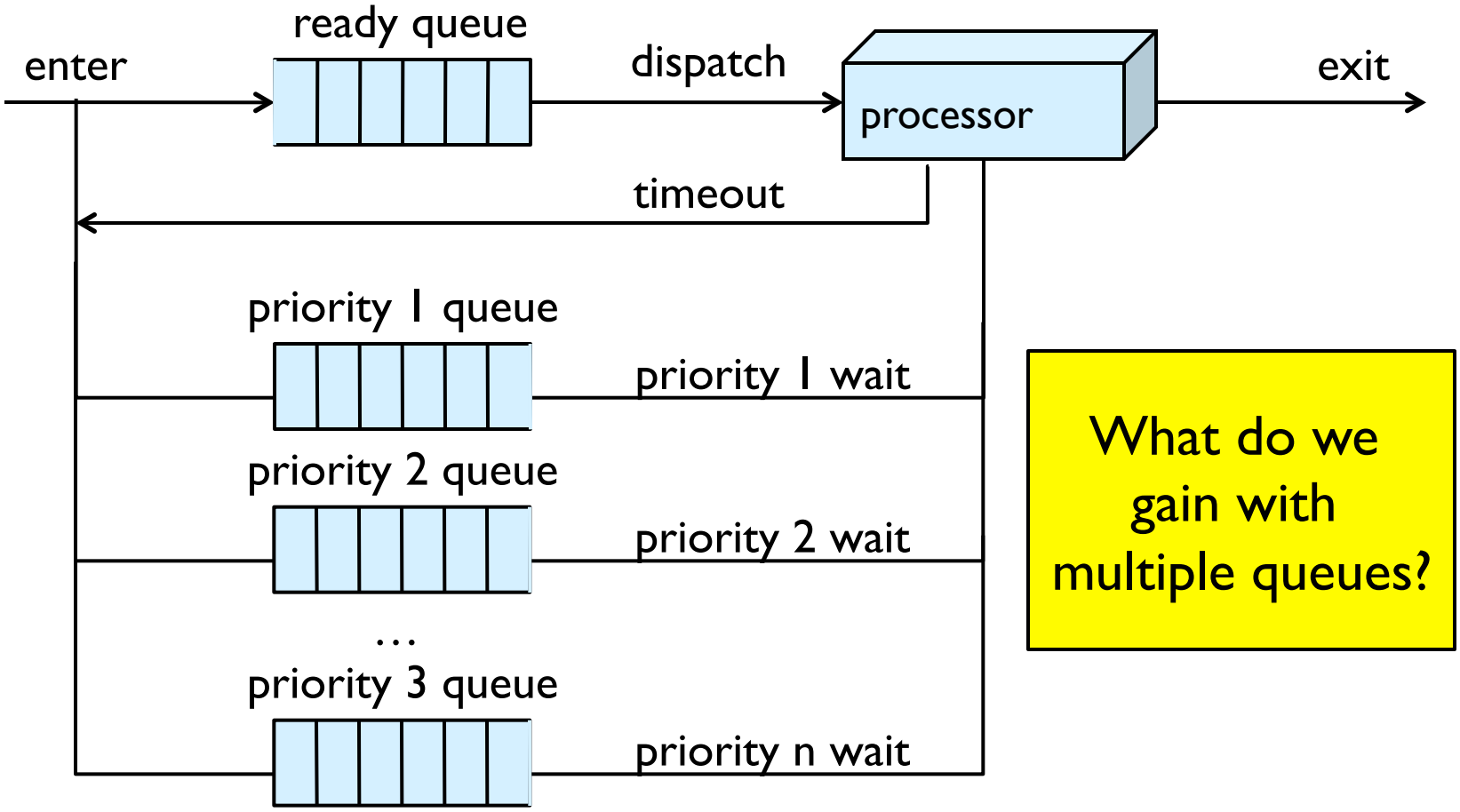
Process makes systems call

# Process Queue Model




What do we gain with multiple queues?

# Process Queue Model




What do we gain with multiple queues?

# Take-away questions

What would happen if user processes were allowed to disable interrupts?

In a single CPU system what is the maximum number of processes that can be in the running state?

# From Processes to Threads

CS 241

February 17, 2012

# Processes vs. threads

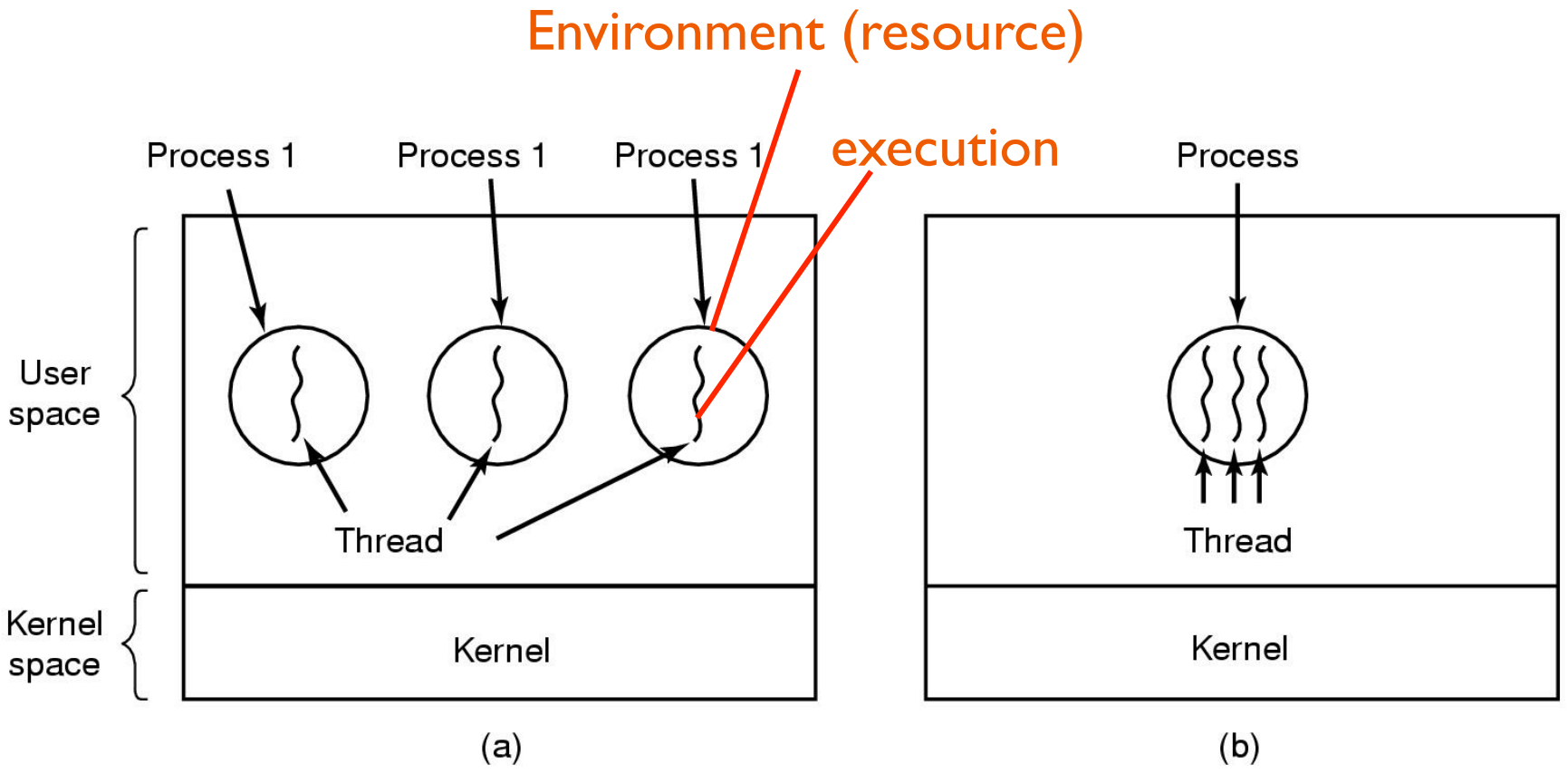
Process

- Fork is expensive (time & memory)

Thread

- A lightweight process: little memory, fast startup
- Shared memory among threads in a process

# Processes vs. threads




Three processes each with one thread

One process with three threads

# Processes vs. threads

Each process can include many threads

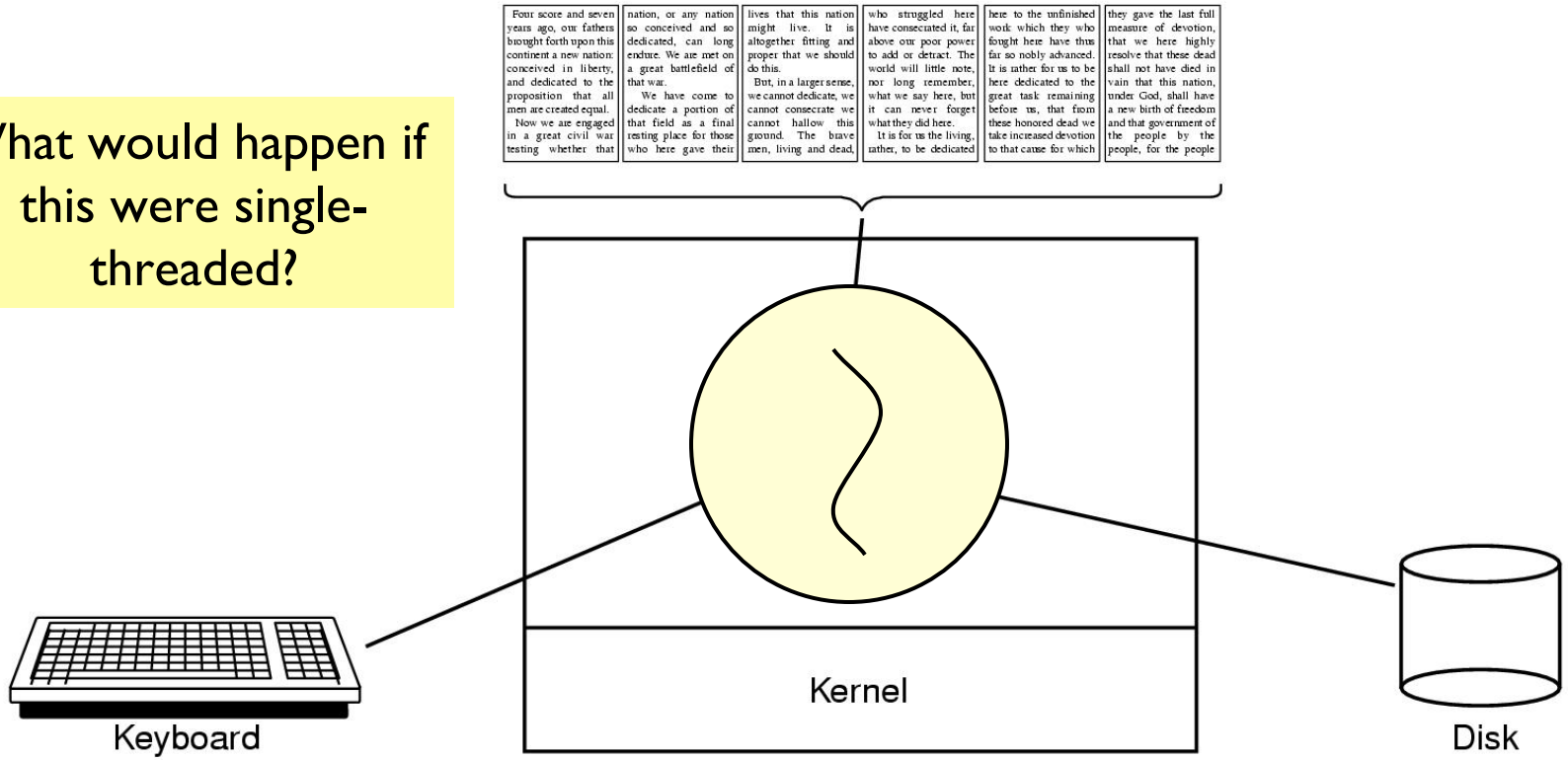
All threads of a process share:

- Process ID
- Memory (program code and global data)
- Open file/socket descriptors
- Working environment (current directory, user ID, etc.)
- Semaphores *(covered later in the course)*
- Signal handlers and signal dispositions *(covered later in the course)*

# Thread usage: word processor

Working file can only be accessed by one process at a time

What would happen if this were single-threaded?



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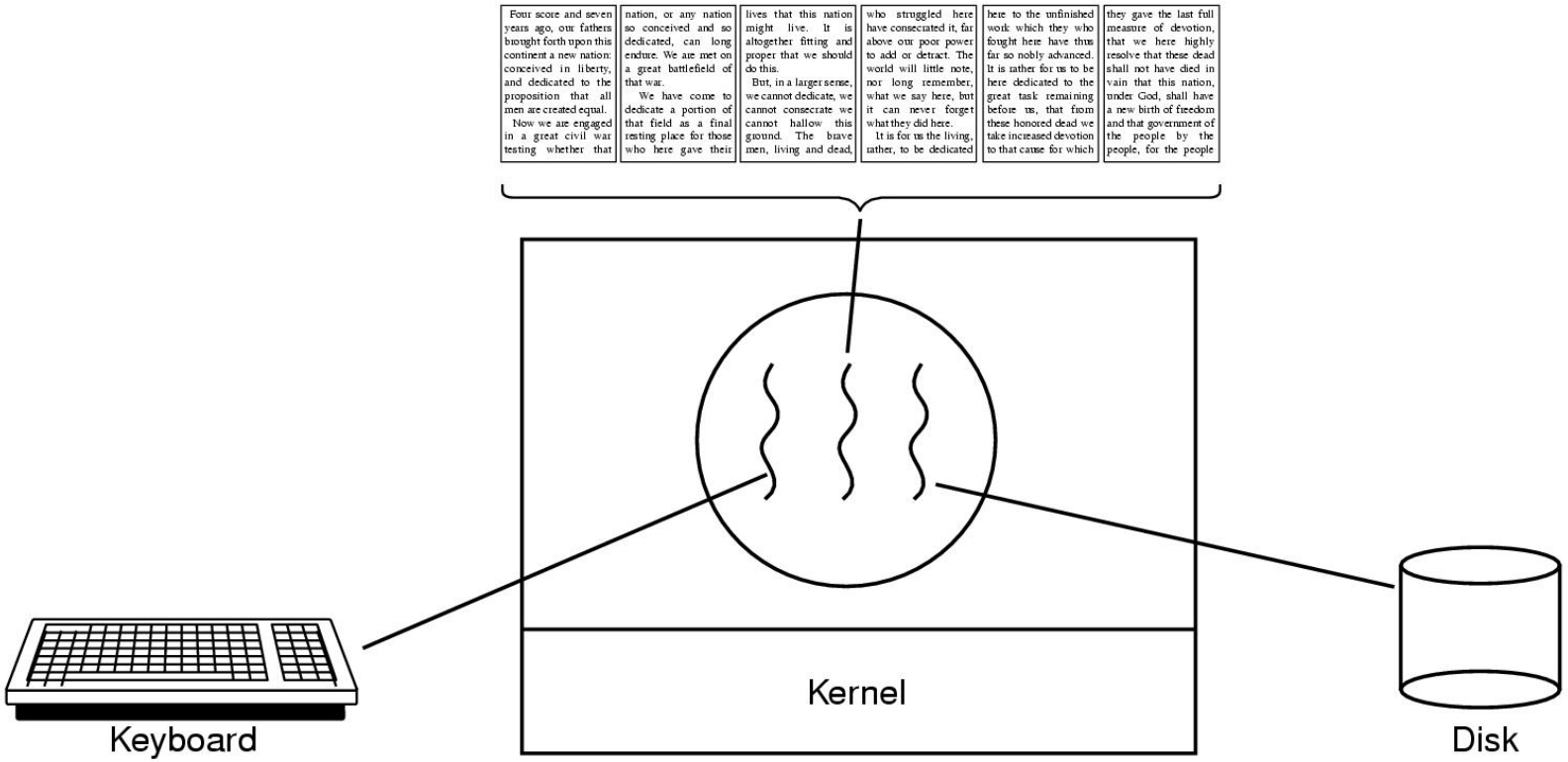
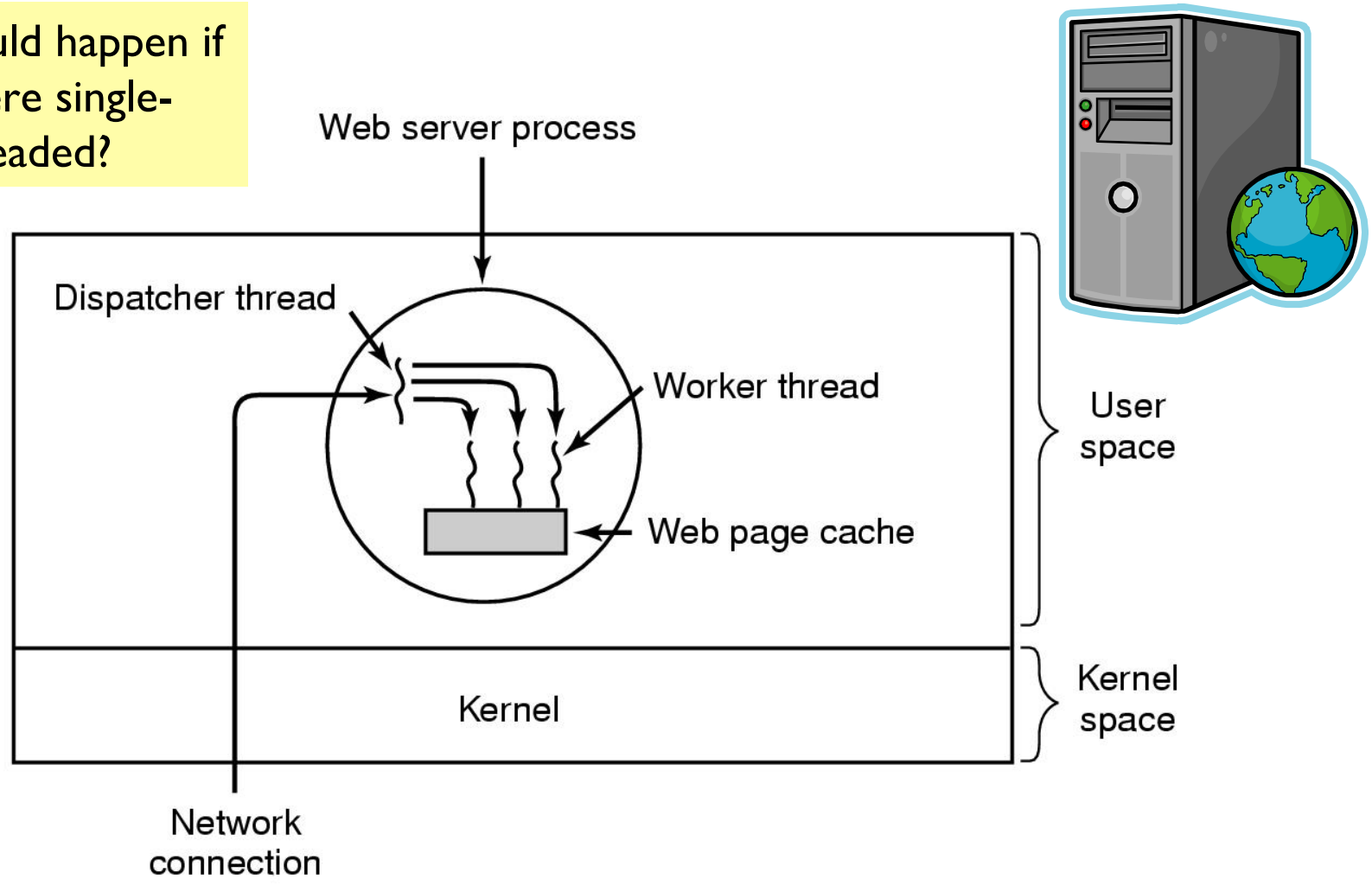


# Thread usage: web server

What would happen if this were single-threaded?

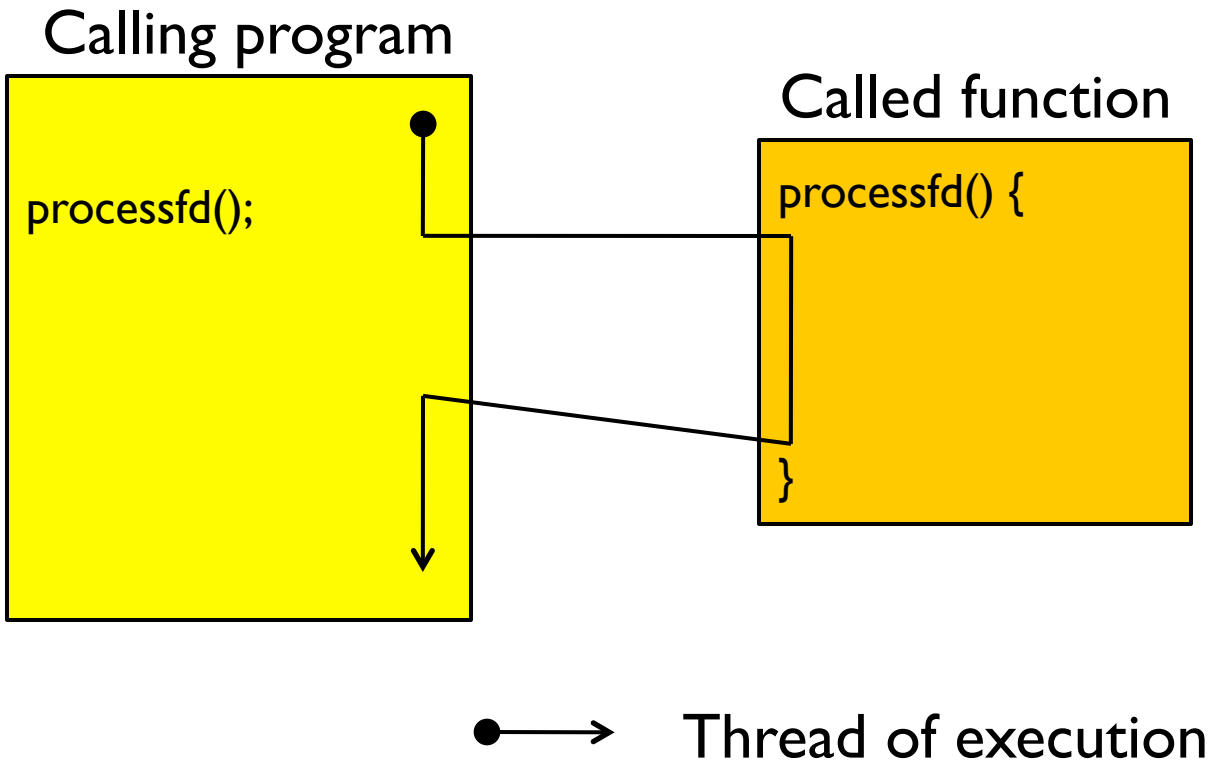


# Thread of execution

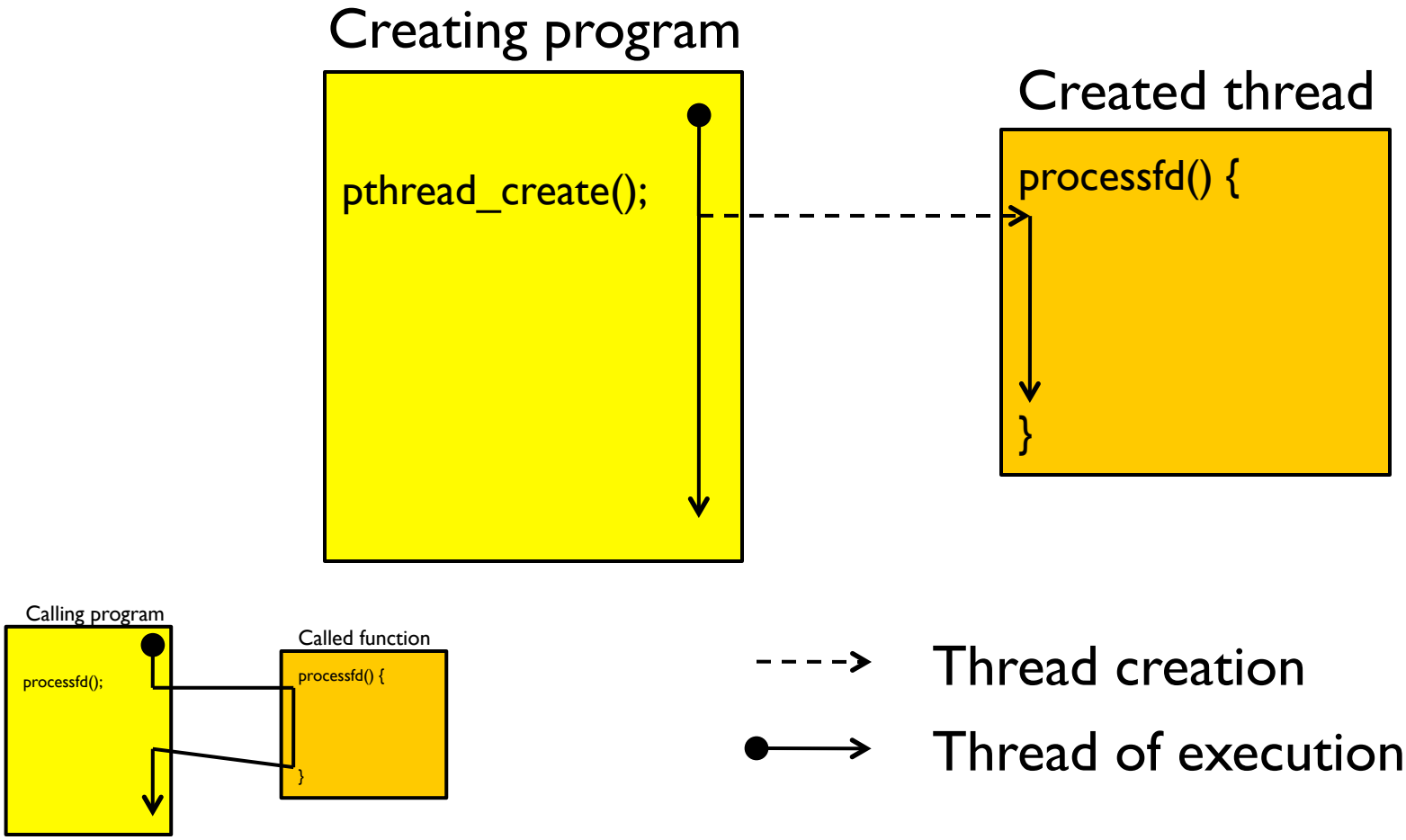
Sequential set of instructions

- Each has its own function calls & automatic (local) variables
- Need program counter and stack for each thread

# Normal 1-thread function call



# Compare: Threaded function call



# Thread Execution States

Events associated with a change in thread state:

- Spawn (another thread)
- Block
  - Should blocking a thread block other, or all, threads?
- Unblock
- Finish (thread)
  - De-allocate register context and stacks

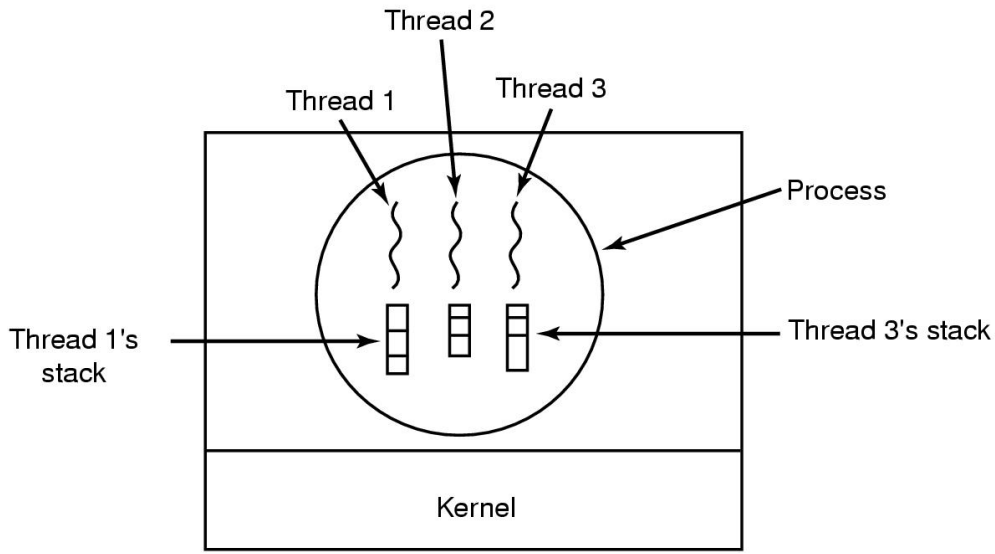
# Thread-Specific Resources

Each thread has its own

- Thread ID (integer)
- Stack, Registers, Program Counter

Threads in one process can communicate via shared memory

- Must be done carefully!



# Processes vs. Threads

| Per Process Items | Per Thread Items |
|---|---|
| Address space<br>Global variables<br>Open files<br>Child processes<br>Pending alarms<br>Signals and signal handlers<br>Accounting information | Program counter<br>Registers<br>Stack<br>State |

Each thread executes separately

Threads in the same process share many resources

No protection among threads!! (What?)

# Process vs. thread creation

| Platform | fork() | | | pthread_create() | | |
|---|---|---|---|---|---|---|
| | real | user | sys | real | user | sys |
| AMD 2.3 GHz Opteron (16 cpus) | 12.5 | 1.0 | 12.5 | 1.2 | 0.2 | 1.3 |
| AMD 2.4 GHz Opteron (8 cpus) | 17.6 | 2.2 | 15.7 | 1.4 | 0.3 | 1.3 |
| IBM 4.0 GHz POWER6 (8 cpus) | 9.5 | 0.6 | 8.8 | 1.6 | 0.1 | 0.4 |
| IBM 1.9 GHz POWER5 p5-575 (8 cpus) | 64.2 | 30.7 | 27.6 | 1.7 | 0.6 | 1.1 |
| IBM 1.5 GHz POWER4 (8 cpus) | 104.5 | 48.6 | 47.2 | 2.1 | 1.0 | 1.5 |
| INTEL 2.4 GHz Xeon (2 cpus) | 54.9 | 1.5 | 20.8 | 1.6 | 0.7 | 0.9 |
| INTEL 1.4 GHz Itanium2 (4 cpus) | 54.5 | 1.1 | 22.2 | 2.0 | 1.2 | 0.6 |

http://www.llnl.gov/computing/tutorials/pthreads.

Timings reflect 50,000 process/thread

Creations were performed with the **`time`** utility, and units are in seconds, no optimization flags.

# Key points

Threads are lightweight

- Is this good or bad?

Threads share memory and other resources

- (Still have own stack, registers, PC, state)
- Is this good or bad?

# Next time

Monday: Using threads

Tuesday: MP3 Shell due