Operating Systems!

Process Implementation

From *"how to use processes"* to *"how an OS implements them!"*

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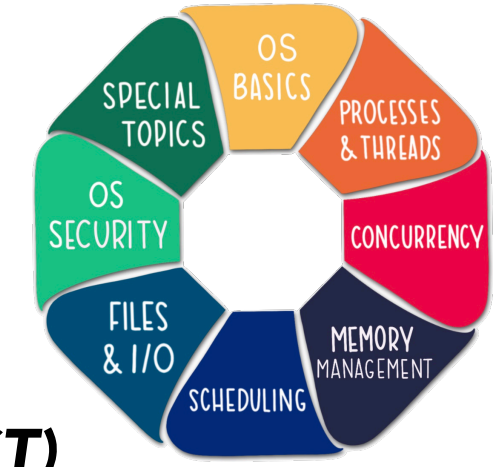
Montana State University

CS 460 - Operating Systems

Fall 2020

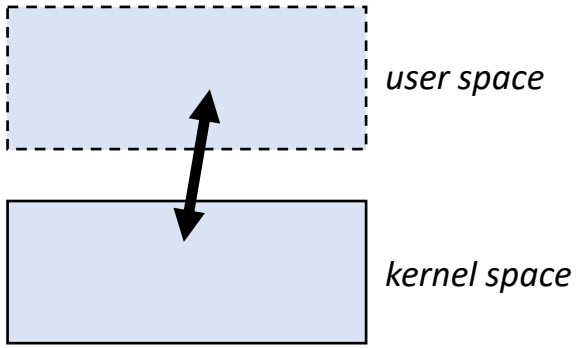
https://www.cs.montana.edu/cs460

Today



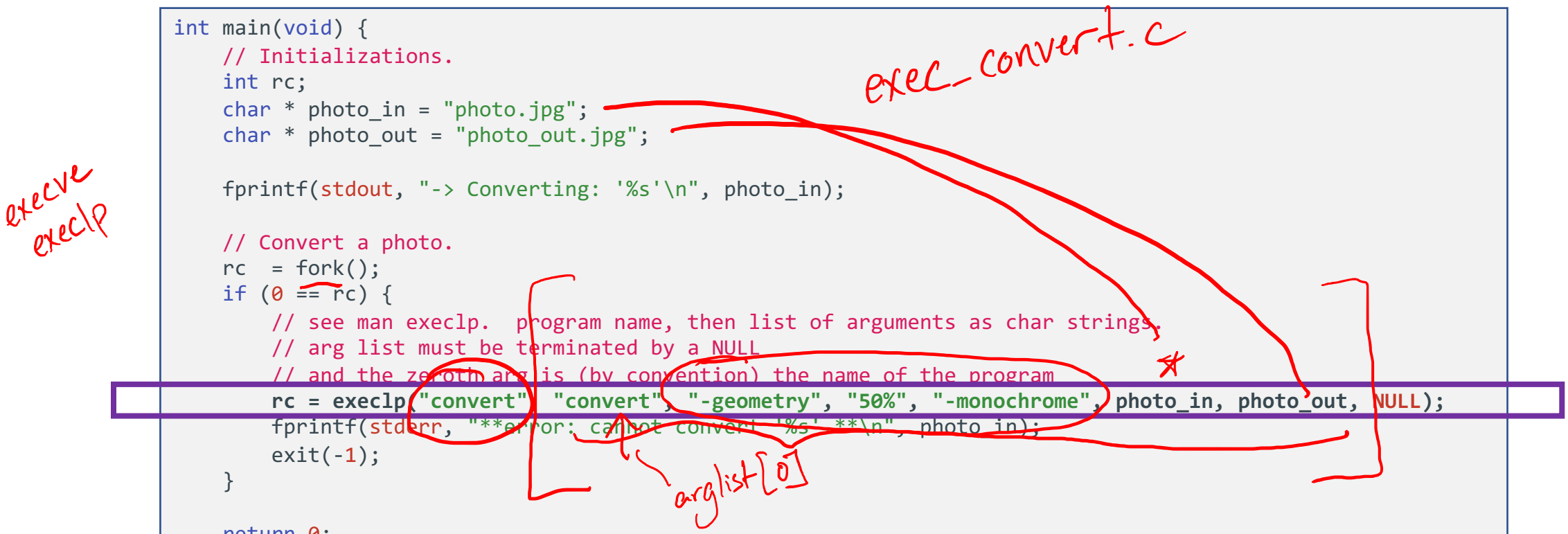
- Announcements
  - *Heads up.... PA1 due* ***Sunday [09/20/2020] @ 11:59 PM (MST)***

- Learning Objectives
  - Understand the big ideas behind the "OS API"
    - ~~**user vs. kernel, modes, syscalls, libraries**~~
  - Understand the big ideas behind process control
    - *[theory]* **control info, creation, termination, states, etc.**
    - *[reality]* ~~**fork, exec, getpid, waitpid, etc.**~~



PA 1… *Don't overthink it! Read directions and study the demos in* ***week04/***

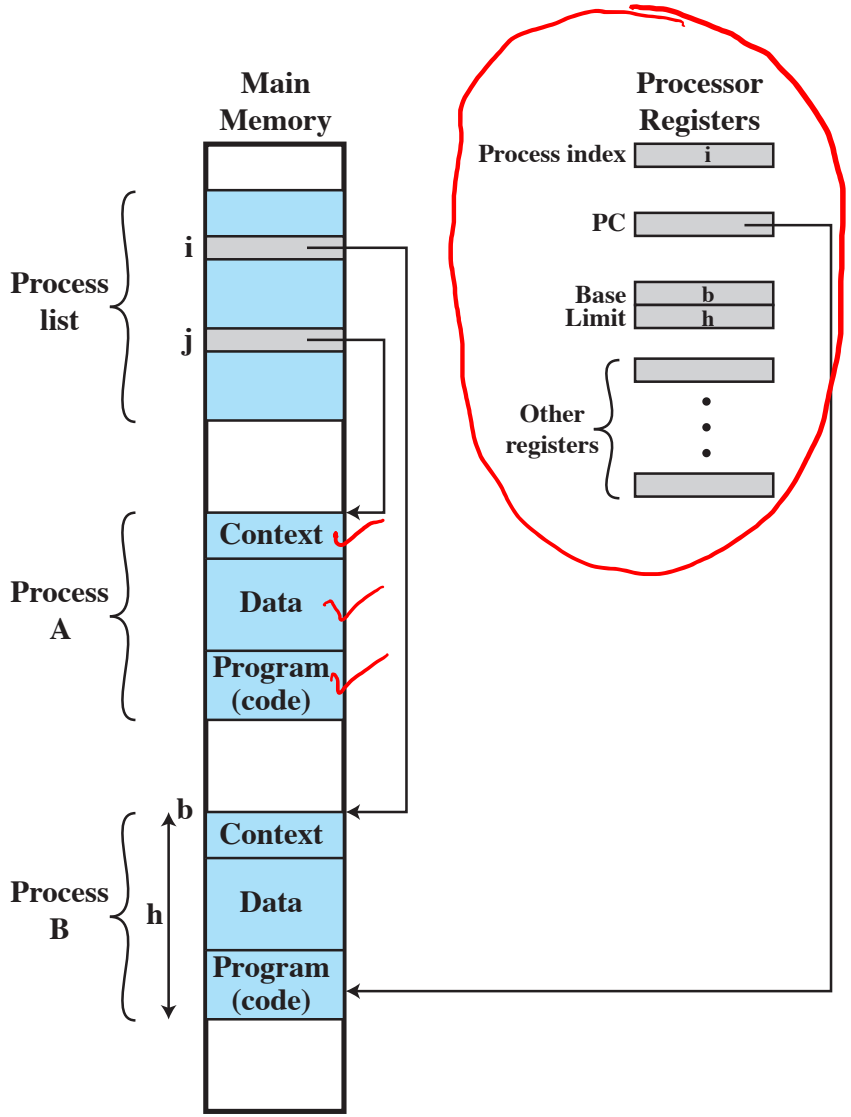
```c
int main(void) {
    // Initializations.
    int rc;
    char * photo_in = "photo.jpg";
    char * photo_out = "photo_out.jpg";

    fprintf(stdout, "-> Converting: '%s'\n", photo_in);

    // Convert a photo.
    rc  = fork();
    if (0 == rc) {
        // see man execlp.  program name, then list of arguments as char strings,
        // arg list must be terminated by a NULL
        // and the zeroth arg is (by convention) the name of the program
        rc = execlp("convert", "convert", "-geometry", "50%", "-monochrome", photo_in, photo_out, NULL);
        fprintf(stderr, "**error: cannot convert '%s' **\n", photo_in);
        exit(-1);
    }

    return 0;
}
```



- ✓ ***Video demo*** *(Use TechSmith or YouTube (unlisted!). Link in the README)*
- ✓ *No code to D2L! Everything must be pushed to* ***GitHub****! (under* **pa1/** *)*
- ✓ *Readable/organized* ***README***
- ✓ ***Read all instructions carefully! e.g., no system() – must use fork() and exec()!***

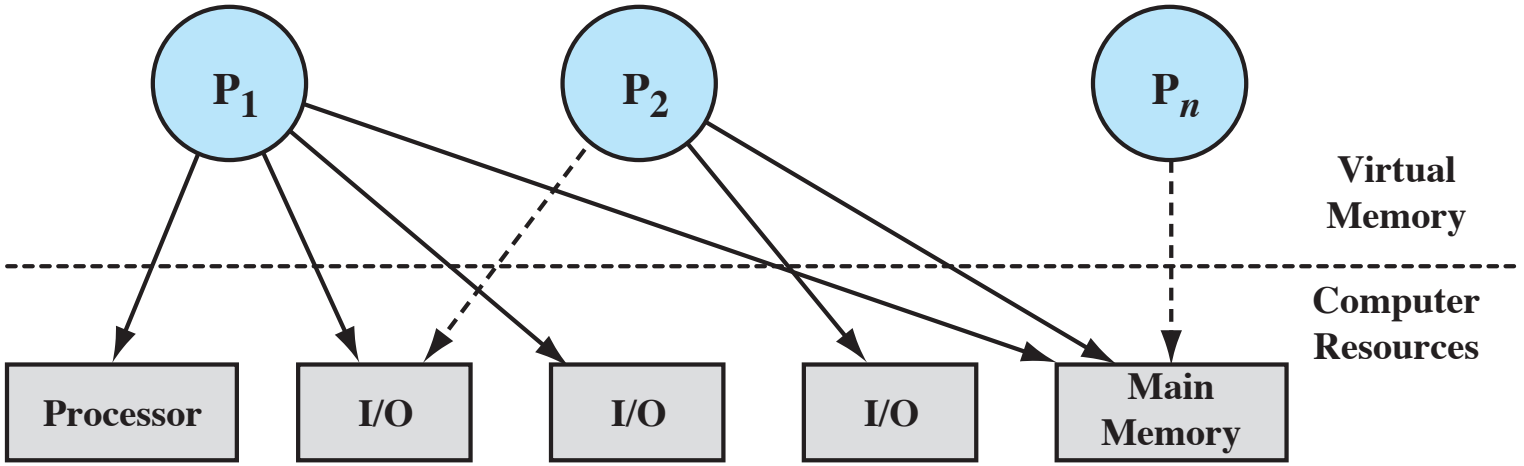
So... *Why Use Processes?*

- To have a nice abstraction / standardization (code & data)
- To exploit (potential) parallelism
- To exploit pipelining
- To permit concurrency
- To accommodate more than one user
- Convenience for programmers
- Easier portability, extensibility, maintenance
- To allow interleaving / multiprogramming
- *etc.*



The OS As The Resource Manager

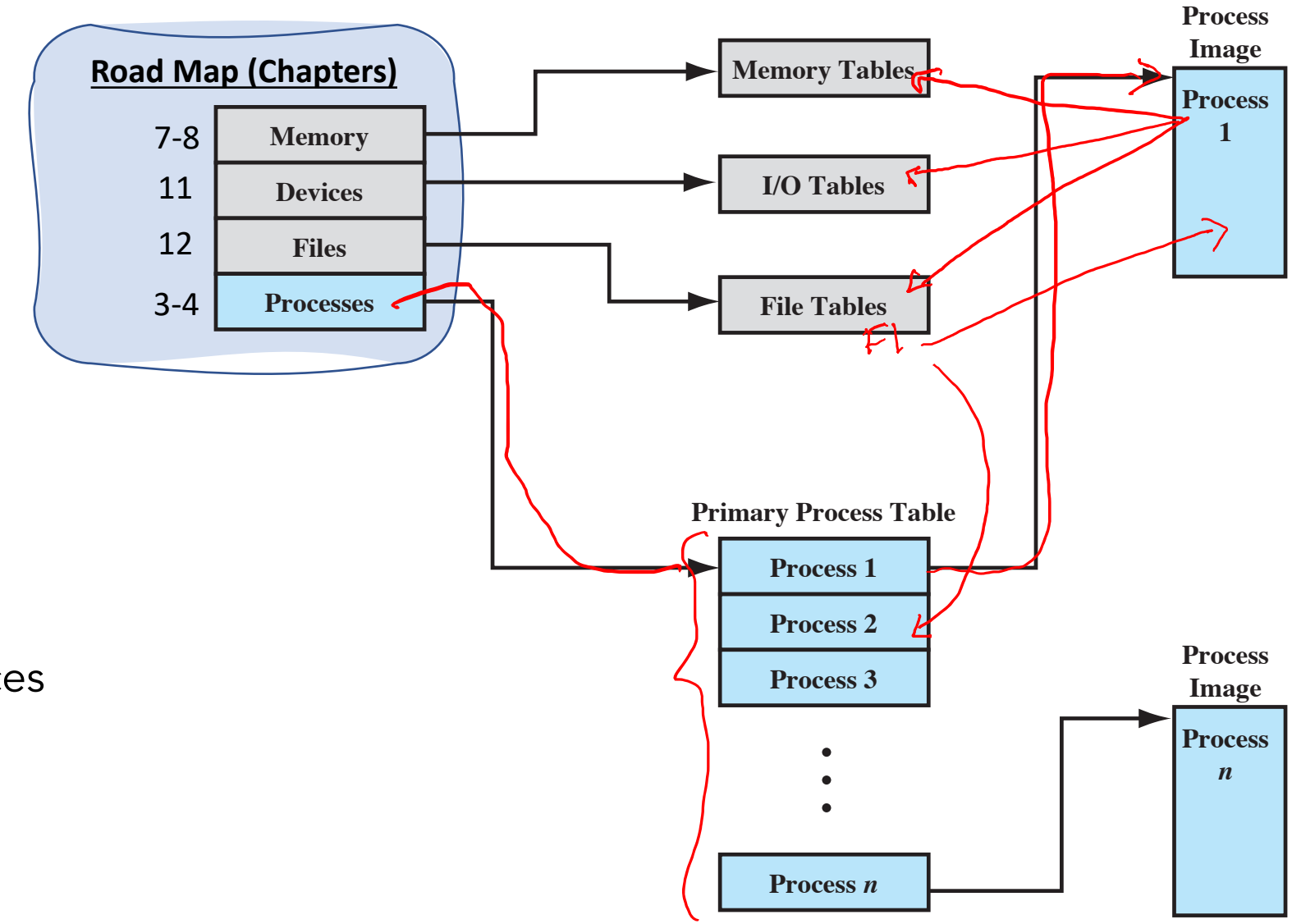
Q: What information does the OS need to know to control processes and manage system resources for them?



- ***Process states & data structures***
- ***Maintaining information about processes***
- ***Address spaces*** *(userspace AND kernelspace)*
- *Reflection/Revisit: Process switching*
- *Reflection/Revisit: Syscalls*

OS Control Structures

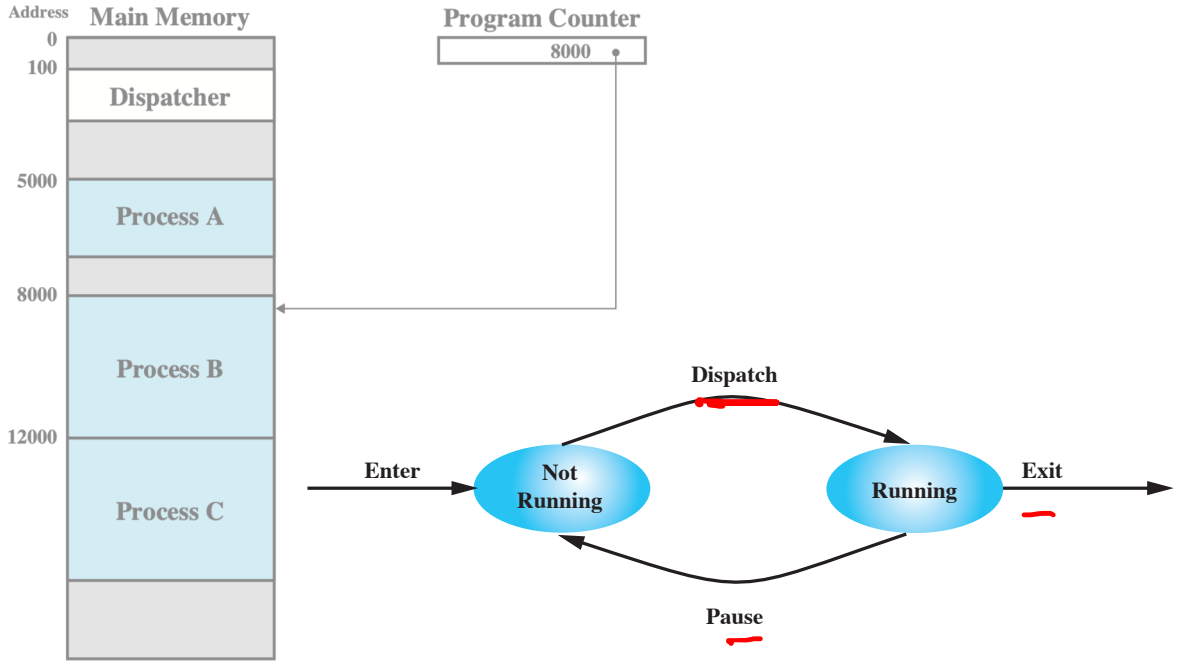
- What does the OS need to know to manage resources?
- The OS maintains tables of information about resources it manages
- There are lots of cross-references between these tables!



Process States
& Data Structures

Process States (2 States)

- Simple two-state process model:
  - process is either **running** or **not running**
  - running == on the processor
  - not running == not on the processor



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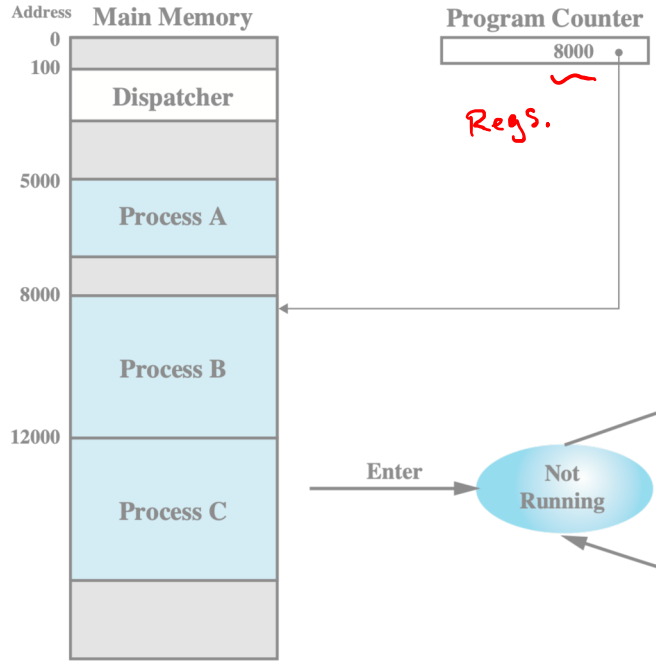
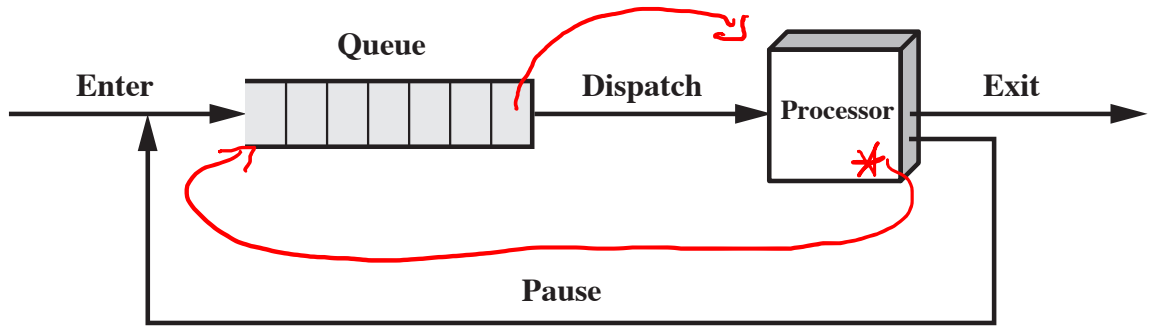


Q: In a single processor machine, how many processes can be running?

Q: What do you do with the other processes?

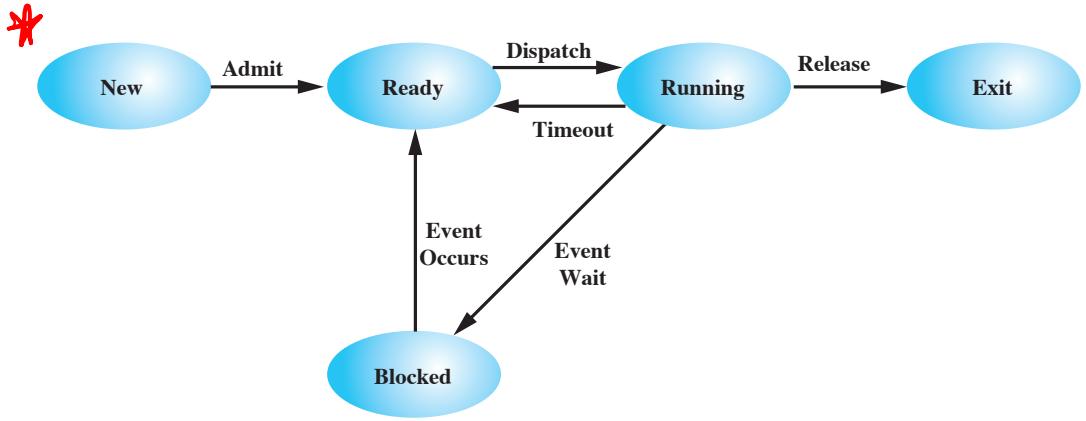


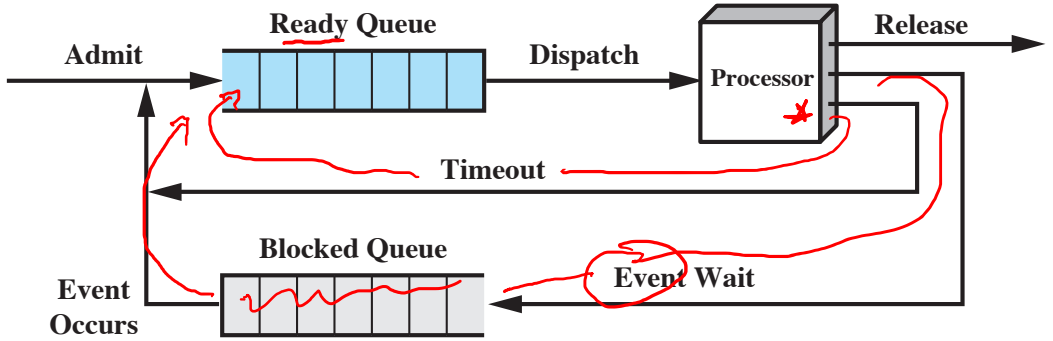
Q: But what if not all processes are ready to execute? (What problems could arise with only a single queue?)

Process States (5 States)

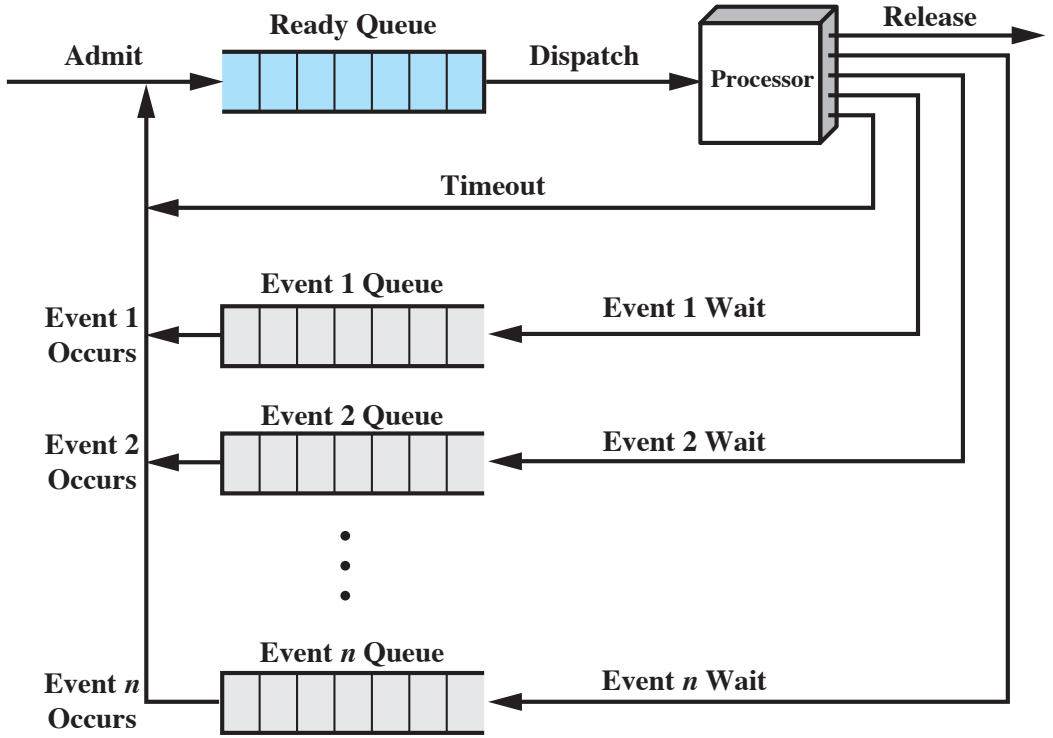
Additional States:

- **New**—the process is being created
- **Ready**—the process is ready to run; waiting to be assigned to a processor
- **Running**—the process is running
- **Blocked**—the process is waiting for an event to occur (e.g., I/O)
- **Exit**—the process has finished execution





(a) Single blocked queue

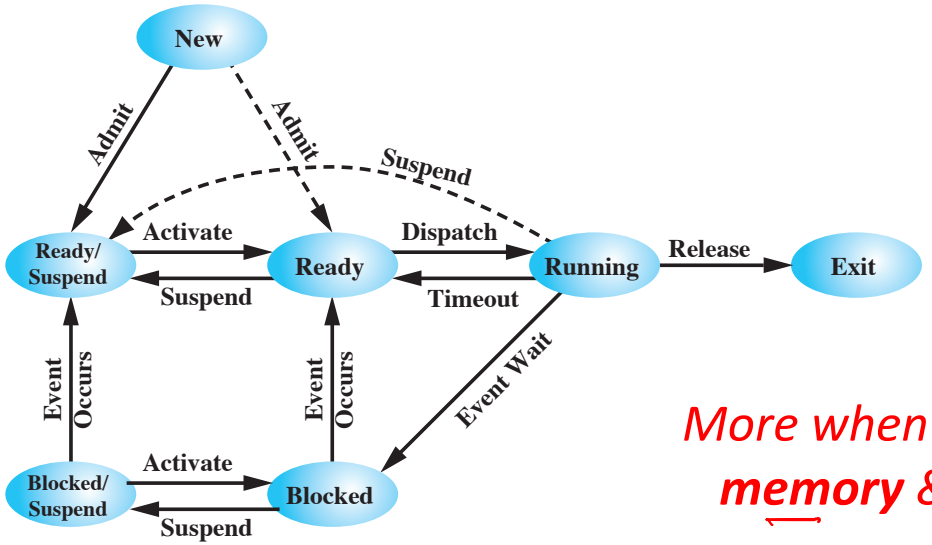


(b) Multiple blocked queues

See Textbook...

- Step by step "traces" *(switching between processes and dispatcher)*

- 5-State Process Model
  + suspension/swapping



More when we talk about ***memory*** *&* ***scheduling***

1	5000	
2	5001	
3	5002	
4	5003	
5	5004	
6	5005	
----------	Timeout	
7	100	
8	101	
9	102	
10	103	
11	104	
12	105	
13	8000	
14	8001	
15	8002	
16	8003	
----------	I/O Request	
17	100	
18	101	
19	102	
20	103	
21	104	
22	105	
23	12000	
24	12001	
25	12002	
26	12003	
27	12004	
28	12005	
----------	Timeout	
29	100	
30	101	
31	102	
32	103	
33	104	
34	105	
35	5006	
36	5007	
37	5008	
38	5009	
39	5010	
40	5011	
----------	Timeout	
41	100	
42	101	
43	102	
44	103	
45	104	
46	105	
47	12006	
48	12007	
49	12008	
50	12009	
51	12010	
52	12011	
----------	Timeout	

100 = Starting address of dispatcher program

Shaded areas indicate execution of dispatcher process;
first and third columns count instruction cycles;
second and fourth columns show address of instruction being executed

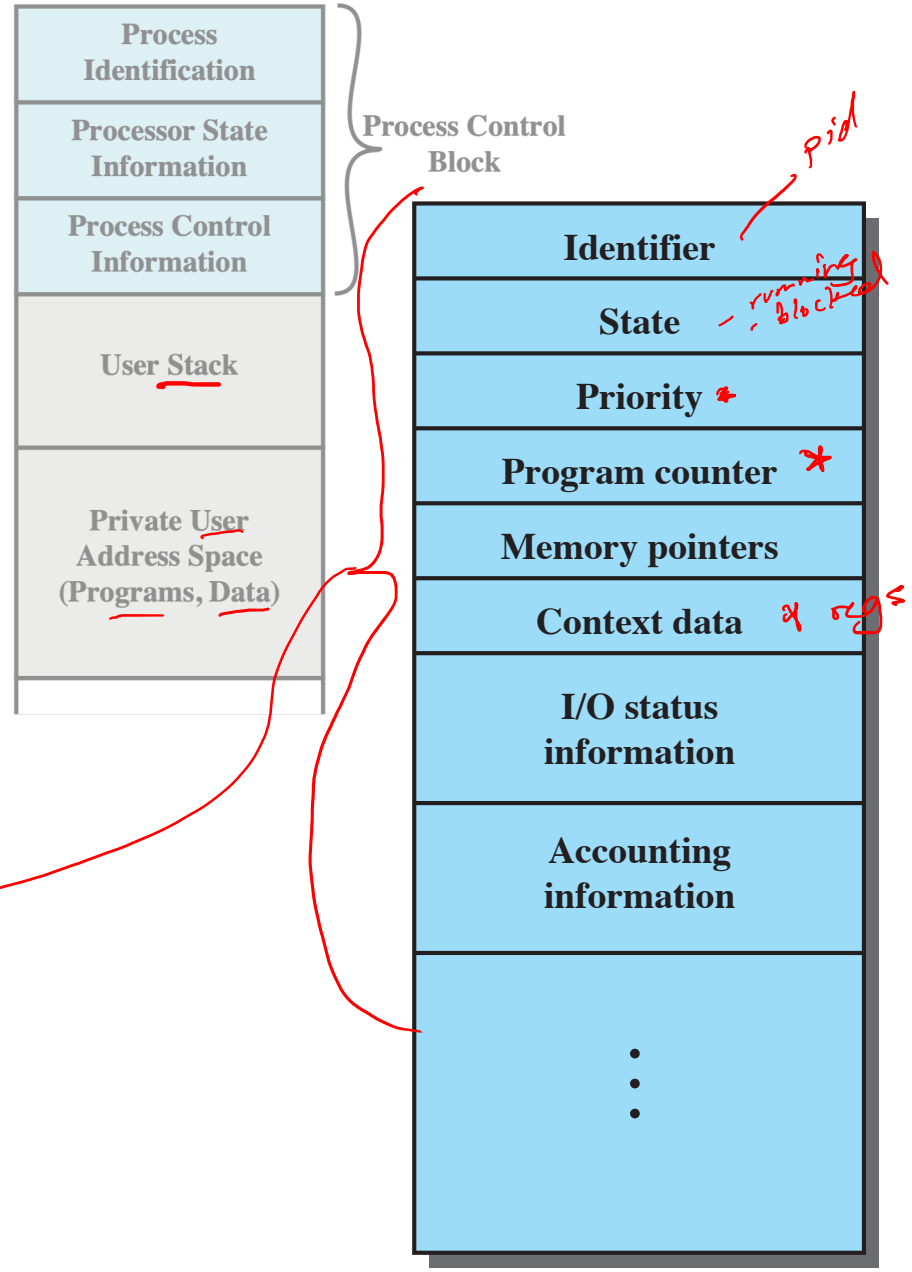
Process Context

The Details of a "Process"

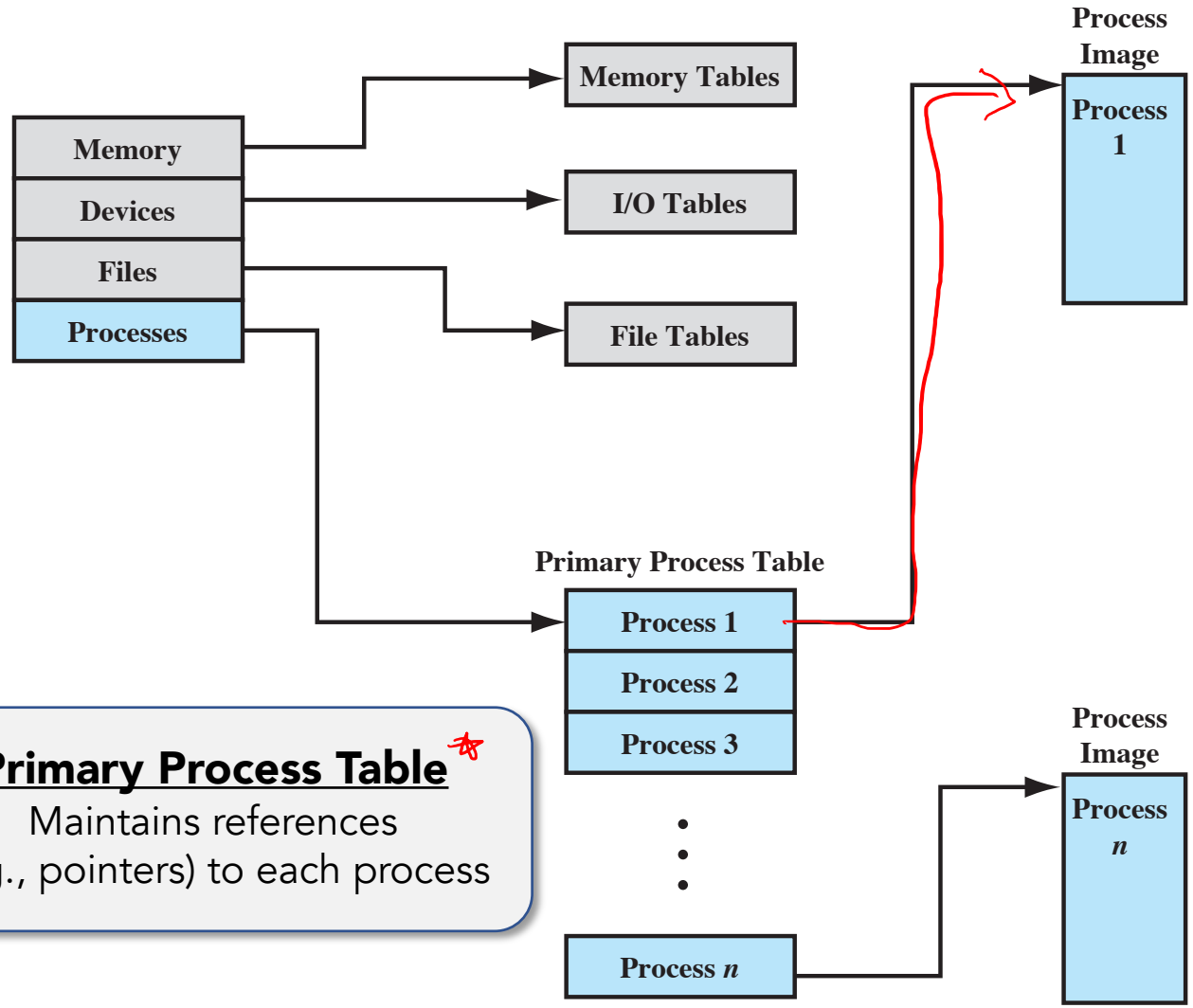
- The **Process Control Block (PCB)**
  - Holds the **"context"**
  - A **"snapshot"** that contains all necessary information to restart a process where it left off.

Textbooks call it a "PCB," but many real-world OSs use a different name for this structure (e.g., `task_struct`)

- We can get all sorts of info about procs.
  - `getpid()`, `getppid()`, `getpriority()`, …
  - *Also:* `ps`, `top`, `htop`, `procfs`



The Details of a "Process"



Primary Process Table
Maintains references (e.g., pointers) to each process

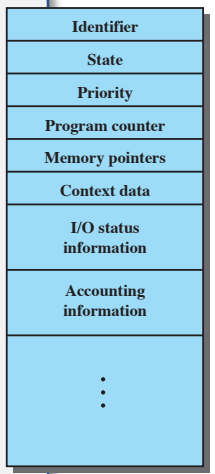
Process Image
Collection of code, data, stack, and attributes (PCB)

Process Attributes

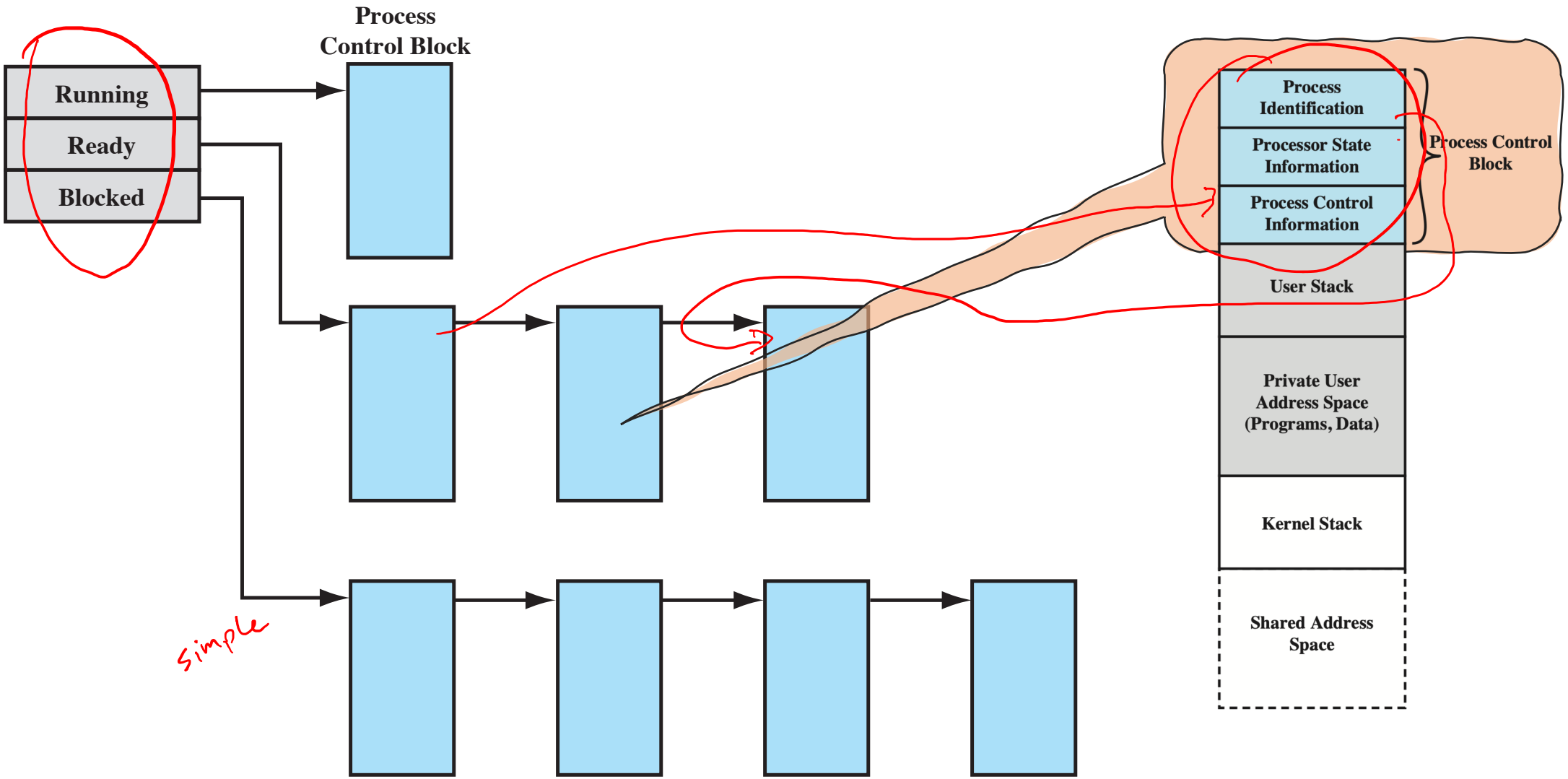
1. Proc. ID Info
PID, PPID, UID, etc.

2. Processor State Info
Registers (User-visible, Status, Control), Stack Pointers, etc.
(maintains info after process is interrupted!)

3. Proc. Control Info
Scheduling & State Info, IPC, Privileges, Files, Page Tables (Memory), etc.



Recall Process States



Summary: The Role of the PCB

- PCB is the most important data structure in a modern OS
  - contains ALL of the information about a process that is needed by the OS
  - Blocks are read and/or modified by virtually *every* module in the OS
  - Defines the state of the OS

- **Q:** What could go wrong?!

- Difficulty is ***not access***, but ***protection***
  - A bug in a single OS routine could damage PCBs, which could destroy the system's ability to manage the affected processes
  - A design change in the structure or semantics of the PCB could affect many modules in the OS
  - Must tightly control access to the PCB…
    …all PCB changes happen through a designated handler routine