Operating System Concepts

Lecture 4b: Process Abstraction

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MWF 12:00-12:50 VVC 2 215

Today's class

- Process Abstraction
  - How does the OS create this abstraction?
  - Why is it useful?
  - What happens during context switching?

Process abstraction

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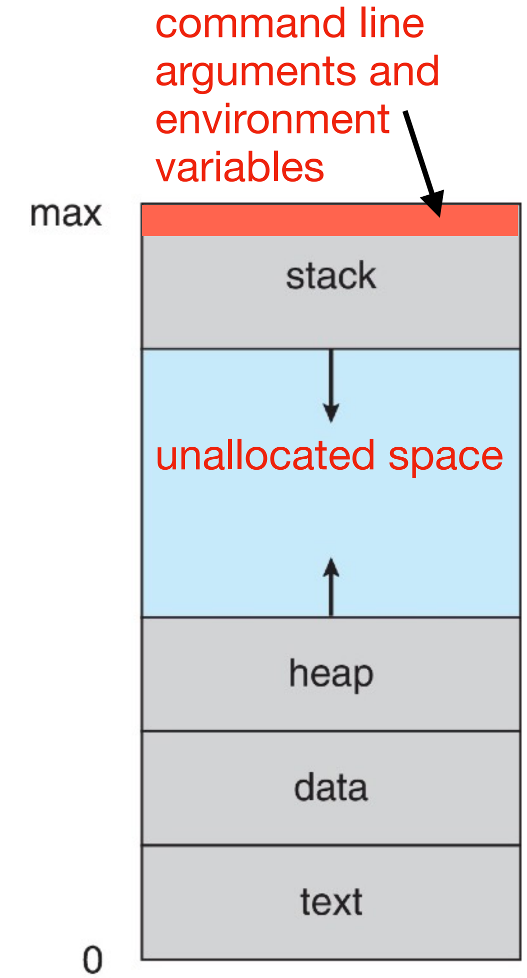
- why do we need the process abstraction?
  - necessary for concurrent execution and protection

Memory layout for process

- each process has multiple parts
  - text section containing the program code
  - data section containing global variables (initialized and uninitialized)
  - stack containing temporary data, function parameters, return addresses, and local variables
  - heap containing memory dynamically allocated during run time using malloc( ) from glibc or the **`sbrk( )` system call**



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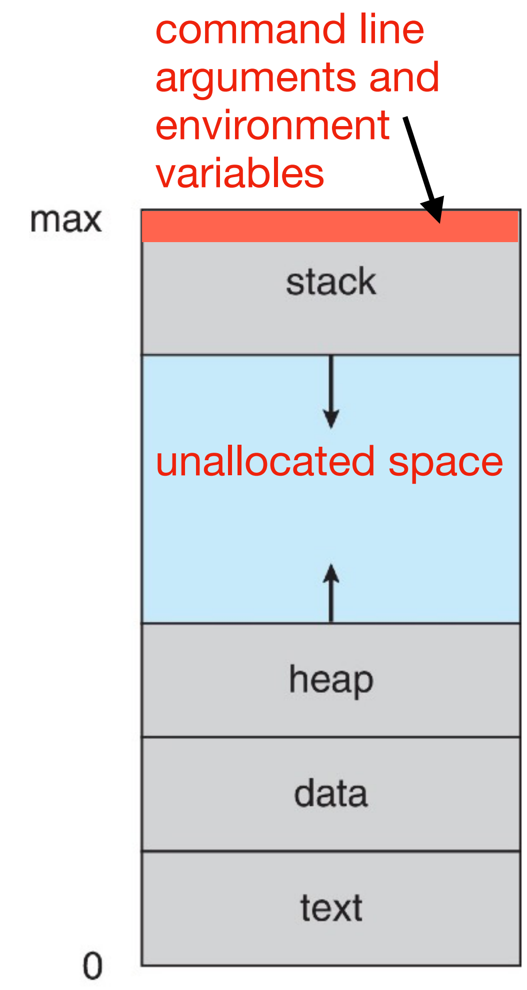
Which variables are in the stack?

```
#include <stdio.h>
void foo (int n) {
   int i, a[5], *b;
   if (n == 0) return;
   b = new int[n];
   printf ("foo(%d): %p,%p,%p,%p \n", n, &i, a, &b, b);
   foo(n-1);
}
main ( ) { foo(10); }
```



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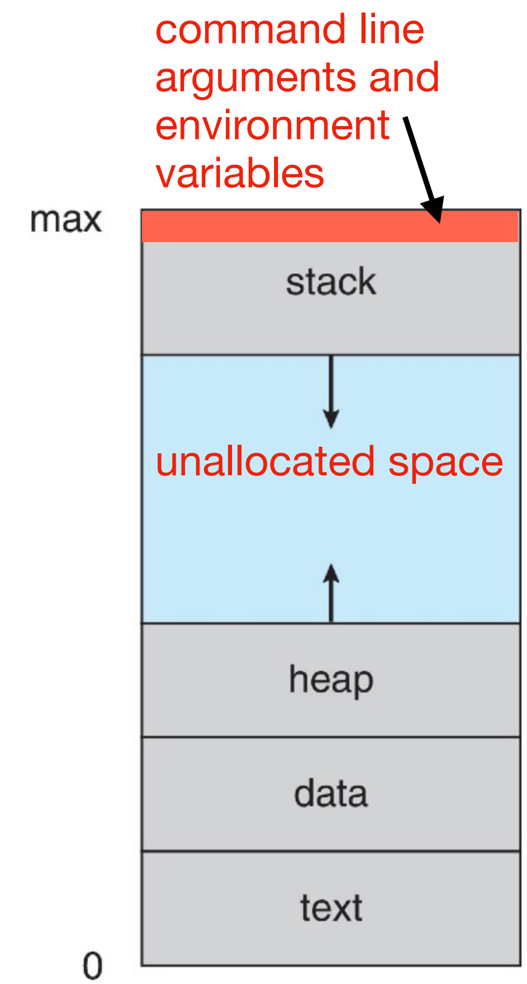

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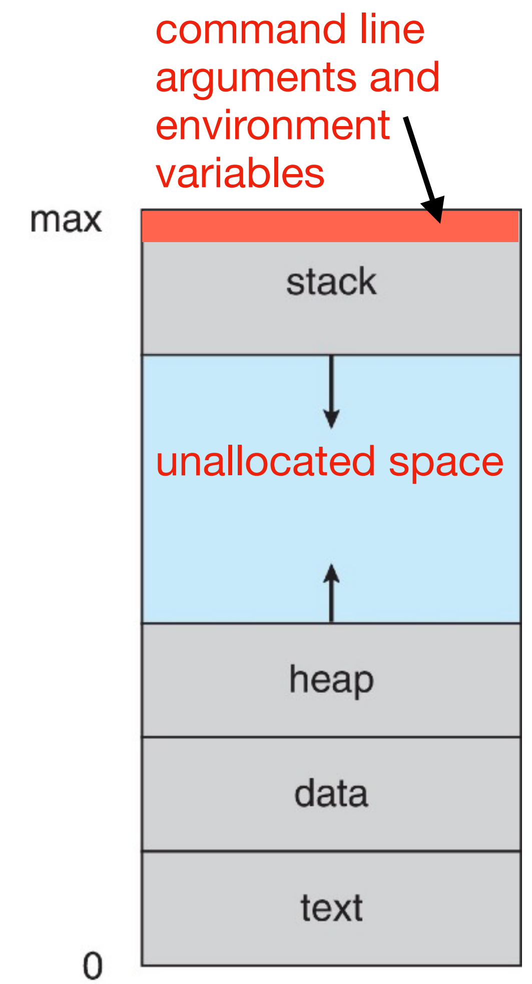
- hardware translates from virtual to physical addresses



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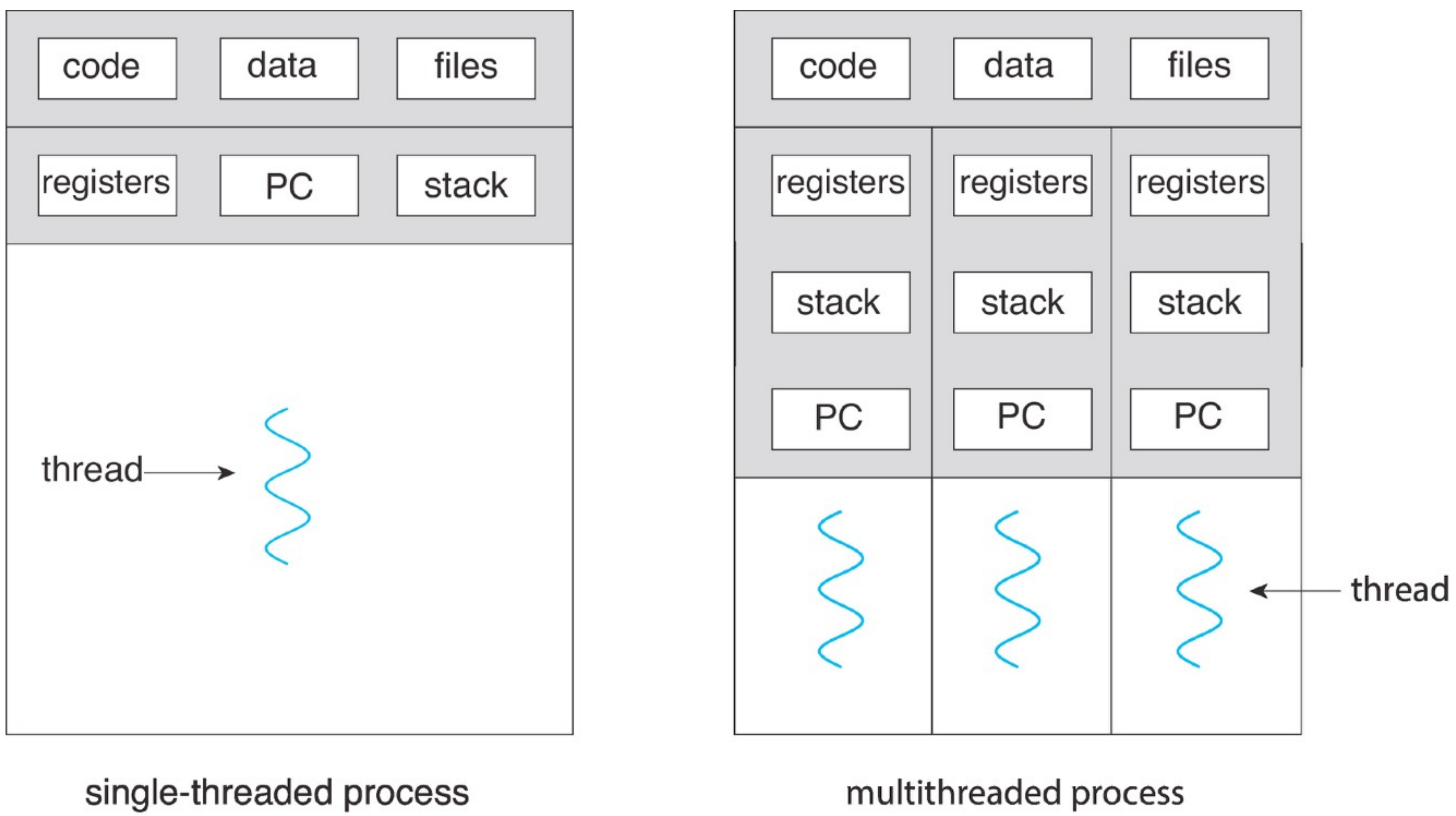

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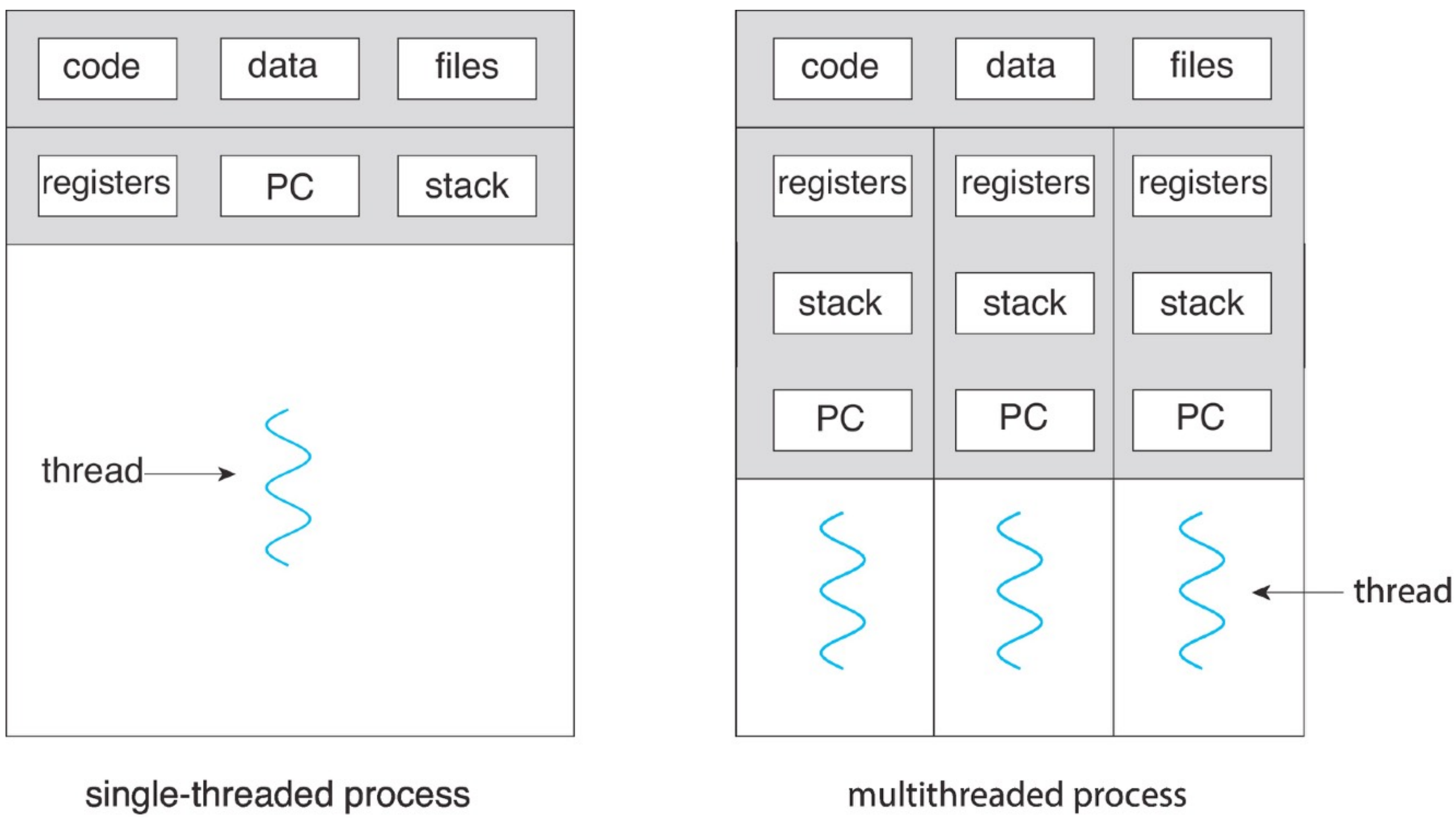
- threads can execute simultaneously on different cores of a multicore system
  - in a word processor you can simultaneously type a character and run the spell checker!



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- PCB is a kernel data structure in memory; it represents run-time information about the process, defining its **context**
  - Process status (running, ready, blocked/waiting)
  - Process ID (PID) and its children's PIDs
  - CPU registers' states, including program counter (PC), stack pointer (SP), heap pointer (HP), base/relocation and limit registers, page-table base register (PTBR), and general-purpose registers
  - Thread control block(s)
  - Address space
  - Accounting information (e.g., execution time, time elapsed since start)
  - Scheduling information (e.g., priorities, queue pointers for state queues)
  - Set of OS resources in use (e.g., list of open files, I/O devices allocated to the process)
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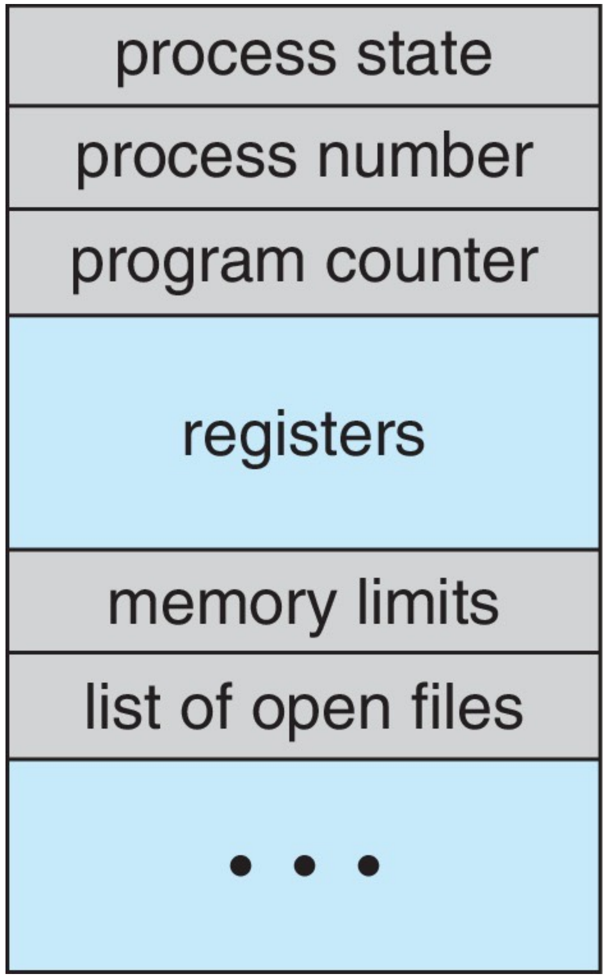
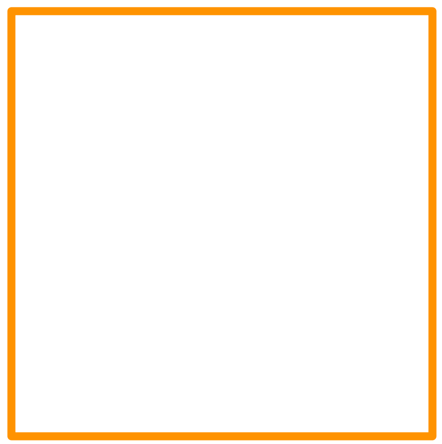
- PCB in Linux is represented by the C structure called task_struct which is defined in `<linux/sched.h>`
  - task_struct contains mm_struct which represents the address space of a given process



Loading — revisited

a.out



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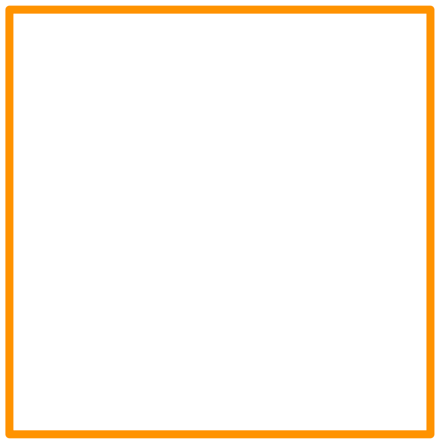

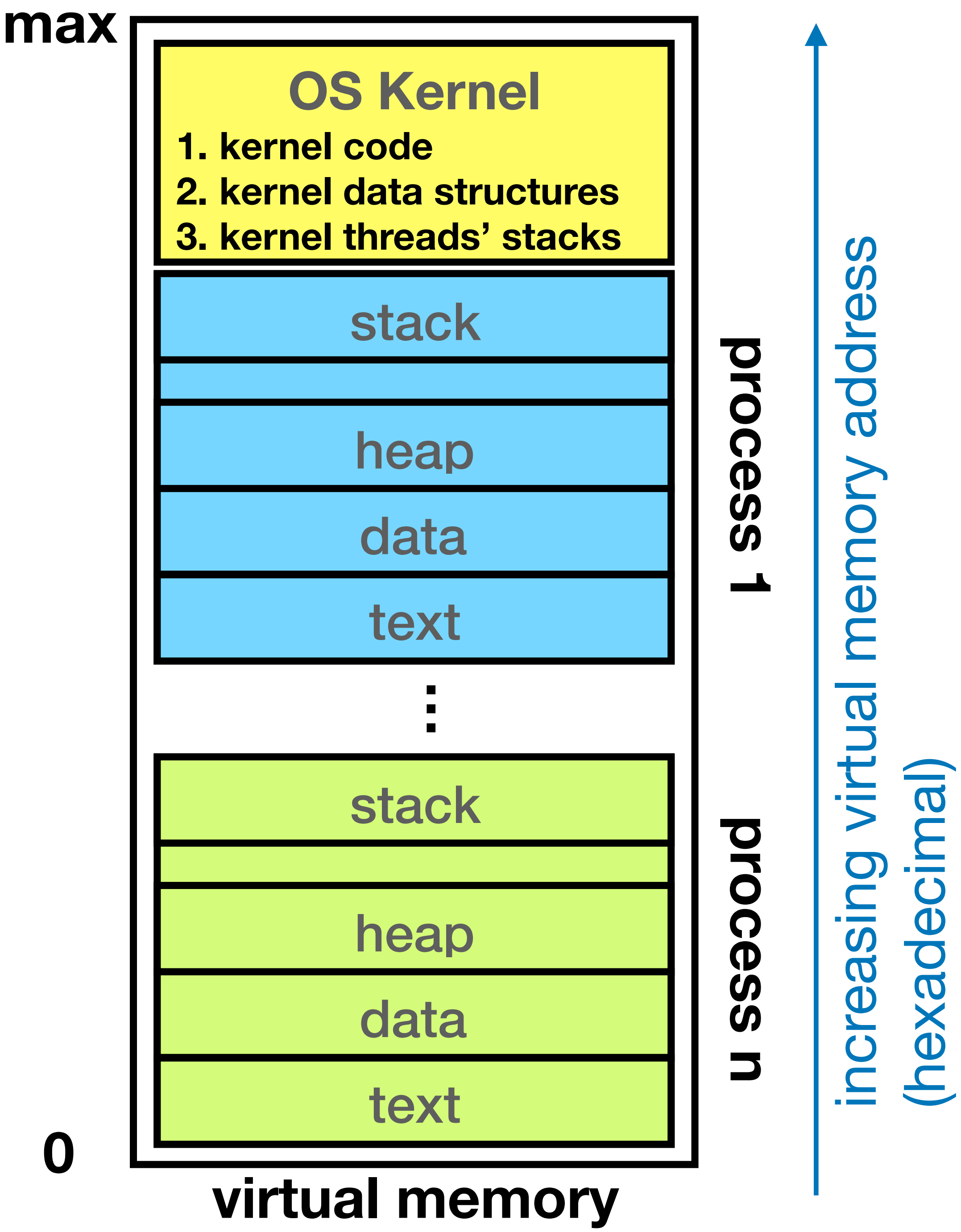

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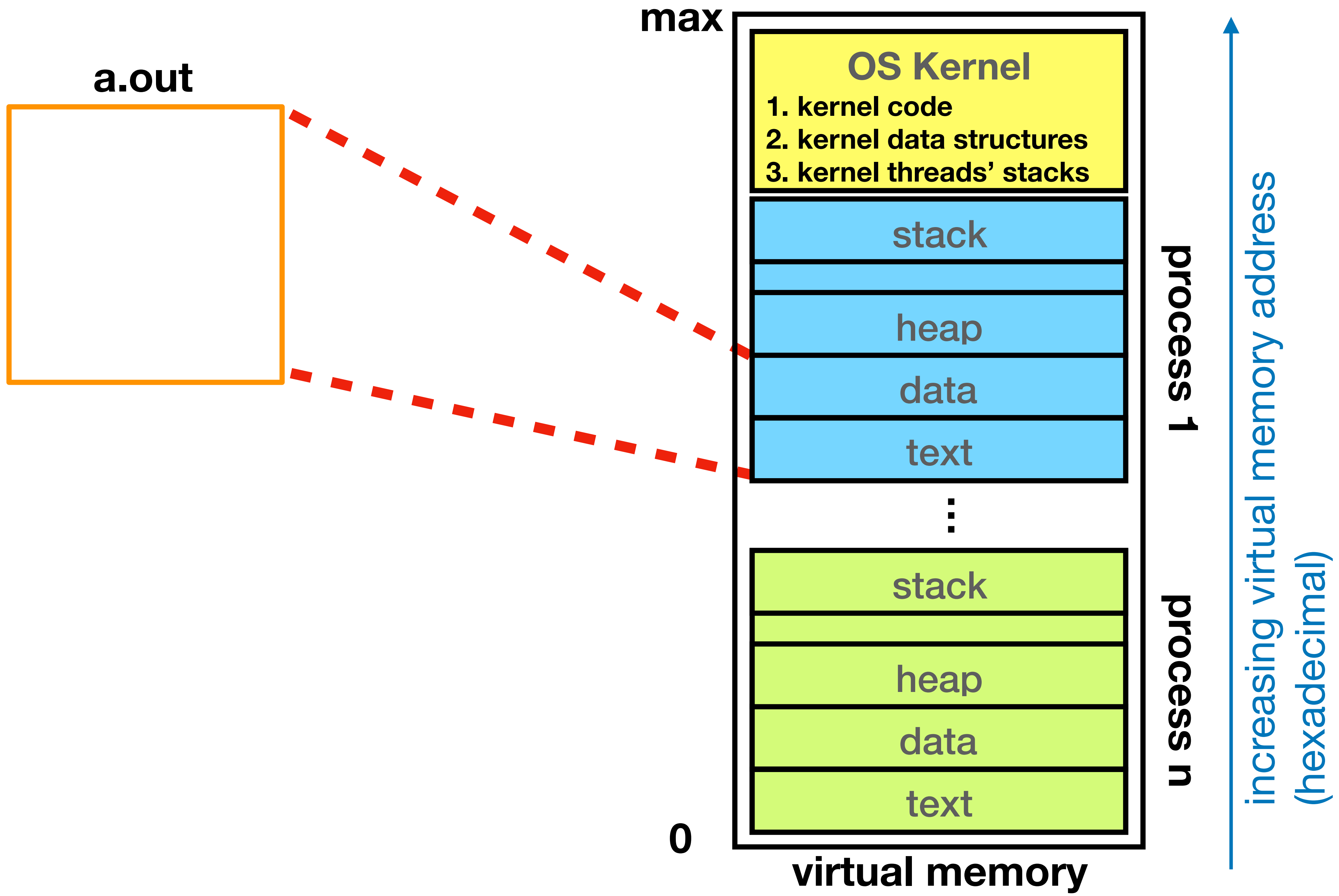

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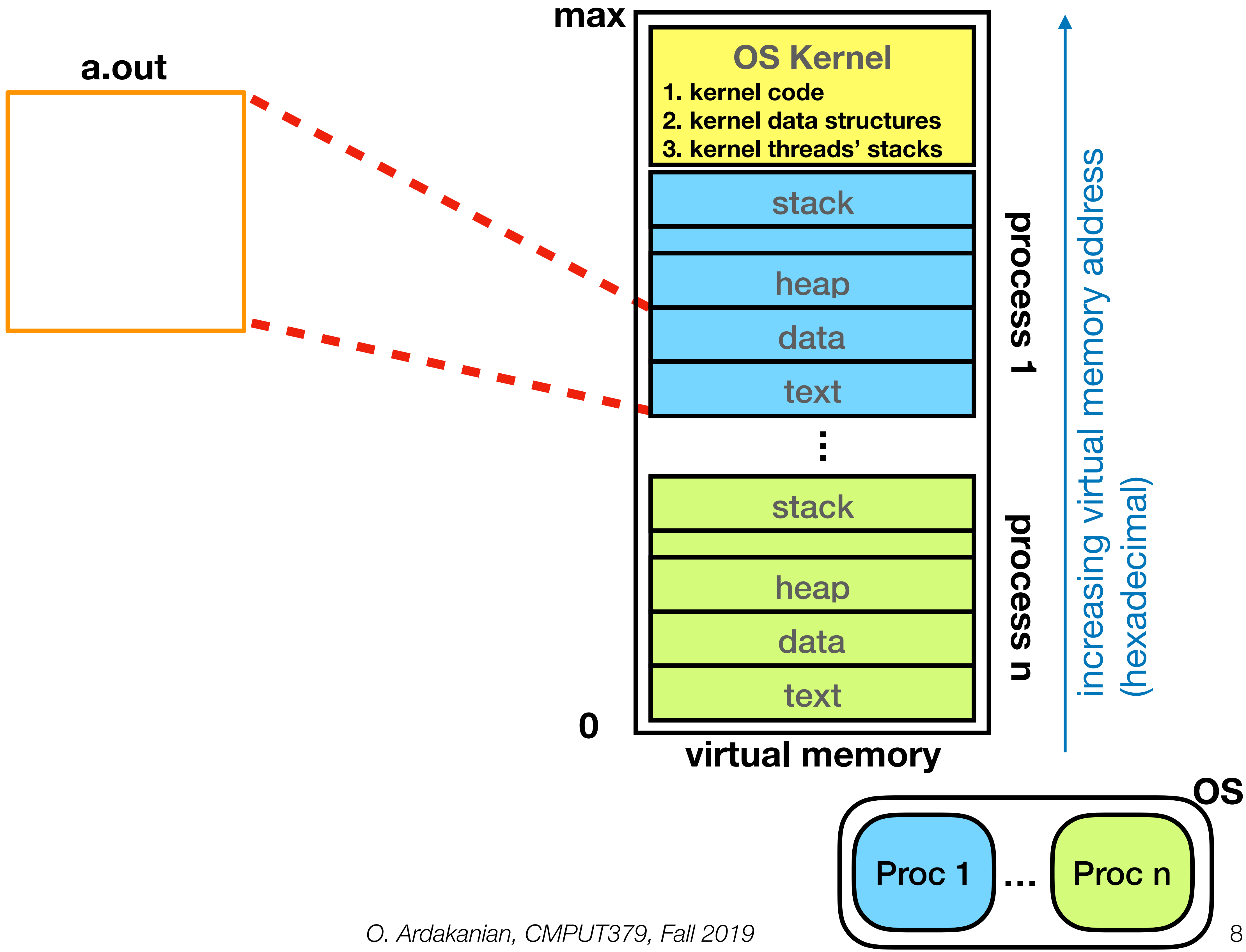

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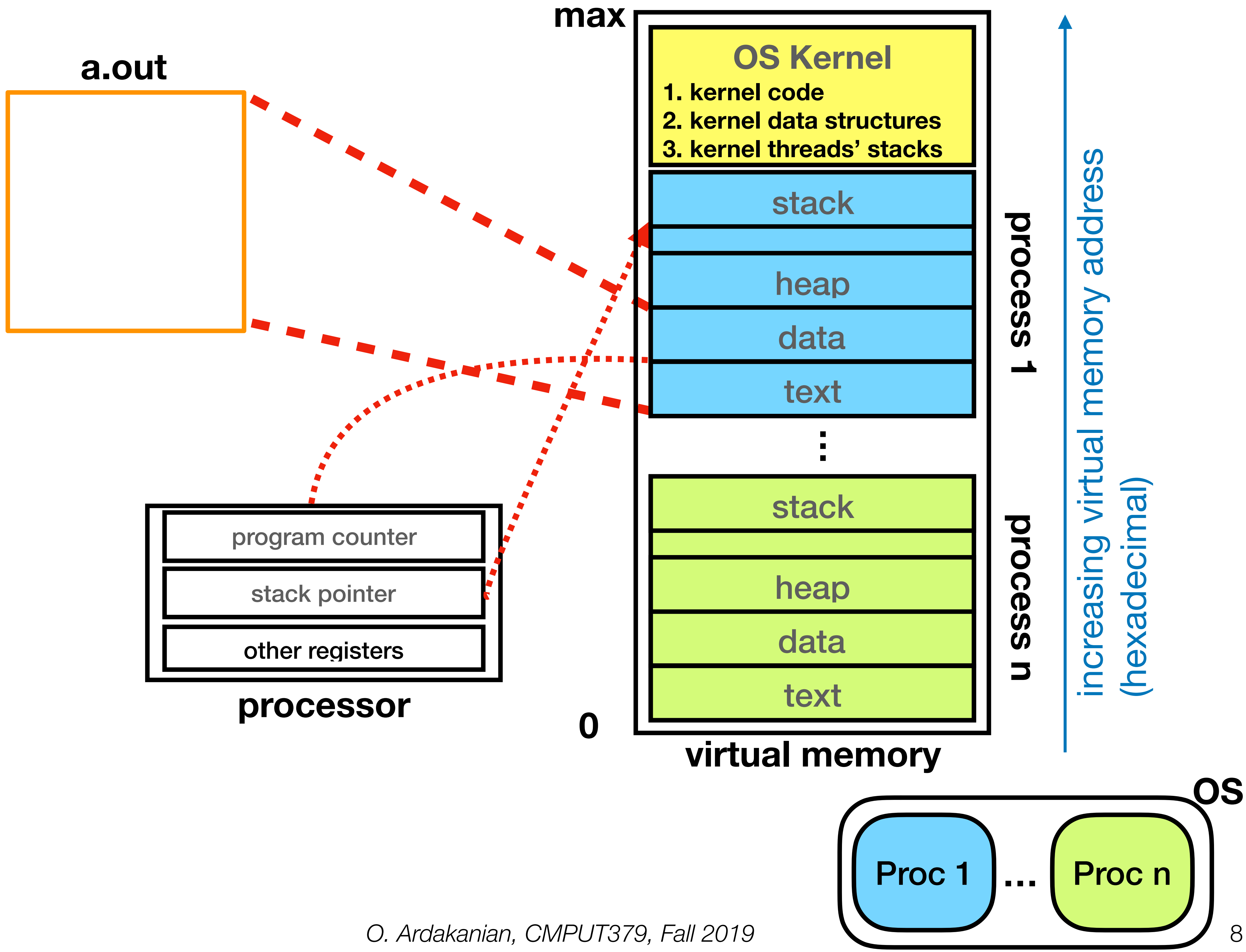

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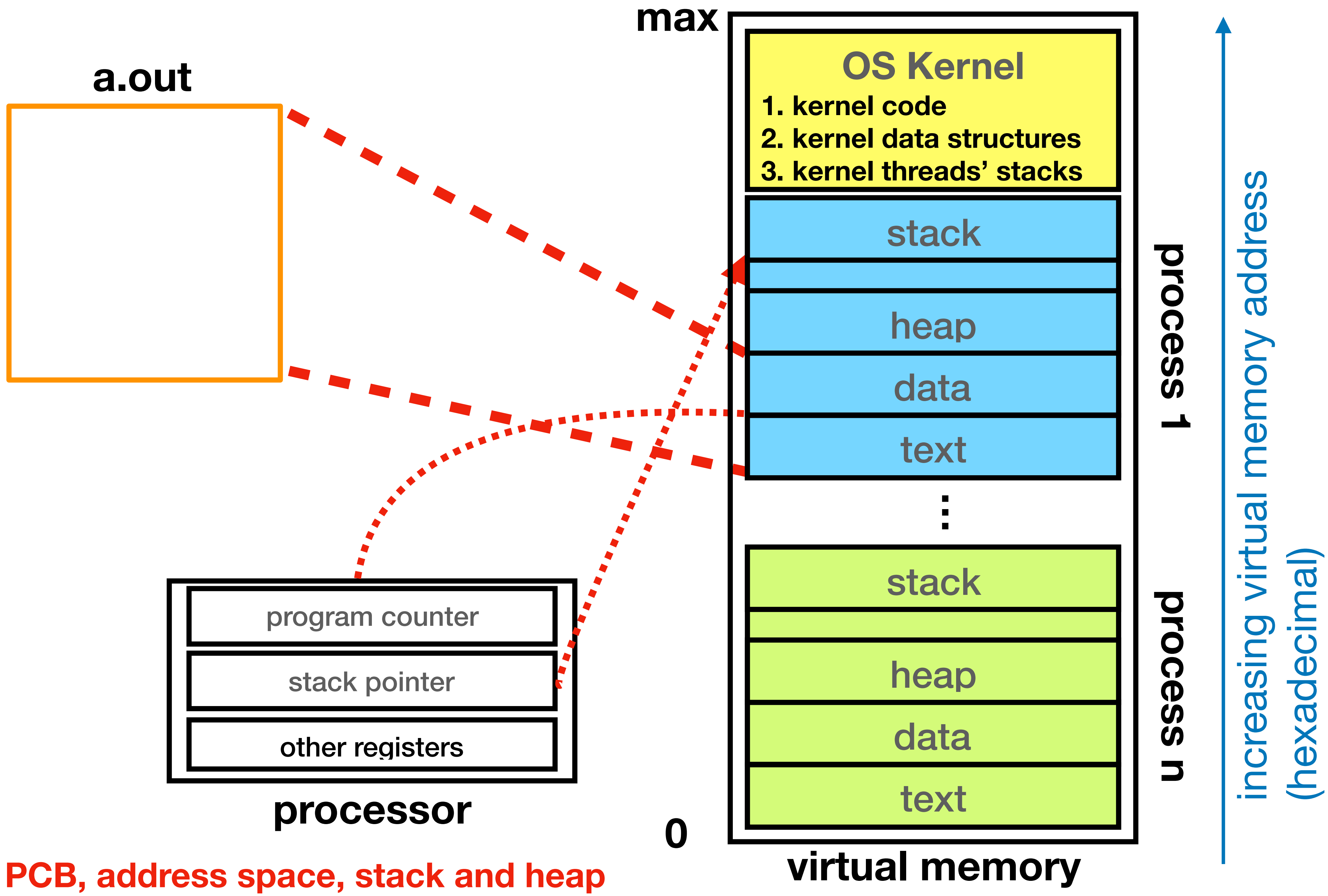
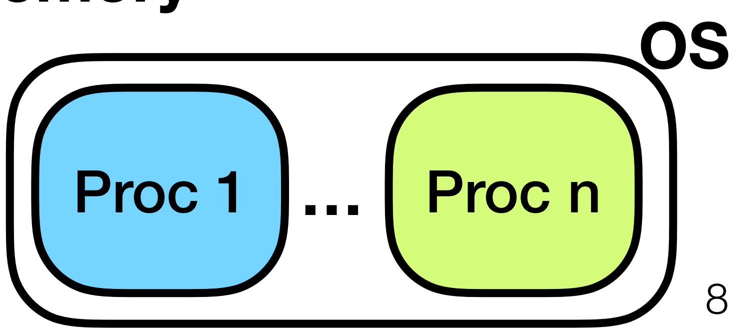


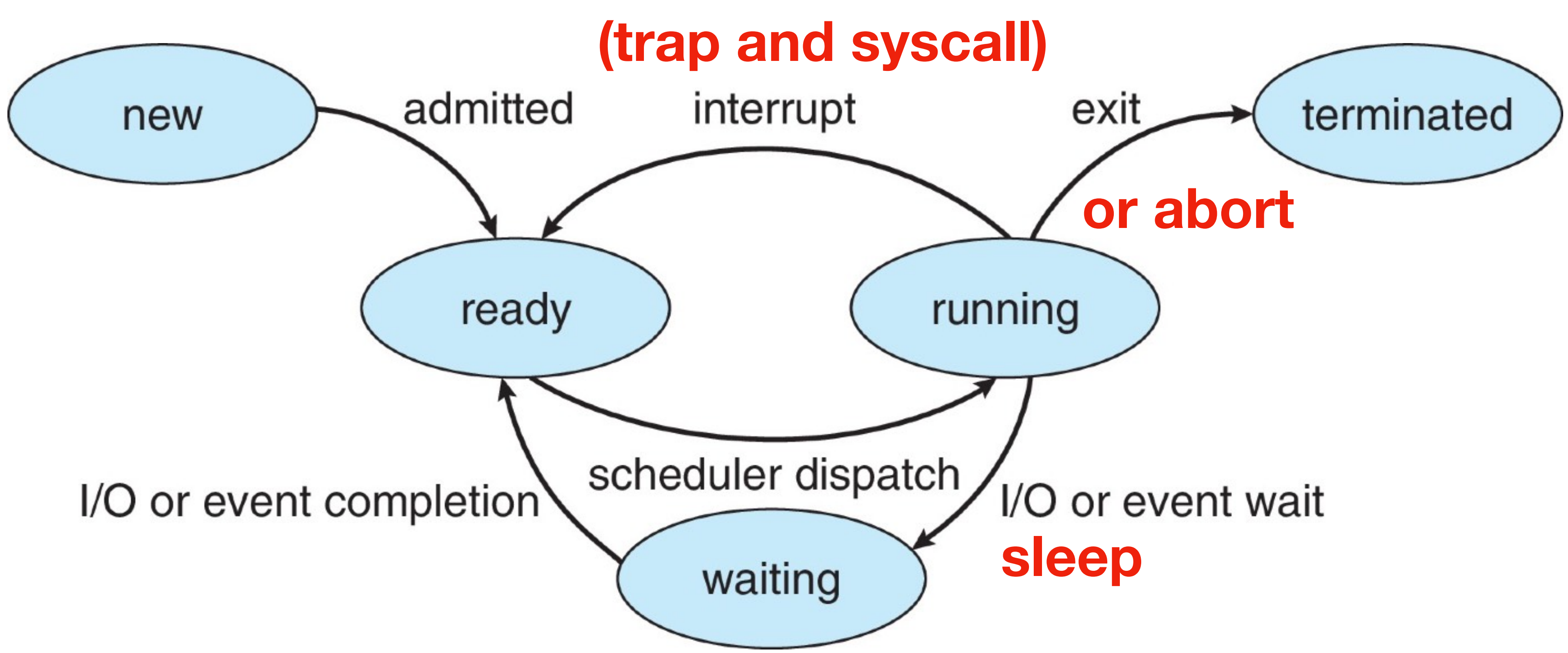
1. create PCB, address space, stack and heap
2. initialize registers and program counter
3. load instruction and data segments of executable file into memory



Keeping track of processes

- OS juggles many processes at a time
  - only one process can be running per core at a time (the kernel maintains a pointer to this process)
  - but many processes can be in ready and waiting states
- OS puts PCBs of the active processes in appropriate queues
  - ready queue (organized by the process-scheduling priority, the arrival time, etc.)
  - wait queue for each device
  - **zombie** queue (child processes terminated with no waiting parent)
- state change happens as a result of the process actions (e.g., termination or invoking system calls), OS actions (scheduling), and external actions (hardware interrupts)

Process lifecycle



Process lifecycle

new process created using `fork( )` and `exec( )`

`init` or `systemd` process is created at boot time