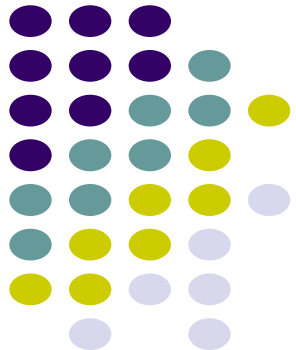
Processes

ECE 469, Feb 01

Aravind Machiry



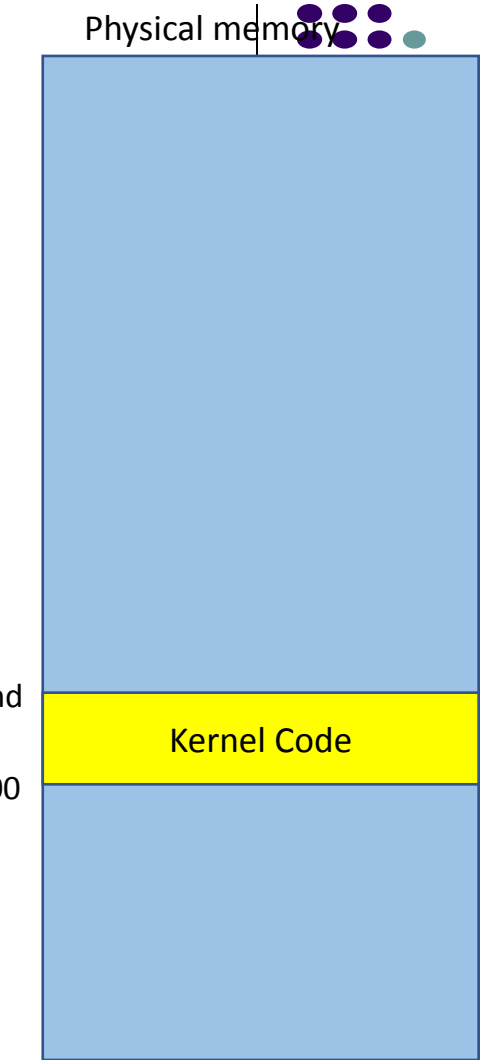
Navigating Lab #2

- **READ COMMENTS IN THE CODE**

Free Physical Memory (init)

In kern/pmap.c, boot_alloc

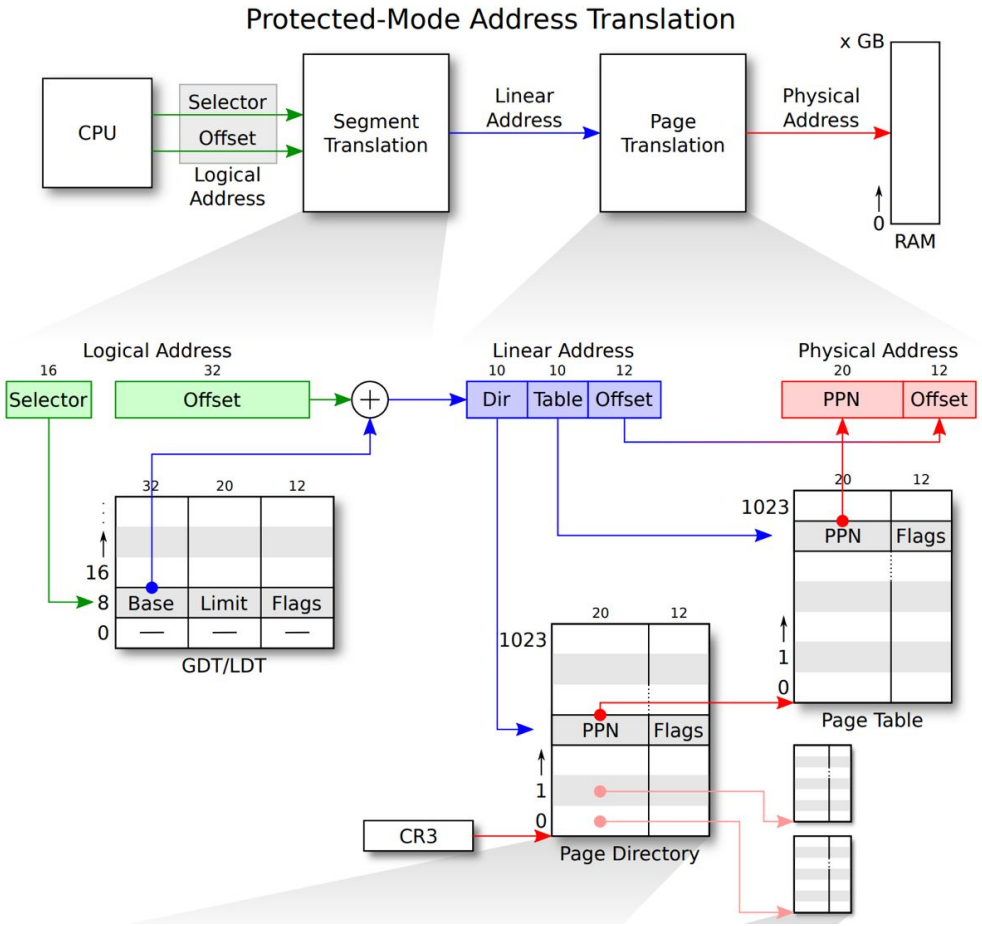
```
static void *
boot_alloc(uint32_t n)
{
    static char *nextfree;  // virtual address of next byte of free memory
    char *result;

    // Initialize nextfree if this is the first time.
    // 'end' is a magic symbol automatically generated by the linker,
    // which points to the end of the kernel's bss segment:
    // the first virtual address that the linker did *not* assign
    // to any kernel code or global variables.
    if (!nextfree) {
        extern char end[];
        nextfree = ROUNDUP((char *) end, PGSIZE);
    }
```



nextfree will point to the end of the kernel code/data

nextfree is virtual address.

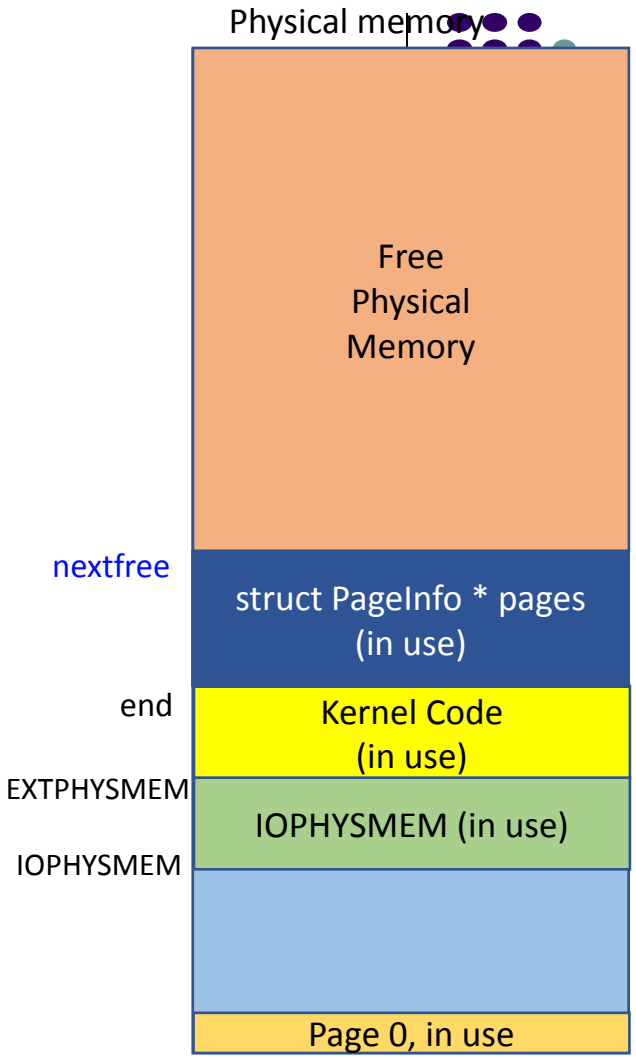
You should allocate n bytes (rounding to PAGE boundary) and return the old pointer and update nextfree.


Protected-Mode Address Translation
CPU
Selector
Offset
Logical Address
Segment Translation
Linear Address
Page Translation
Physical Address
x GB
0
RAM
Logical Address
16
32
Selector
Offset
32
20
12
16
8
0
Base
Limit
Flags
GDT/LDT
Linear Address
10
10
12
Dir
Table
Offset
1023
0
PPN
Flags
Page Table
CR3
Page Directory
Physical Address
20
12
PPN
Offset

page_init: free pages!

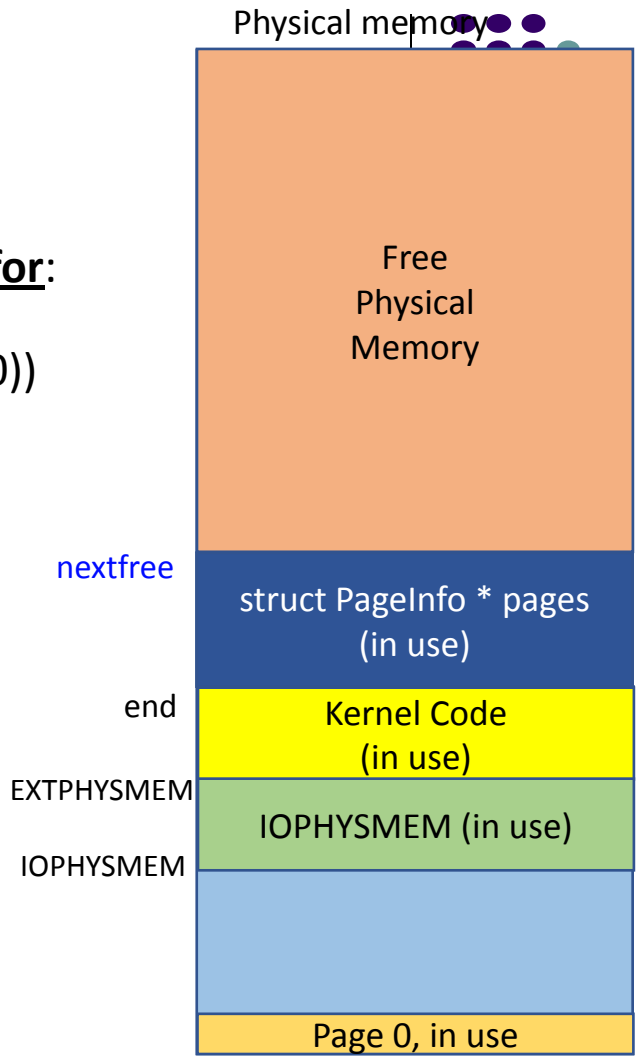
- in page_init()

```
// The example code here marks all physical pages as free.
// However this is not truly the case.  What memory is free?
//  1) Mark physical page 0 as in use.
//     This way we preserve the real-mode IDT and BIOS structures
//     in case we ever need them.  (Currently we don't, but...)
//  2) The rest of base memory, [PGSIZE, npages_basemem * PGSIZE)
//     is free.
//  3) Then comes the IO hole [IOPHYSMEM, EXTPHYSMEM), which must
//     never be allocated.
//  4) Then extended memory [EXTPHYSMEM, ...).
//     Some of it is in use, some is free. Where is the kernel
//     in physical memory?  Which pages are already in use for
//     page tables and other data structures?
//
// Change the code to reflect this.
// NB: DO NOT actually touch the physical memory corresponding to
// free pages!
```



page_init: free pages!

- Iterate through the pages and mark all pages **except for**:
  - Page 0
  - Pages from IOPHYSMEM to nextfree (bootalloc(0))
- Add free pages to the list.



Reuse your code

- **boot_map_region**: Inserts mapping of given VA -> PA of given size (page aligned) with the given permission into a page directory.
- **pgdir_walk**: Gets the page table entry (or creates) corresponding to the given va in the given page directory.
- **page_lookup**: Look up PageInfo corresponding to the given VA.
- Functions can be written by re-using other functions:
  - page_lookup:
    i. *Can use pgdir_walk to get the pte*
    ii. *Can get the physical address of the pte*
    iii. *Convert the physical address to PageInfo using pa2page*

Today's Class

- Users, Programs and Process

Users, Programs, Processes

- Users have accounts on the system

Users, Programs, Processes

- Users have accounts on the system
- Users launch programs

Users, Programs, Processes

- Users have accounts on the system
- Users launch programs
  - Can many users launch the same program?
  - Can one user launch many instances of the same program?

Users, Programs, Processes

- Users have accounts on the system
- Users launch programs
  - Can many users launch the same program?
  - Can one user launch many instances of the same program?

- A process is an “instance” of a program

Program vs. Process

```
main()
{
...
foo()
...
}

foo()
{
     ...
}
```

Program

```
main()
{
...
foo()
...
}

foo()
{
     ...
}
```

Code

Data

heap

stack

main

foo

registers

PC

Process

So What Is A Process?

- It is a running instance of a program.
- Program becomes **alive** through a process.
- Any relation between multiple instances of a program?

So What Is A Process?

- It is a running instance of a program.
- Program becomes **alive** through a process.
- Any relation between multiple instances of a program?
  - Ideally, No!
  - How is the separation maintained?

Process needs to communicate with OS

- Access system resources :
  - Network, Memory, Bluetooth, etc.
  - Maintained by OS.

- How does the communication happen between a process and OS?

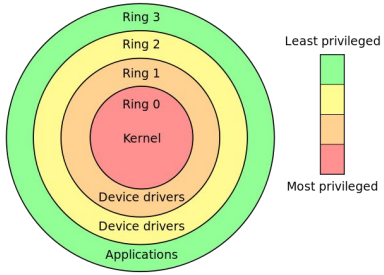
Quick Detour: System Calls

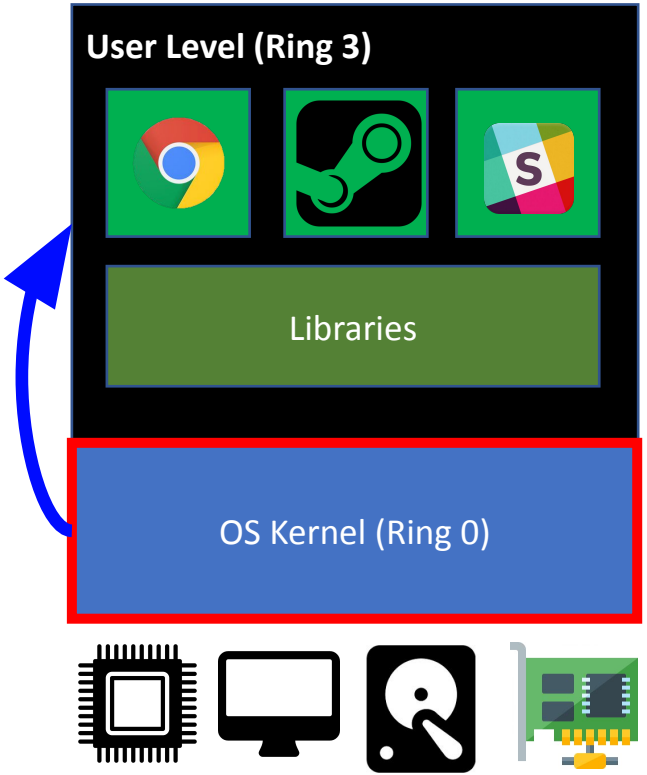
- Interface between a process and the operating system kernel
  - Kernel manages shared resources & exports interface
  - Process requests for access to shared resources

- Generally available as assembly-language instructions:
  - `syscall`

Why can’t a process directly execute kernel code? Because Kernel code …

- Runs with the highest privilege level (Ring 0)
- Configures system (devices, memory, etc.)
- Manages hardware resources
  - Disk, memory, network, video, keyboard, etc.
- Manages other jobs
  - Processes and threads
- Serves as trusted computing base (TCB)
  - Set privilege
  - Restrict other jobs from doing something bad..

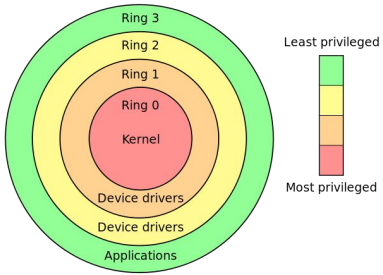


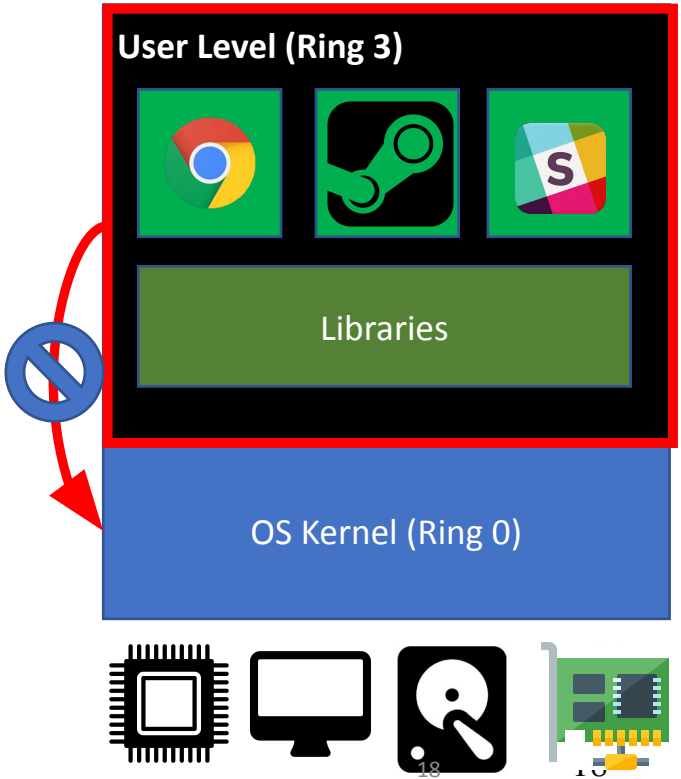


User mode process runs at Ring 3

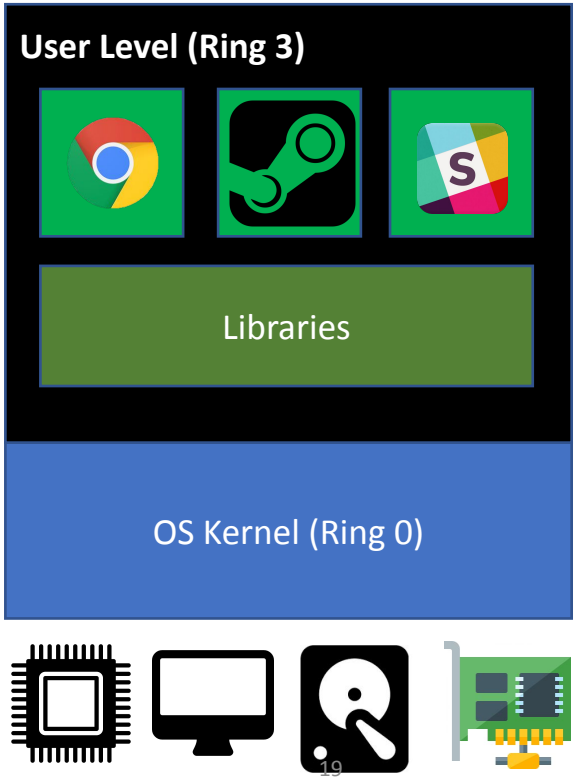
- Runs with a restricted privilege (Ring 3)
  - The privilege level for running an application…
- Most of regular applications runs in this level

- Cannot access kernel memory
  - Can only access pages set with PTE_U
- Cannot talk directly to hardware devices
  - Kernel must mediate the access





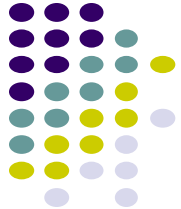
Syscall: User/Kernel communication




```
int main() {
   printf("ECE469");
}
```

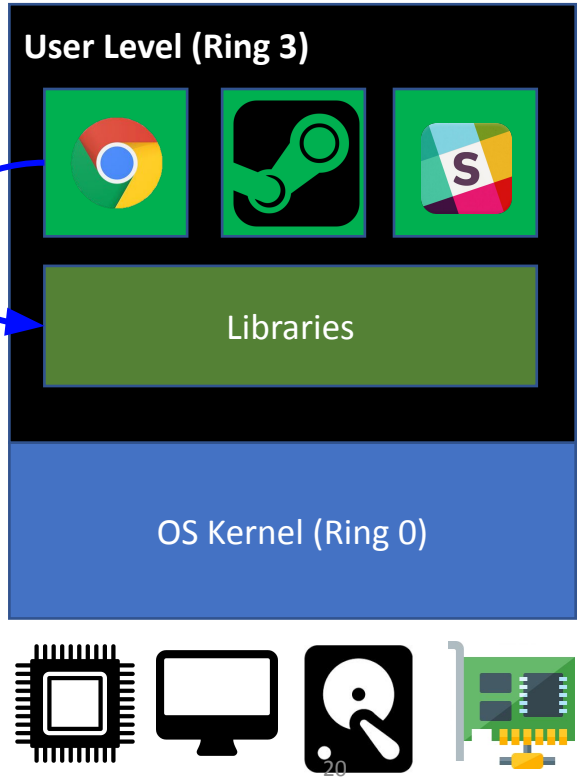

19

Syscall: User/Kernel communication



printf(“ECE469”)

A library call in ring 3




```
int main() {
   printf("ECE469");
}
```


20

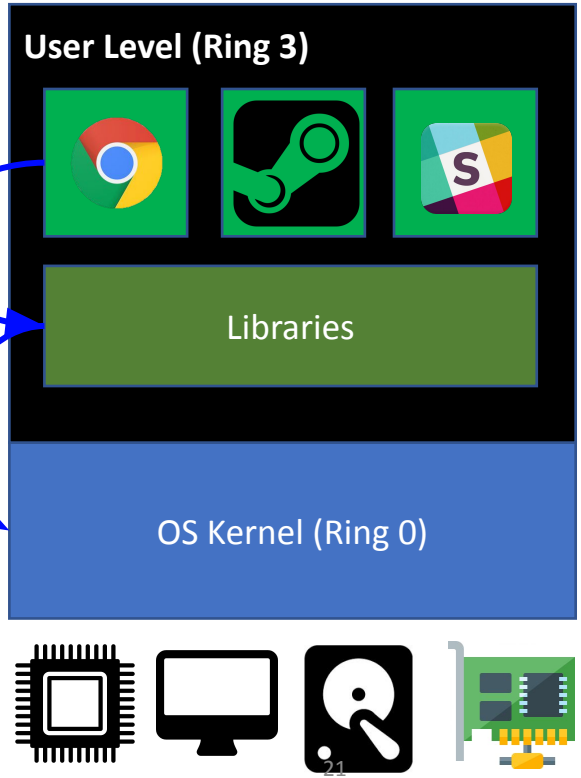
Syscall: User/Kernel communication

printf(“ECE469”)

A library call in ring 3

sys_write(1, “ECE469”, 6);

A system call, **From ring 3**




```
int main() {
   printf("ECE469");
}
```


21

Syscall: User/Kernel communication

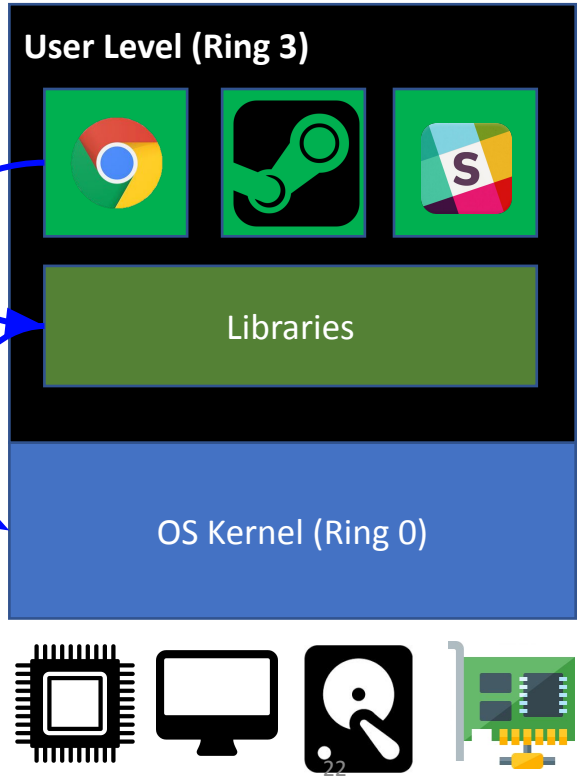
printf(“ECE469”)

A library call in ring 3

sys_write(1, “ECE469”, 6);

A system call, **From ring 3**

Interrupt!, switch from ring3 to ring0




```
int main() {
   printf("ECE469");
}
```


22

Syscall: User/Kernel communication

printf(“ECE469”)

A library call in ring 3

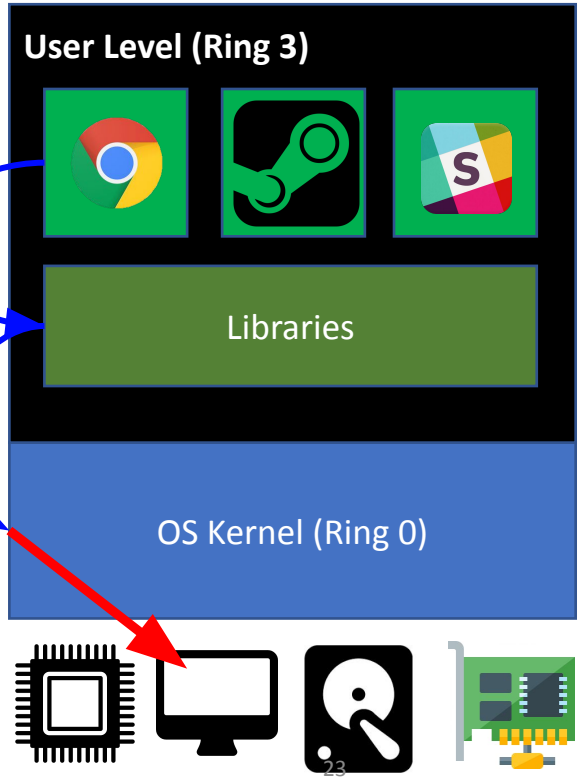
sys_write(1, “ECE469”, 6);

A system call, **From ring 3**

Interrupt!, switch from ring3 to ring0

A kernel function

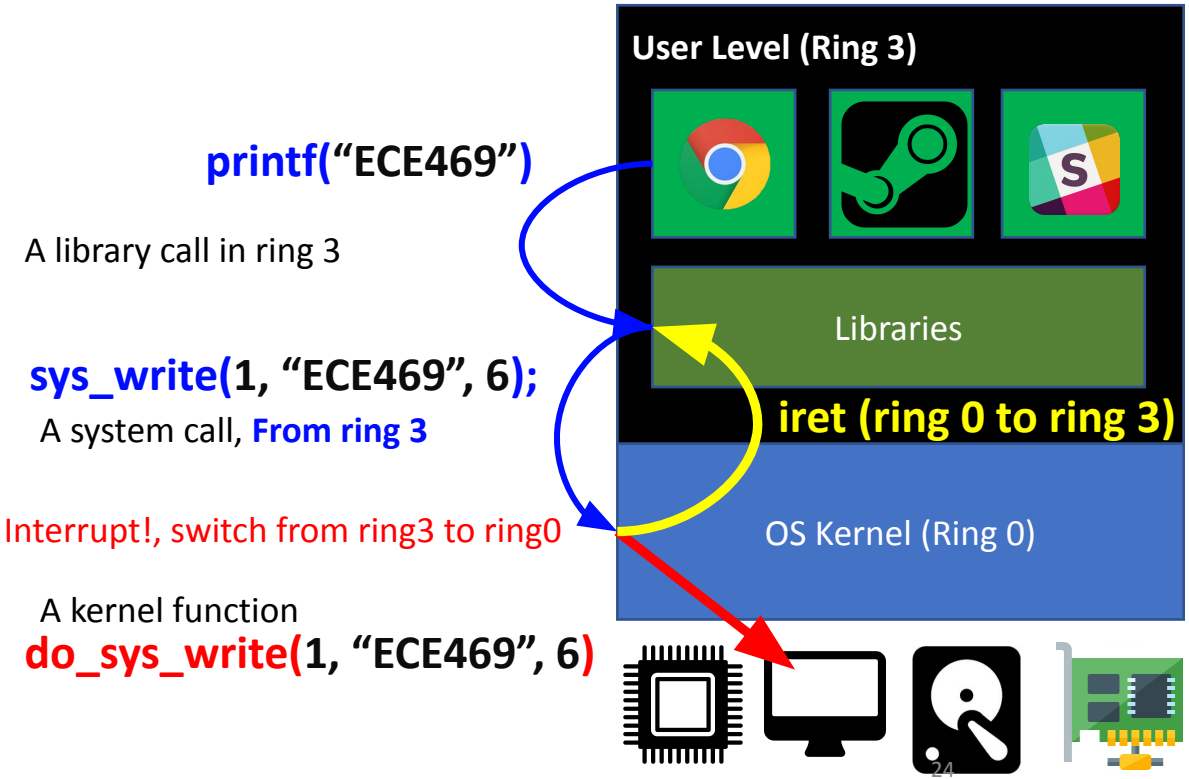
do_sys_write(1, “ECE469”, 6)




```
int main() {
   printf("ECE469");
}
```


23

Syscall: User/Kernel communication




```
int main() {
   printf("ECE469");
}
```


24

Syscall: User/Kernel communication

printf("ECE469")

A library call in ring 3

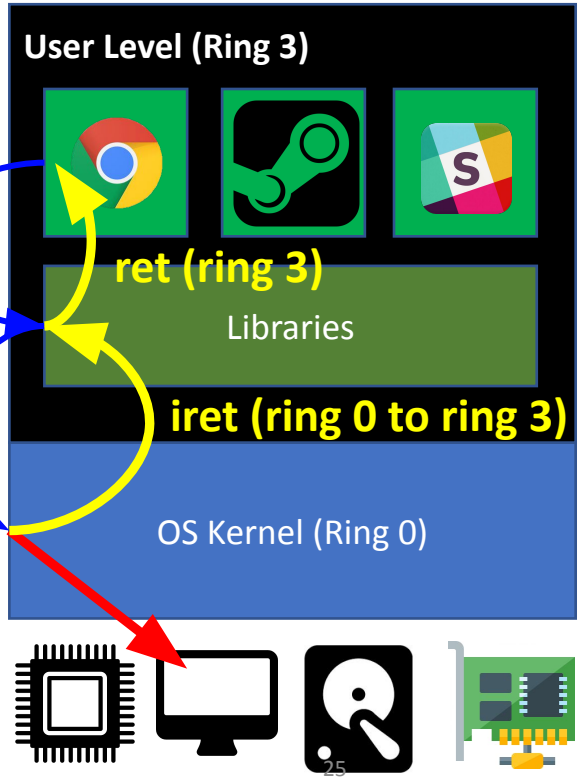
sys_write(1, "ECE469", 6);

A system call, From ring 3

Interrupt!, switch from ring3 to ring0

A kernel function

do_sys_write(1, "ECE469", 6)




```
int main() {
   printf("ECE469");
}
```


25

Let's get back: Process

- Who has the ability to create a process?
  - OS
- Who whats to create a process?
- How can we create a process?

Let's get back: Process

- Who has the ability to create a process?
  - OS
- Who whats to create a process?
  - User/Program
- How can we create a process?

Let's get back: Process

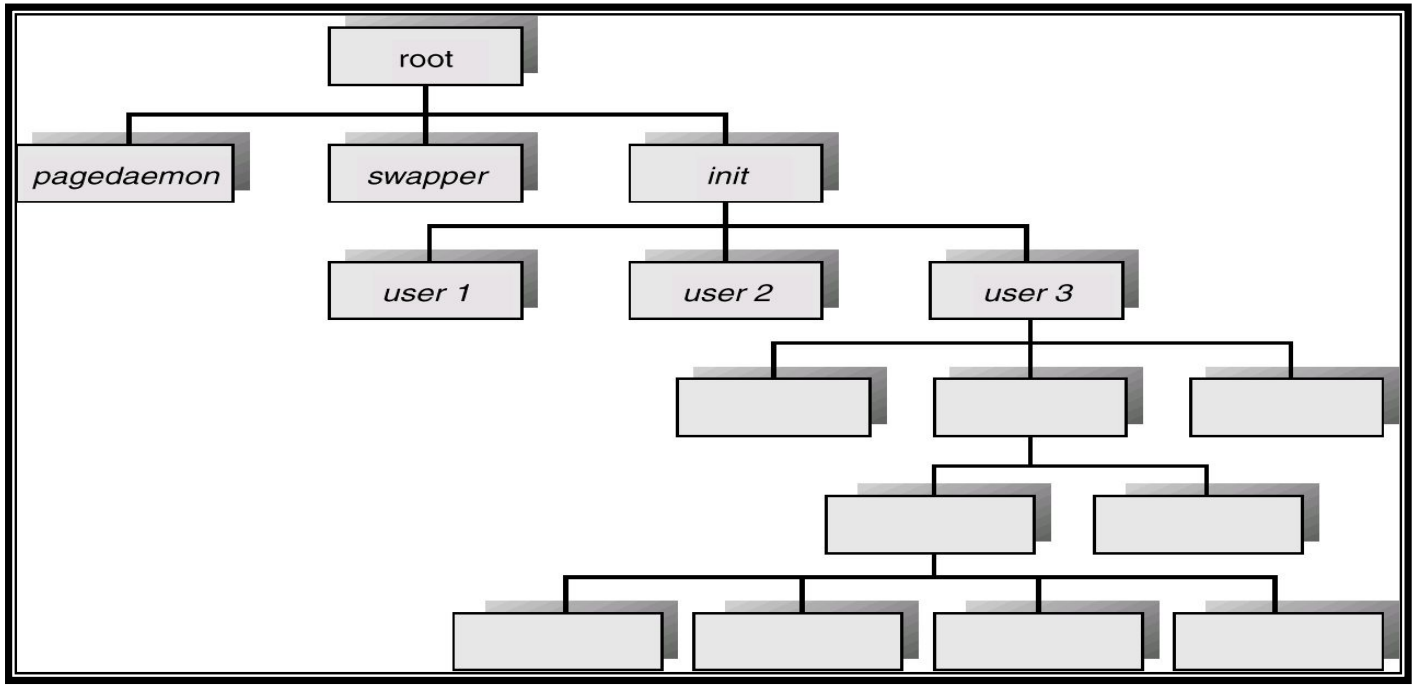
- Who has the ability to create a process?
  - OS
- Who whats to create a process?
  - User/Program
- How can we create a process?
  - System call
    - But, to do a syscall, we need a process!!!

Process Creation

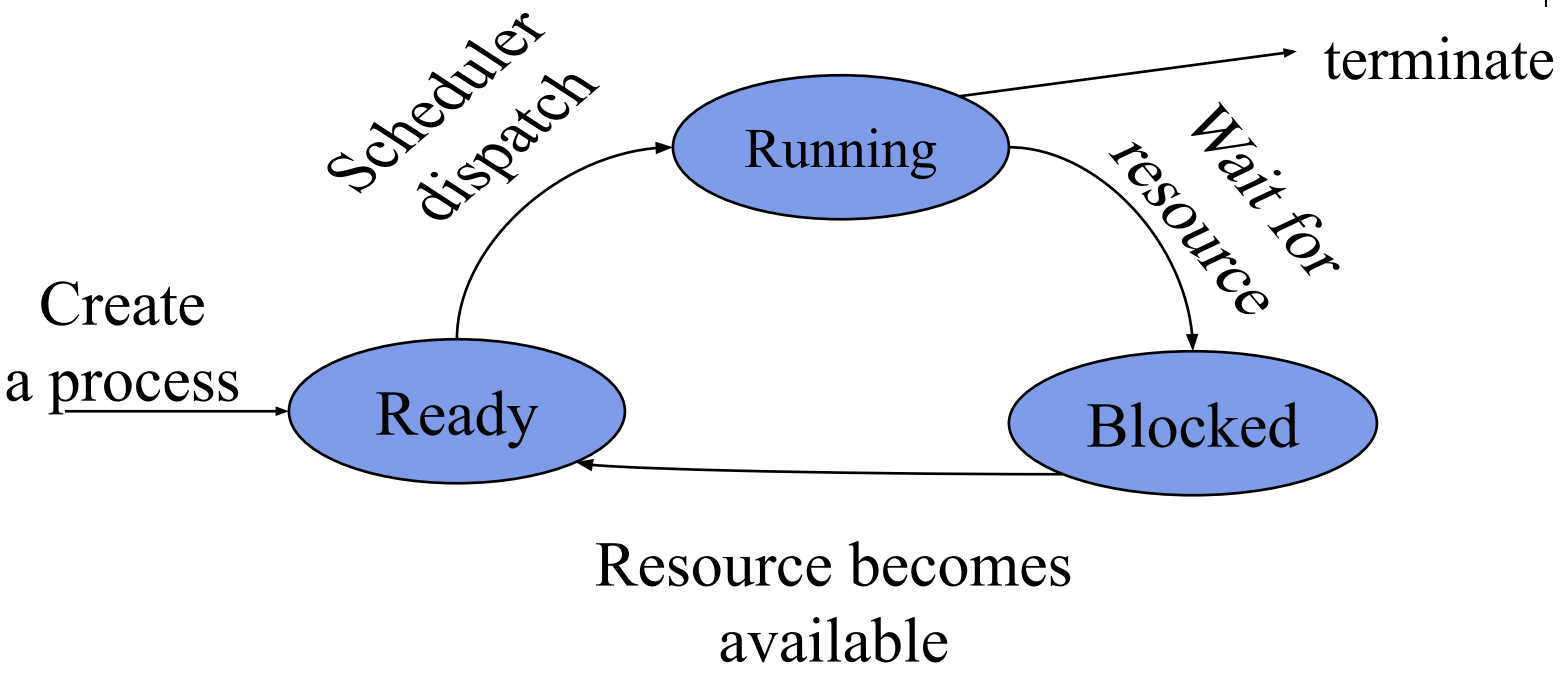
On boot, kernel starts an init process (usually systemd on ubuntu systems), which takes care of creating all other process.

Init can never die.

Process Tree



Process State Transition



30

Process Information maintained by OS

- Usually Maintained in a structure called **Process Control Block (PCB)**

- Process management info
  - State (ready, running, blocked)
  - PC & Registers, parents, etc
  - CPU scheduling info (priorities, etc.)

- Memory management info
  - Segments, page table, stats, etc

Process Identifier

- Every process has an ID – process ID
- Does a program know its process ID?
- When a program is running, how does the process know its ID?

OS Support for Process

- Support to create process
- Support to wait for a process completion
- Support to terminate a process

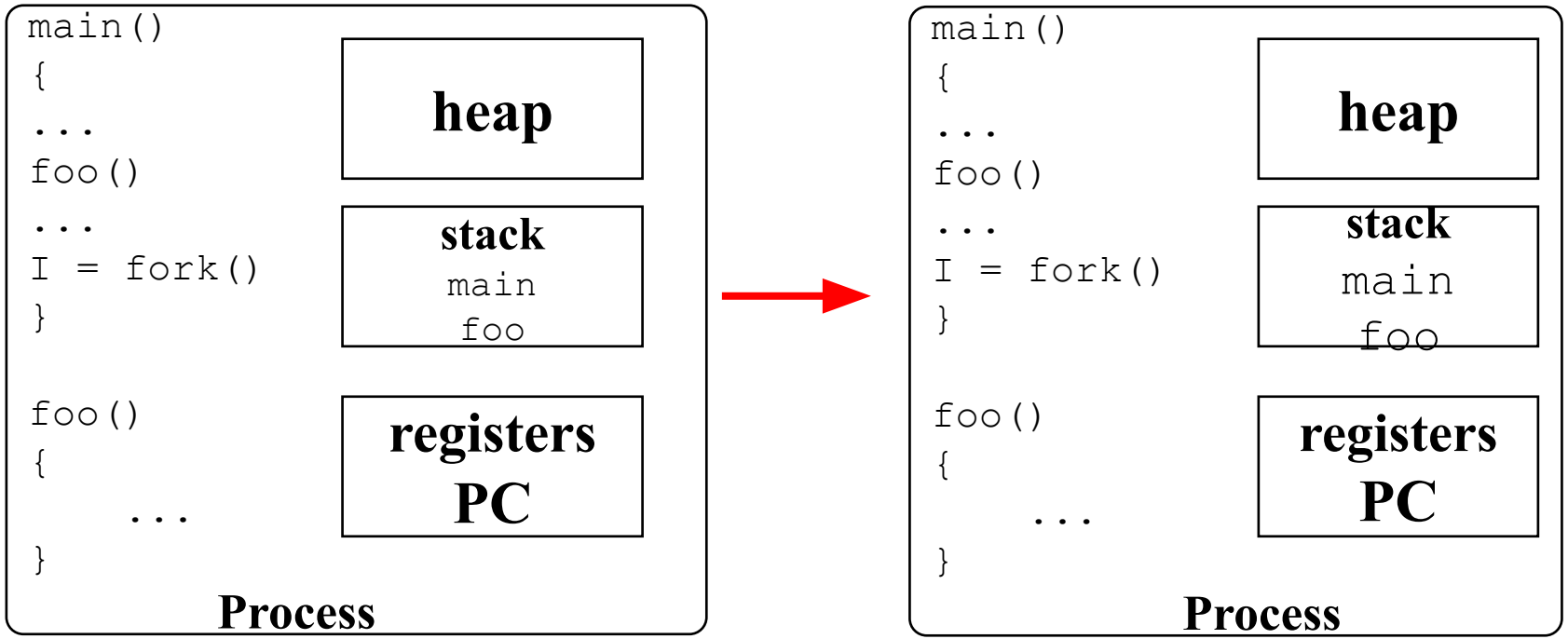
OS Process API

- 4 system calls related to process creation/termination:
  - Process Creation:
    - fork/clone – create a copy of this process
    - exec – replace this process with this program
  - Wait for completion:
    - wait – wait for child process to finish
  - Terminate a process:
    - kill - send a signal (to terminate) a process

fork

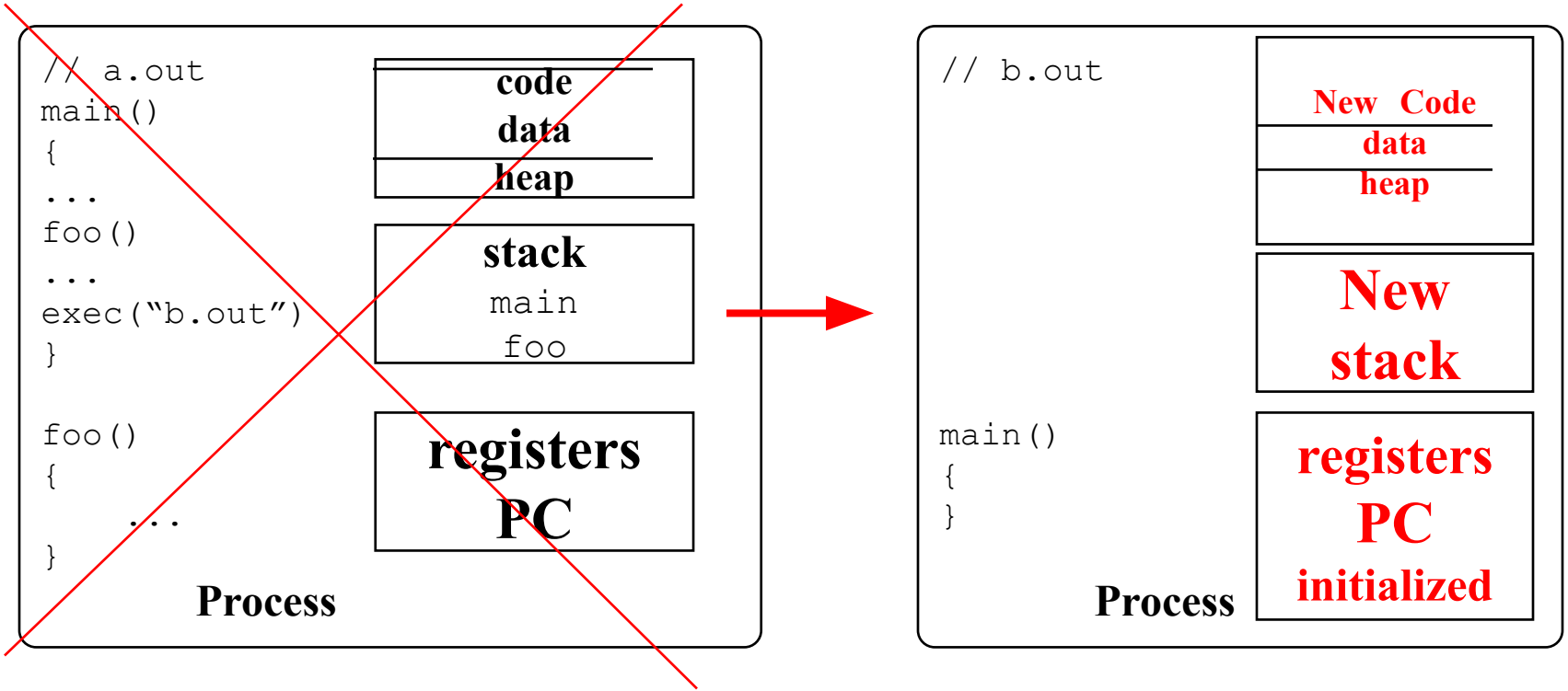
fork causes OS creates a copy of the calling process:

- Why?
- How can we disambiguate between new process and the calling process?



exec

Replaces current process with the content from new program.

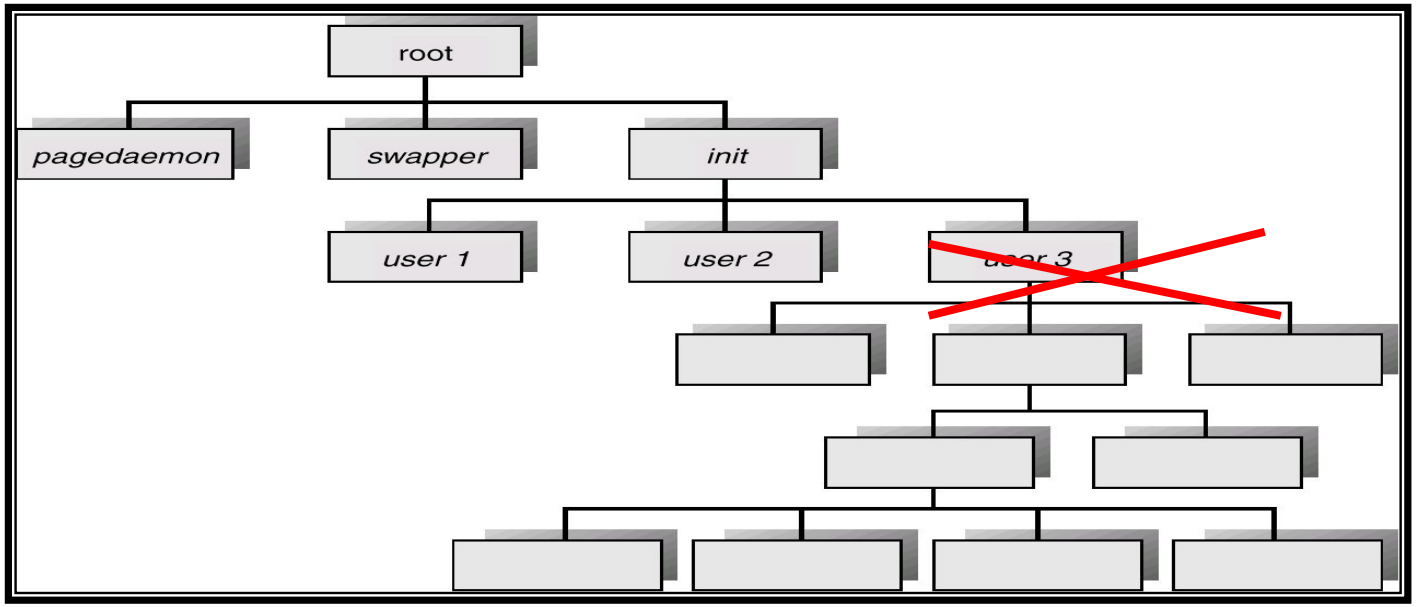


wait

wait for a child process to finish

wait

What happens when the parent process dies? what happens to child process?



How our shell works?

- Fork/exec