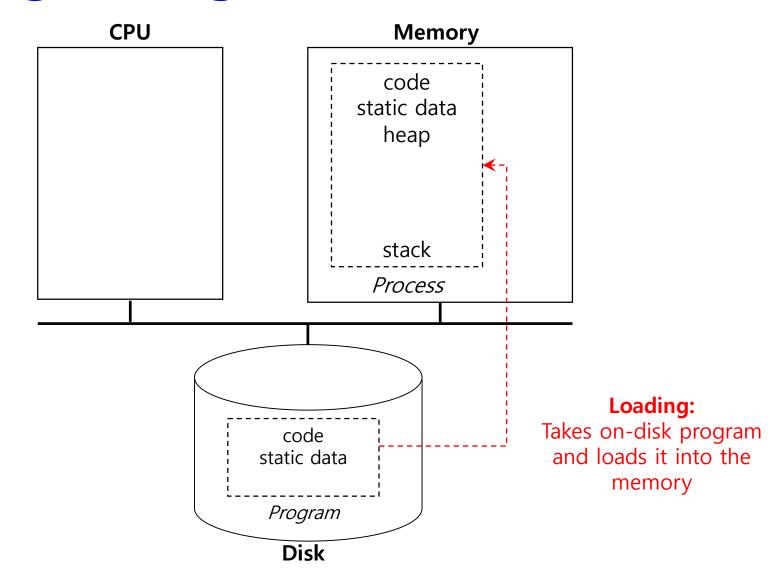
### Virtualization: The CPU

Sridhar Alagar

## Executing a Program



#### What is a Process?

- A program in execution
- It is an abstraction
- What constitutes a process?
  - Whatever it can affect
  - Memory: Address space code, heap, stack
  - Registers, IP
  - Open files

#### Process API

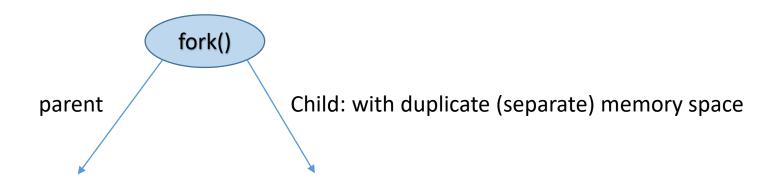
- Creation
- Destroy
- Wait
  - wait for a process to stop running
- Control
  - suspend and resume
- Status
  - get some status info about the process

#### Process creation

#### **UNIX** examples

**fork()** system call creates new child process

Parent and child processes have separate memory spaces and execute independently

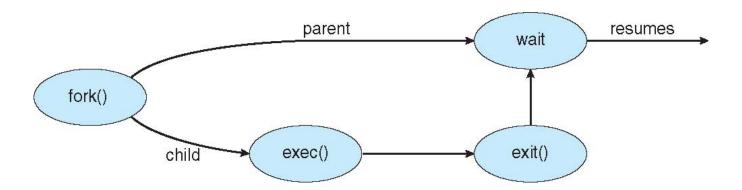


5

#### Process creation

#### **UNIX** examples

fork() system call creates new child process
exec() system call used after a fork() to replace the process' memory space
with a new program

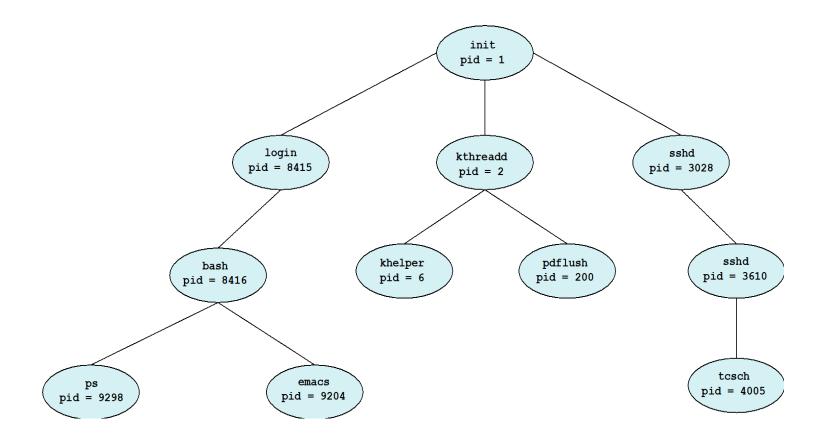


6

#### Virtualize the CPU

- CPU needs to be (time) shared by many processes
- Transparent to the process (app)
- Give an illusion that a process own the CPU
  - Each process is allocated a virtual CPU

### Processes tree



8

## How to provide good CPU performance?

- Direct Execution
  - Runs directly on CPU
  - Full control of CPU OS creates process and transfers control to it

Who should be in control?

#### Problems with direct execution?

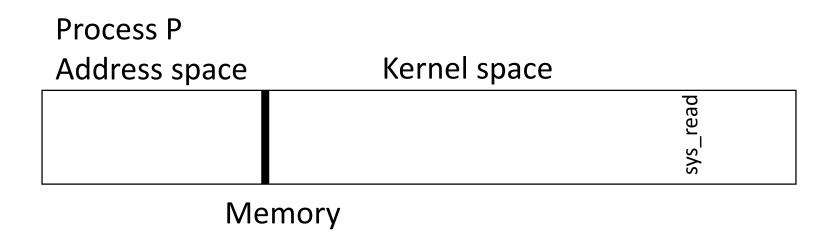
- Process could do something restricted
   Could read/write other process data (disk or memory)
- 2. Process could run forever (slow, buggy, or malicious)
  OS needs to be able to switch between processes
- 3. Process could do something slow (like I/O)
  OS wants to use resources efficiently and switch CPU to other process

#### Solution:

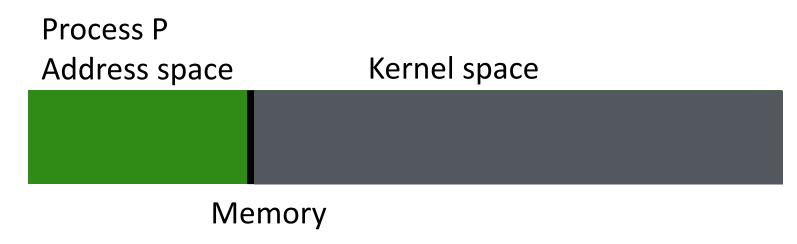
Limited direct execution – OS and hardware maintain some control

## Problem 1: How to restrict process?

- Use privilege levels supported by the hardware
  - Process runs in user level (restricted)
  - OS runs in kernel level (unrestricted)
- How can processes access devices?
  - Need to request OS to do the job through System calls
  - Change privilege level through trap (int)



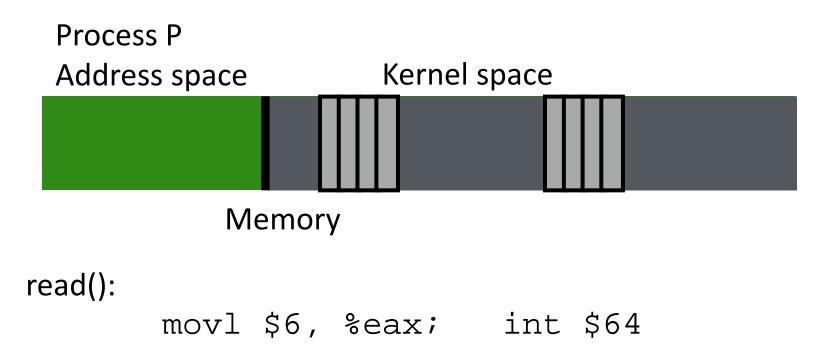
P needs to call sys\_read()

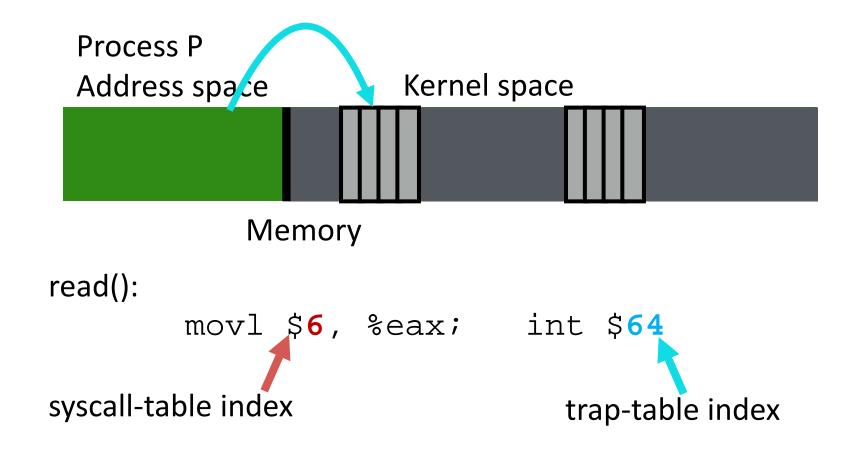


P is in user mode (restricted). It cannot see kernel space or any other space

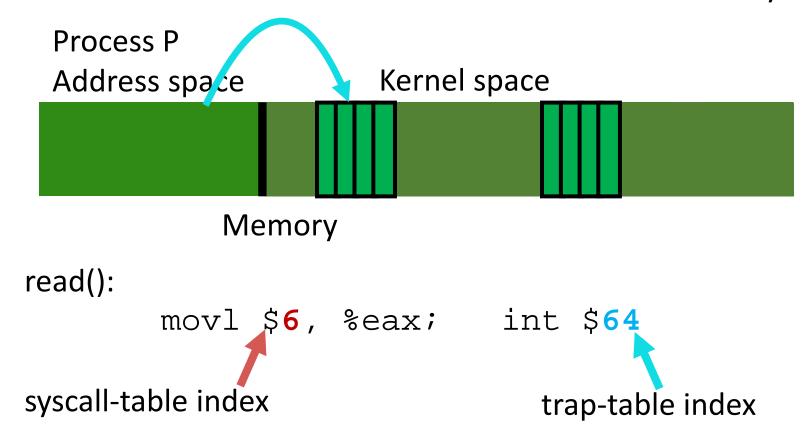
P wants to call sys\_read. But no way to call directly

Need hardware instruction (int) to indirectly call the routine

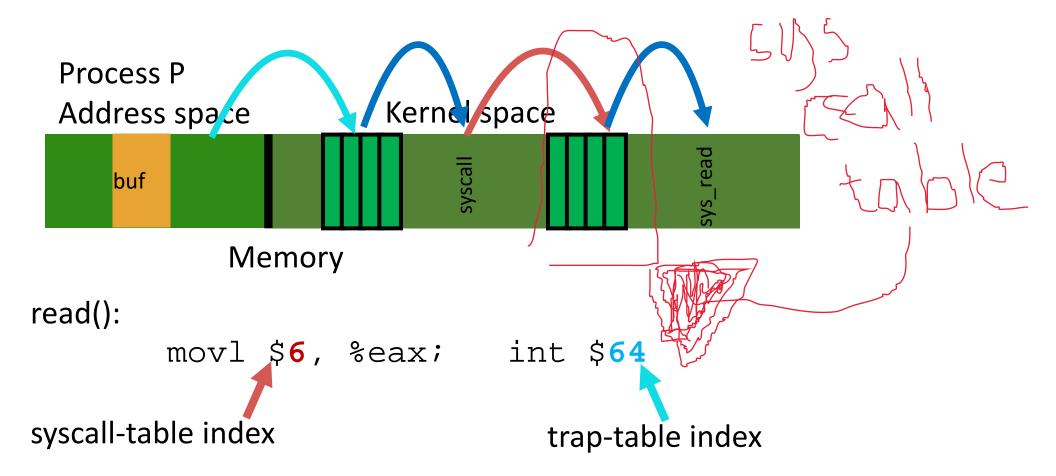




Kernel mode: all are visible and we can do anything



Kernel can access user memory to fill in user buffer; return-from-trap at end to return to Process P



## Limited direct execution protocol

OS @	boot
(kernel	mode)
initializ	ze trap

#### **Hardware**

table

remember address of ... syscall handler

#### OS @ run (kernel mode)

**Hardware** 

**Program** (user mode)

Create entry for process list Allocate memory for program Load program into memory Setup user stack with argv Fill kernel stack with reg/PC return-from -trap

restore regs from kernel stack move to user mode jump to main

Run main()

Call system **trap** into OS

## Limited direct execution protocol

OS @ run (kernel mode)	Hardware	Program (user mode)
	(Cont.)	
Handle trap Do work of syscall return-from-trap	save regs to kernel stack move to kernel mode jump to trap handler	
	restore regs from kernel stack move to user mode jump to PC after trap	
		 return from main trap (via exit())
Free memory of process Remove from process list		

#### What to limit?

- User process are not allowed to perform
  - General memory access
  - Disk I/O
  - Special x86 instructions like lidt
- What if process tries to do something restricted?





•

•

•