بسم الله الرحمن الرحیم

۱ «سیستم عامل»

جلسه ۳:

فهرست مطالب

OS-Related Hardware & Software

Complications in real systems

Brief introduction to

- memory protection and relocation
- virtual memory & MMUs
- I/O & Interrupts

The "process" abstraction

Process scheduling

Process states

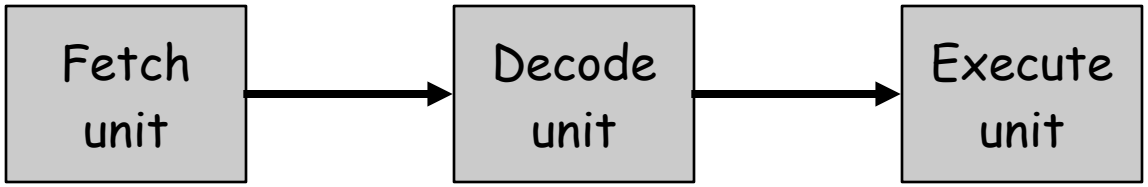
Process hierarchies

Process system calls in Unix

Why its not quite that simple ...

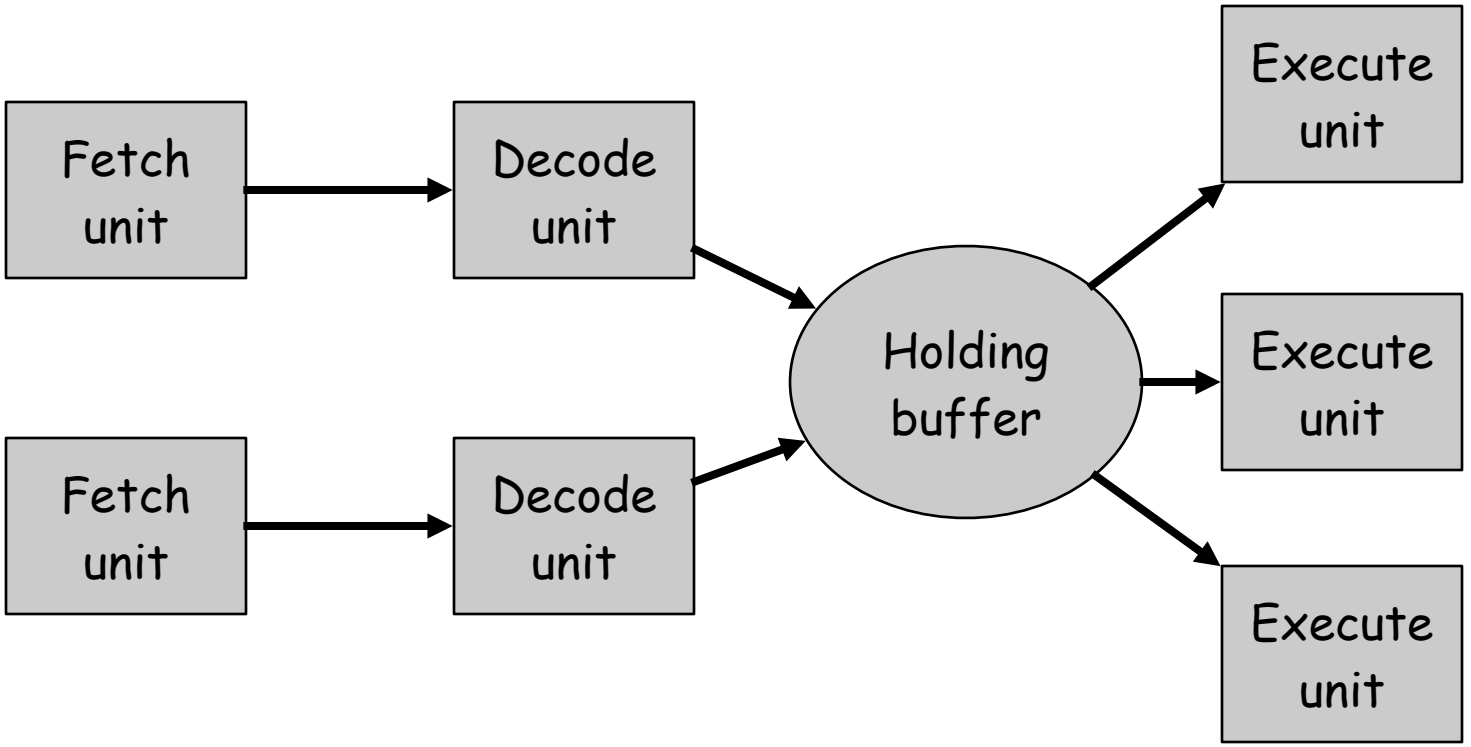
- **The basic model introduced in lecture 1 still applies, but the following issues tend to complicate implementation in real systems:**
  - Pipelined CPUs
  - Superscalar CPUs
  - Multi-level memory hierarchies
  - Virtual memory
  - Complexity of devices and buses

Pipelined CPUs



Execution of current instruction performed in parallel with decode of next instruction and fetch of the one after that

Superscalar CPUs



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- **More details, but fundamentally the same task**
- **The BLITZ CPU is not pipelined or superscalar**
  - BLITZ has precise interrupts

The memory hierarchy

- 2GHz processor → 0.5 ns clock cycle
- Data/instruction cache access time → 0.5ns – 10 ns
  - This is where the CPU looks first!
  - Memory this fast is very expensive !
  - Size ~64 kB- 1MB (too small for whole program)
- Main memory access time → 60 ns
  - Slow, but cheap
  - Size 1GB+
- Magnetic disk →
  10 ms, 200+ Gbytes

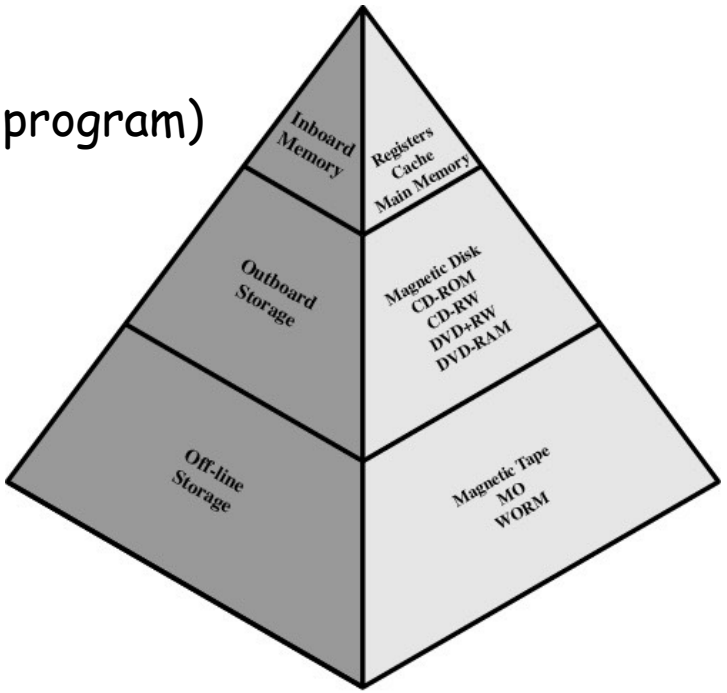

Figure 1.14 The Memory Hierarchy

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- **Movement of data among lower levels of the memory hierarchy is under direct control of the OS**
  - virtual memory page faults
  - file system calls

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- How do you hide the latency of the slower subsystems?
  - Main memory?
  - Disk

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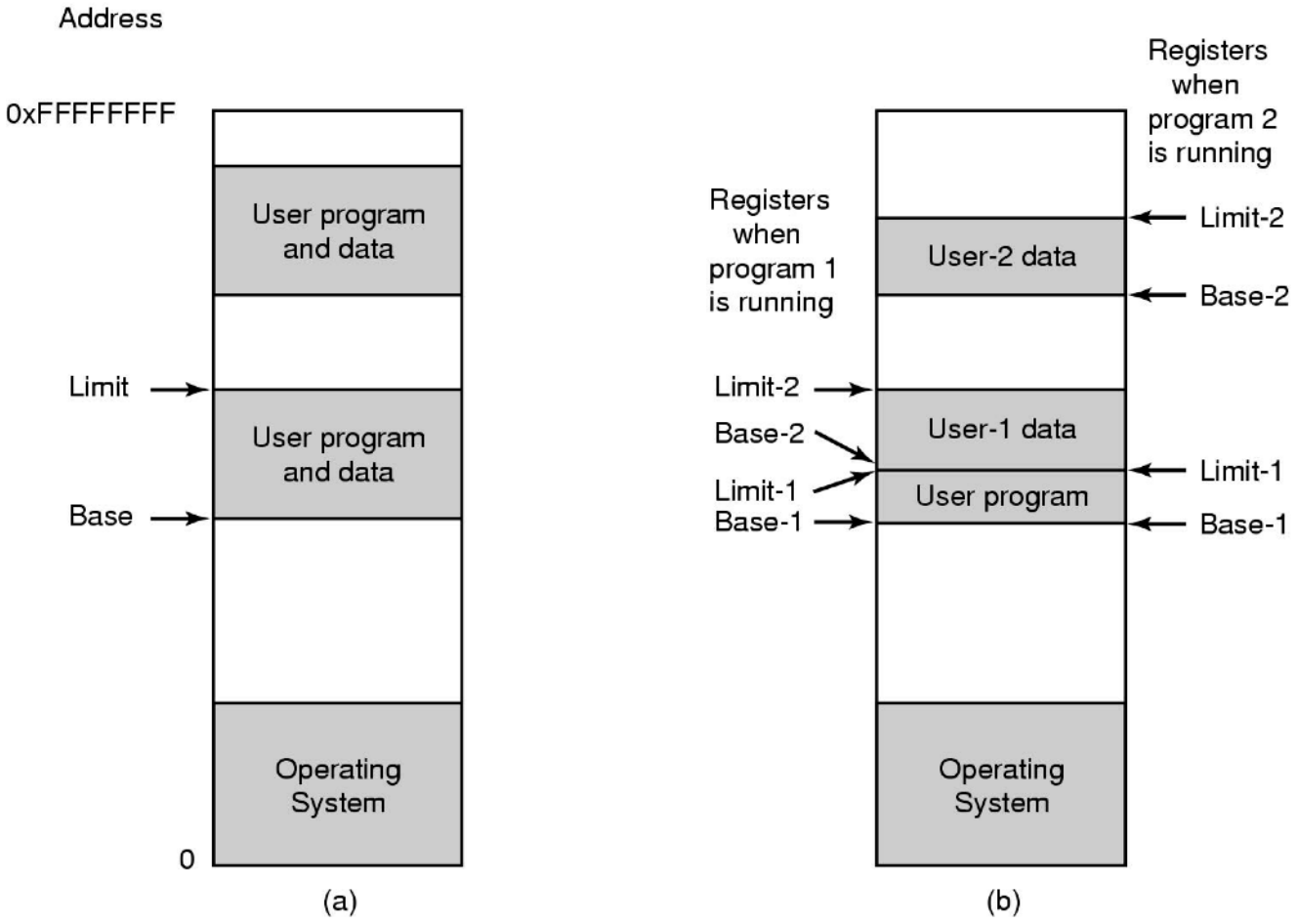
- **How do you protect one application's area of memory from other applications?**
- **How do you relocate an application in memory?**
  - How does the programmer know where the program will ultimately reside in memory?

Memory protection and relocation ...

- **Memory protection – the basic ideas**
  - virtual vs physical addresses
    - **address range in each application starts at 0**
  - Possible solution with base and limit registers
    - **Get CPU to interpret address indirectly, via registers**
    - **base register holds starting address**
    - **Limit register holds ending address**
    - **Add base value to address to get a real address before main memory is accessed**
    - **Compare address to "limit register" to keep memory references within bounds**
  - Relocation
    - **by changing the base register value**

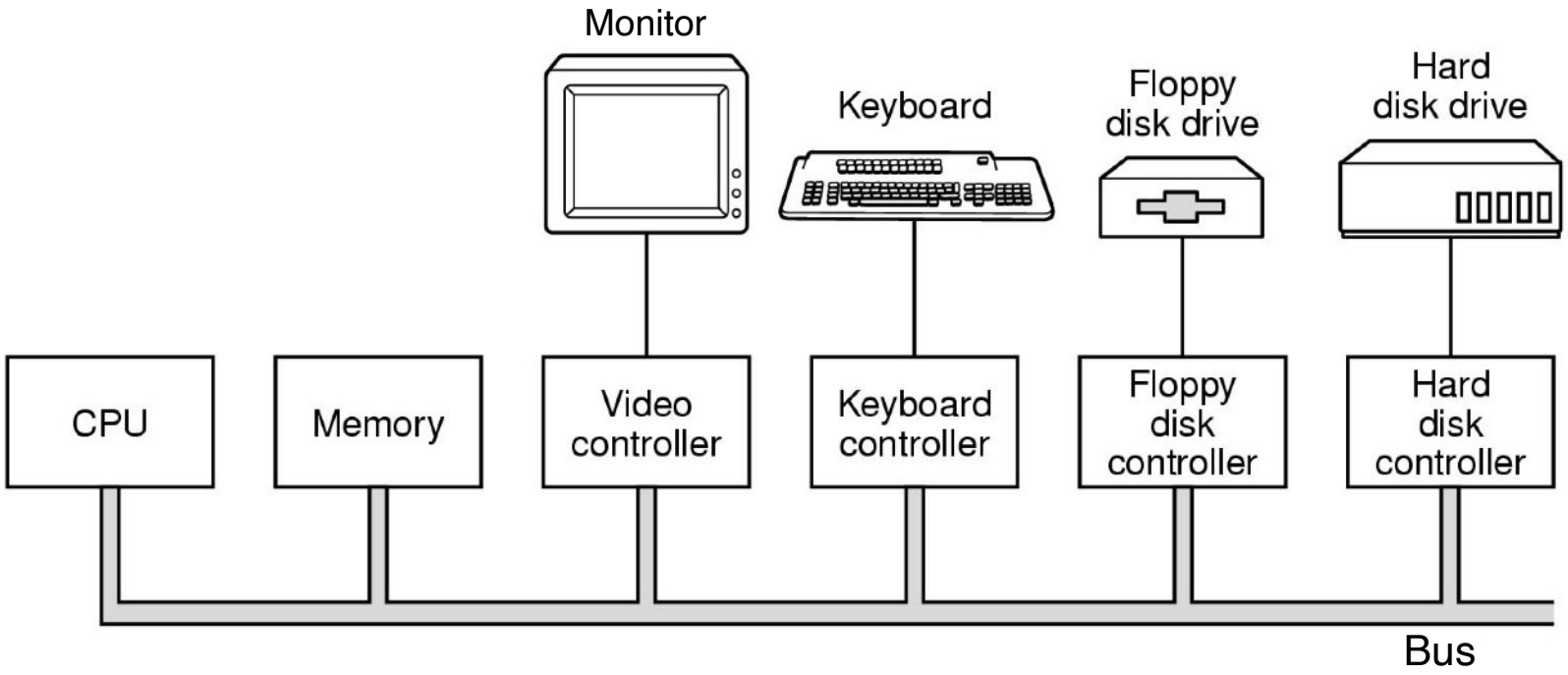
Base & Limit Registers (single & multiple)



Paged virtual memory

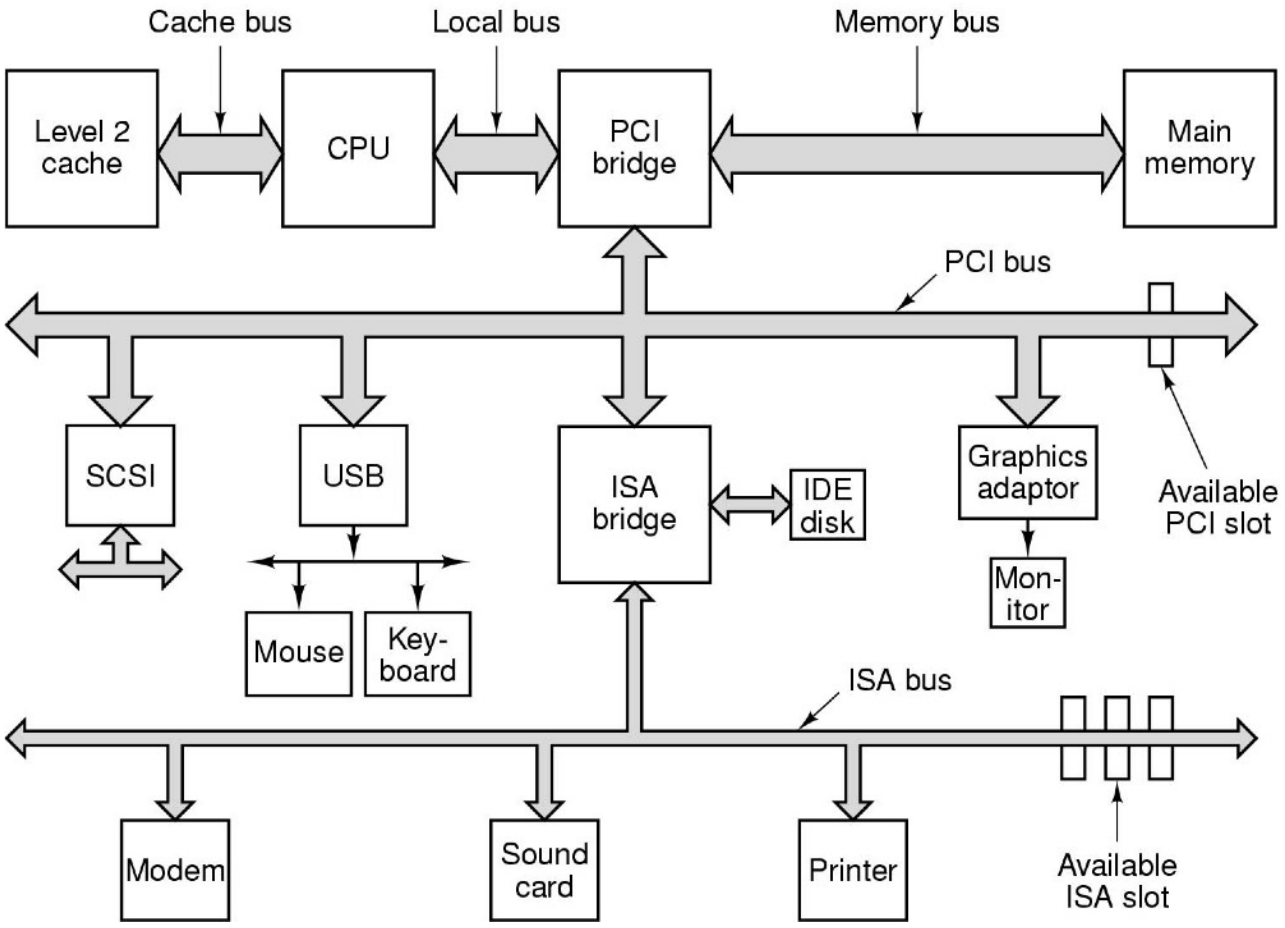
- **The same basic concept, but ...**
  - Supports non-contiguous allocation of memory
  - Allows processes to grow and shrink dynamically
  - Requires hardware support for page-based address translation
    - **Sometimes referred to as a memory management unit (MMU) or a translation lookaside buffer (TLB)**
  - More later ...

What about I/O devices?



A simplified view of a computer system

Structure of a Pentium system



How do programs interact with devices?

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- **Why protect access to devices by accessing them indirectly via the OS?**

- Devices **vs** device controllers **vs** device drivers
  - device drivers are part of the OS (ie. Software)
  - programs call the OS which calls the device driver

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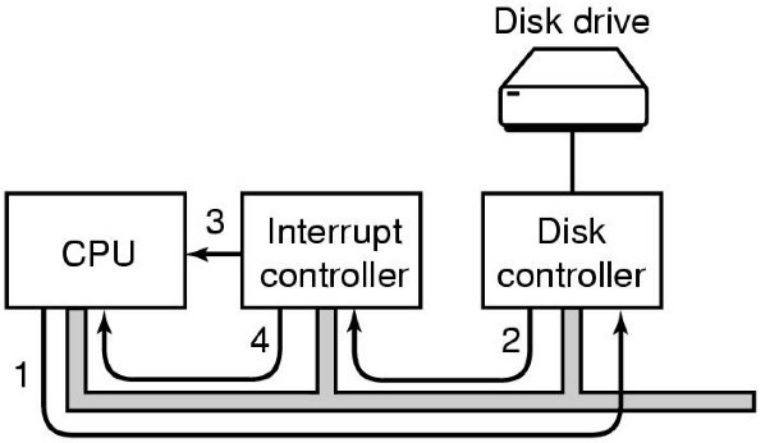
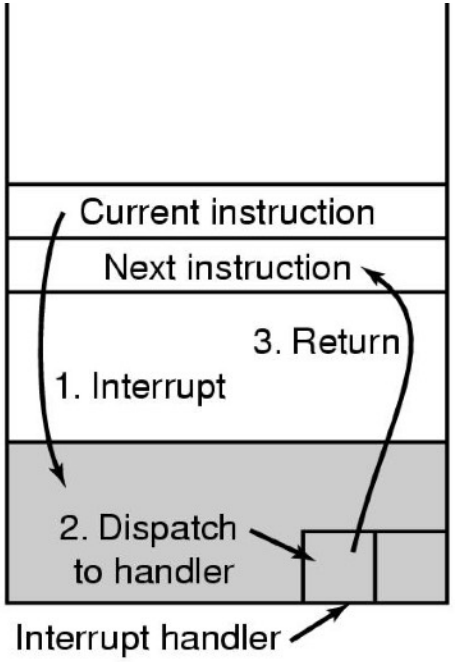
- **Device drivers interact with device controllers**
  - either using special IO instructions
  - or by reading/writing controller registers that appear as memory locations
  - Device controllers are hardware
  - They communicate with device drivers via interrupts

How do devices interact with programs?

- **Interrupts**





Different types of interrupts

- **Timer interrupts**
  - Allows OS to regain control of the CPU
  - One way to keep track of time
- **I/O interrupts**
  - Keyboard, mouse, disks, network, etc…
- **Program generated (traps & faults)**
  - Address translation faults (page fault, TLB miss)
  - Programming errors: seg. faults, divide by zero, etc.
  - System calls like read(), write(), gettimeofday()

System calls

- System calls are the mechanism by which programs communicate with the O.S.
- Implemented via a TRAP instruction
- Example UNIX system calls:

```
open(), read(), write(), close()
kill(), signal()
fork(), wait(), exec(), getpid()
link(), unlink(), mount(), chdir()
setuid(), getuid(), chown()
```

The inner workings of a system call

User-level code

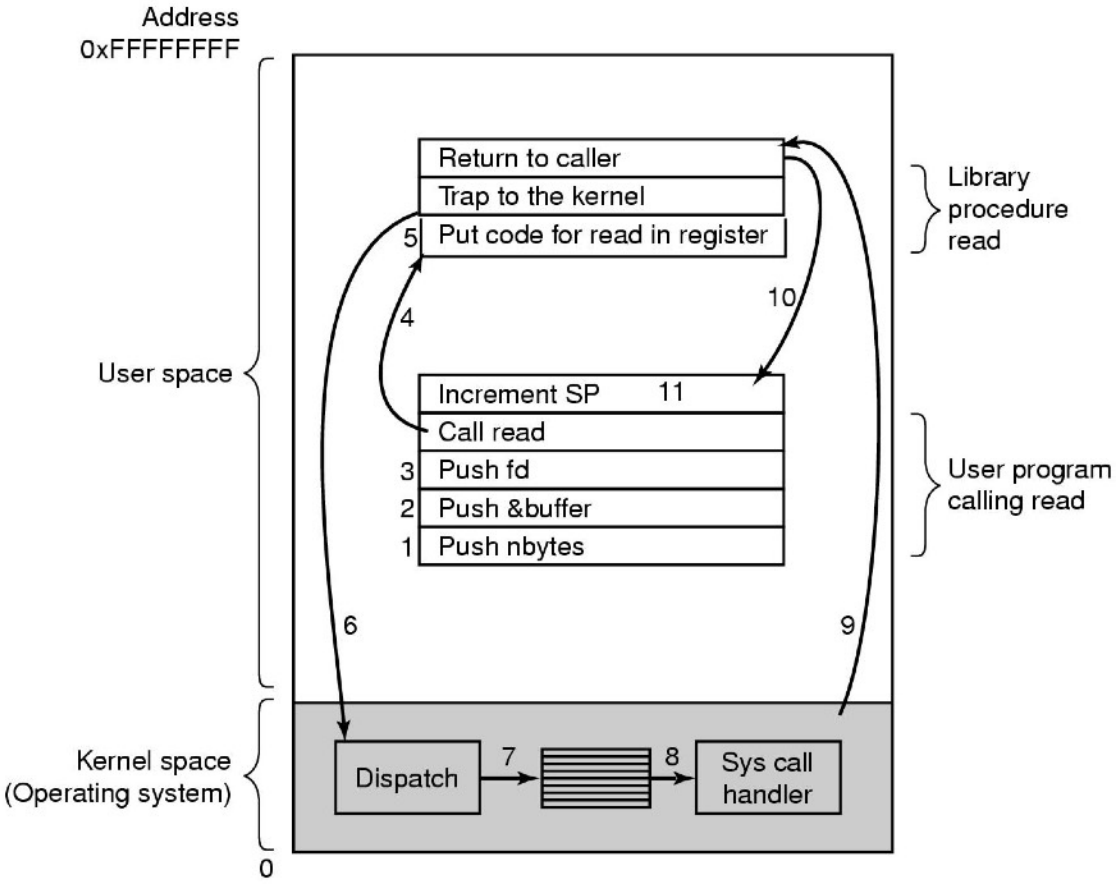
```
Process usercode
  {
   ...
   read (file, buffer, n);
   ...
  }
```

Library code

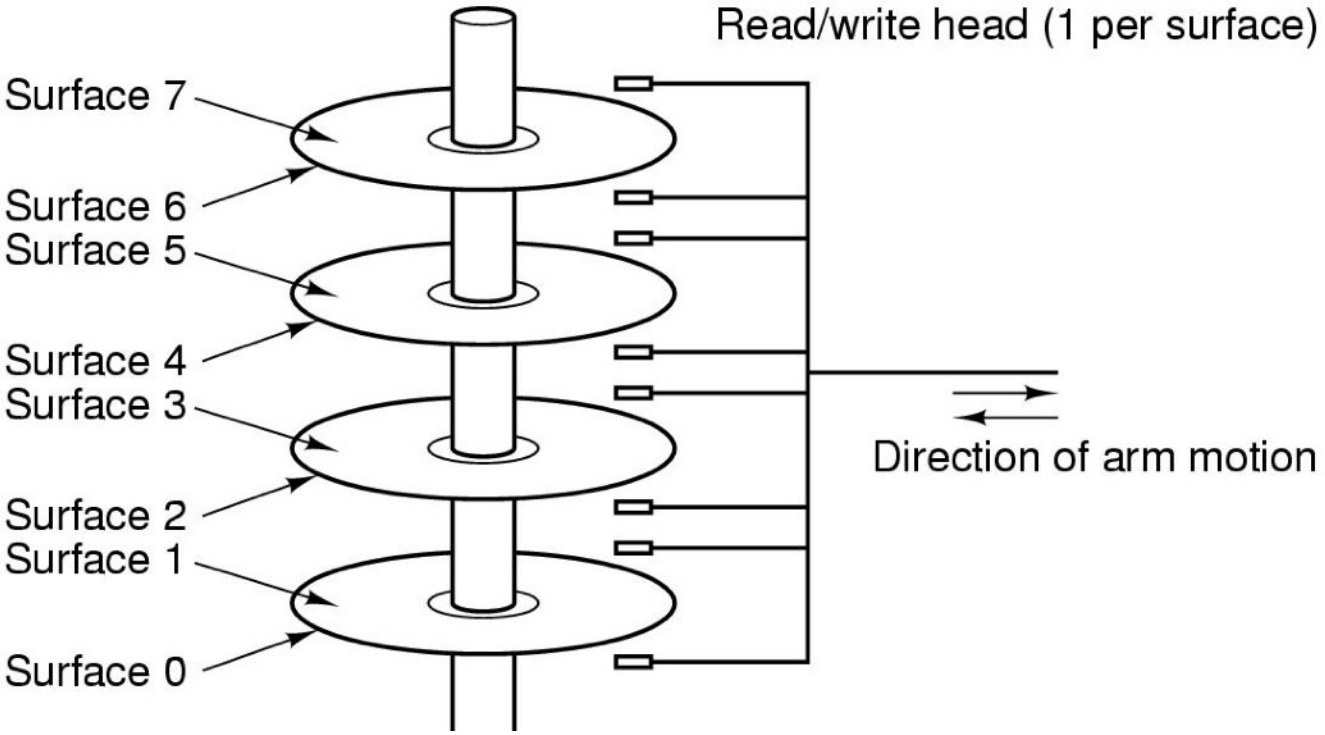
```
Procedure read(file, buff, n)
  {
   ...
   read(file, buff, n)
   ...
  }

_read:
  LOAD r1, @SP+2
  LOAD r2, @SP+4
  LOAD r3, @SP+6
  TRAP Read_Call
```

Steps in making a read() system call



What about disks and file storage?

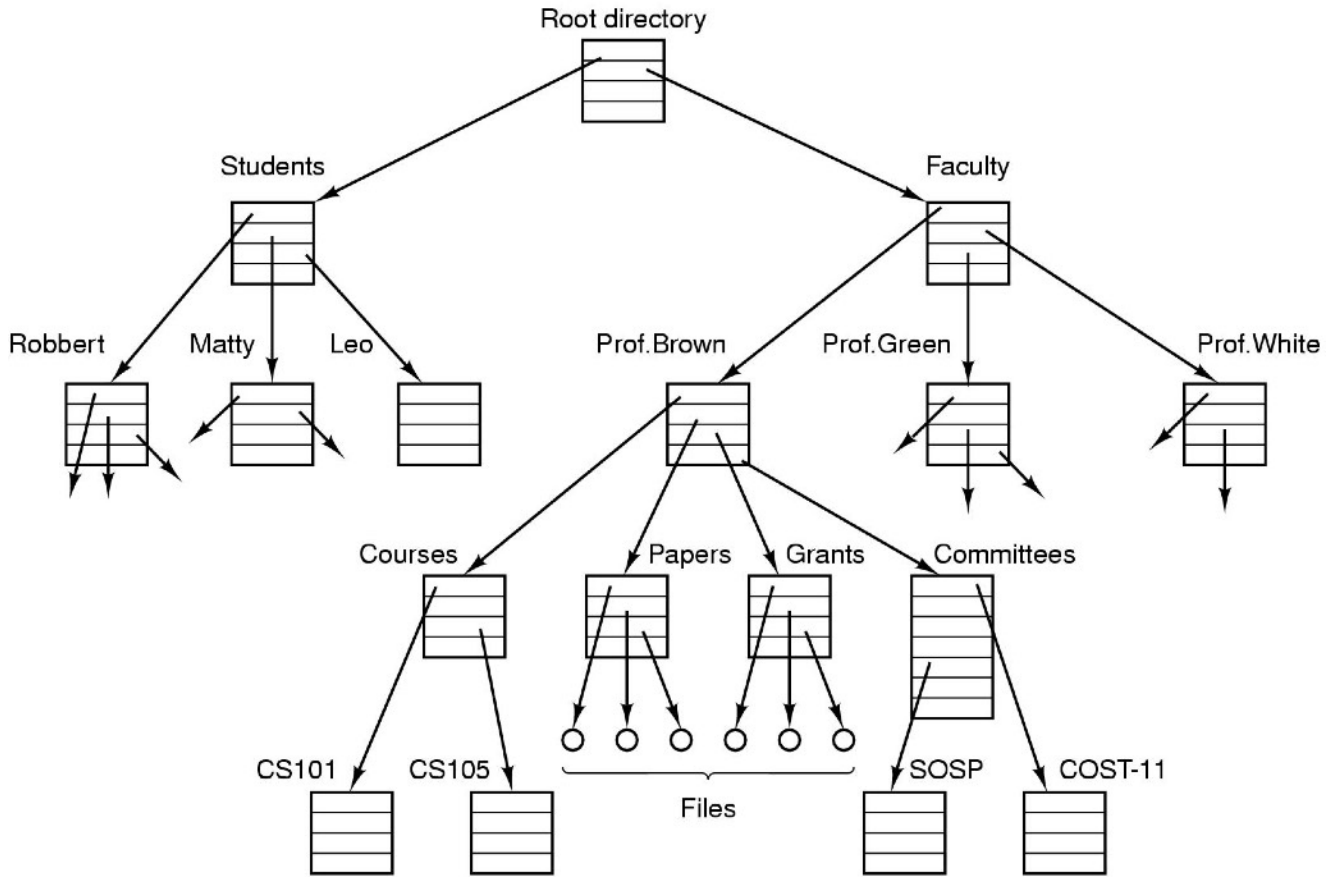


Structure of a disk drive

Disks and file storage

- **Manipulating the disk device is complicated**
  - hide some of the complexity behind disk controller, disk device driver
- **Disk blocks are not a very user-friendly abstraction for storage**
  - contiguous allocation may be difficult for large data items
  - how do you manage administrative information?
- **One application should not (automatically) be able to access another application's storage**
  - OS needs to provide a "file system"

File systems



File system - an abstraction above disk blocks

What about networks?

- **Network interfaces are just another kind of shared device/resource**
- **Need to hide complexity**
  - send and receive primitives, packets, interrupts etc
  - protocol layers
- **Need to protect the device**
  - access via the OS
- **Need to allocate resources fairly**
  - packet scheduling

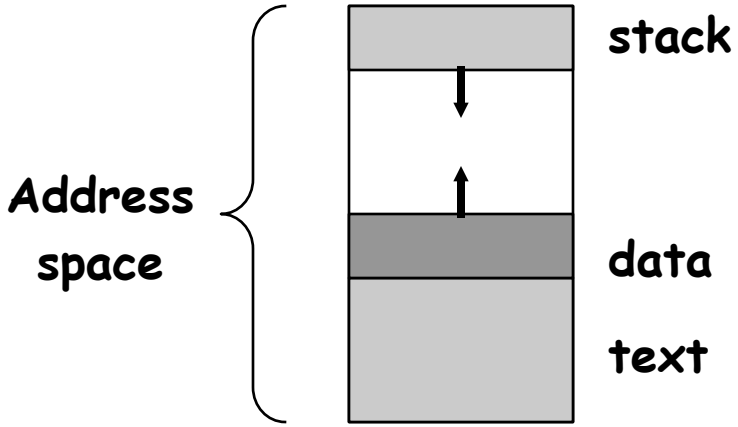
The Process Concept

The Process Concept

- **Process – a program in execution**
  - Program
    - **description of how to perform an activity**
    - **instructions and static data values**
  - Process
    - **a snapshot of a program in execution**
    - **memory (program instructions, static and dynamic data values)**
    - **CPU state (registers, PC, SP, etc)**
    - **operating system state (open files, accounting statistics etc)**

Process address space

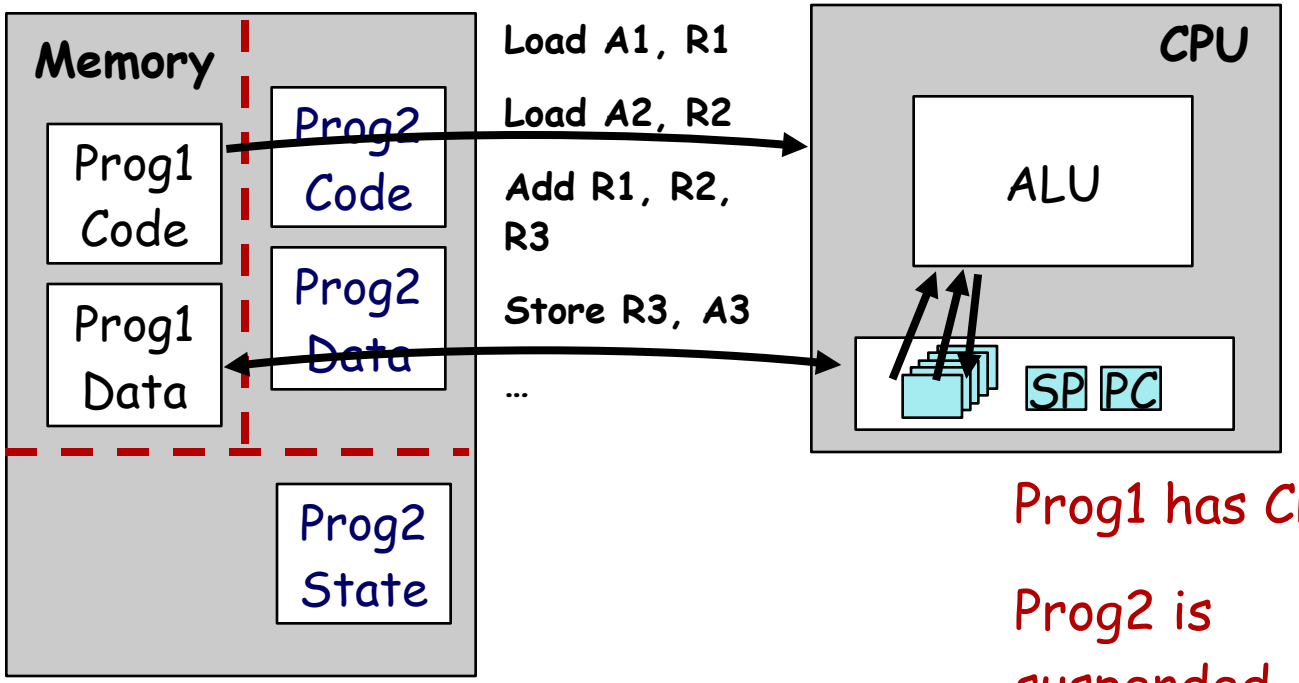
- **Each process runs in its own virtual memory address space that consists of:**
  - Stack space – used for function and system calls
  - Data space – variables (both static and dynamic allocation)
  - Text – the program code (usually read only)



- **Invoking the same program multiple times results in the creation of multiple distinct address spaces**

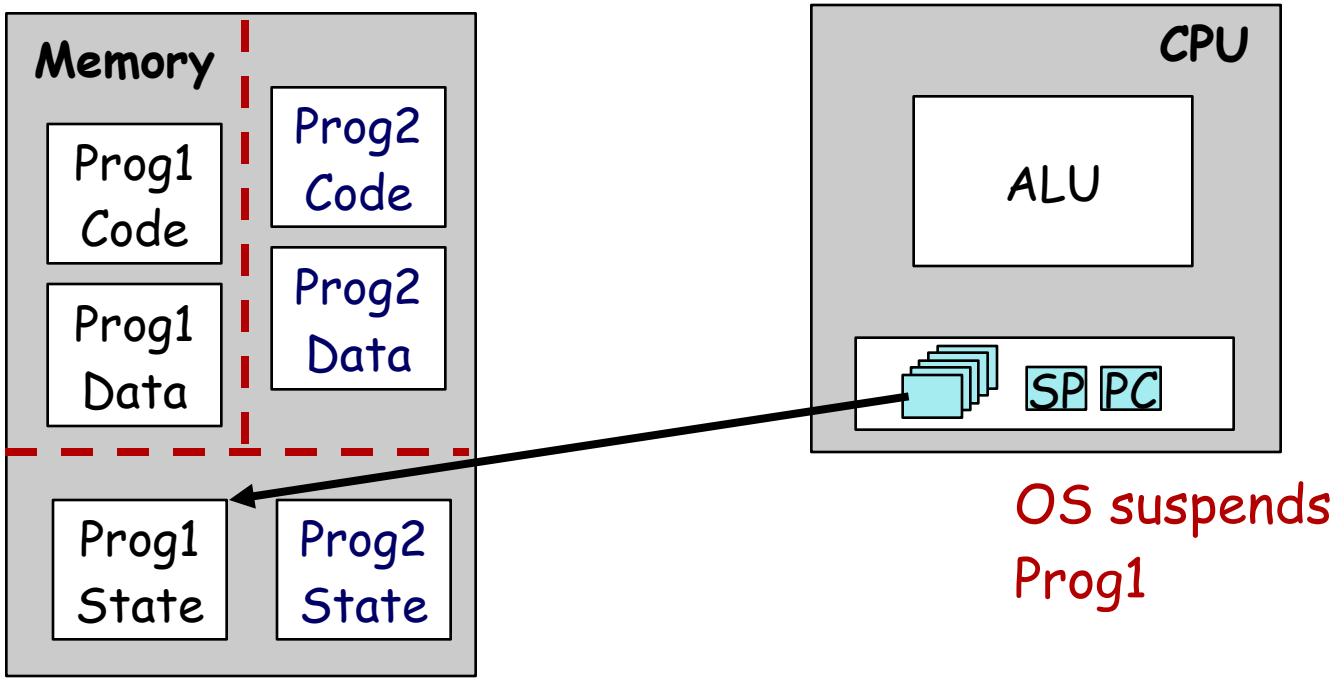
Switching among multiple processes

- Program instructions operate on operands in memory and (temporarily) in registers



Switching among multiple processes

- Saving all the information about a process allows a process to be temporarily suspended and later resumed from the same point



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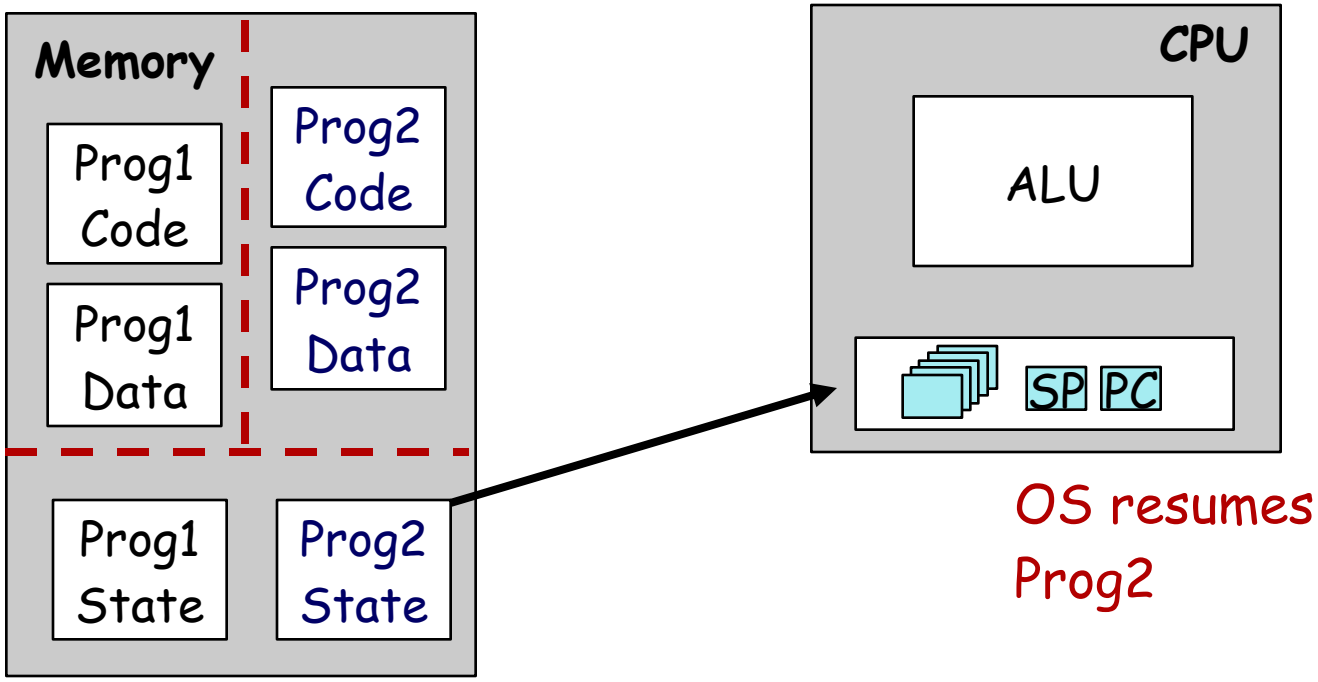

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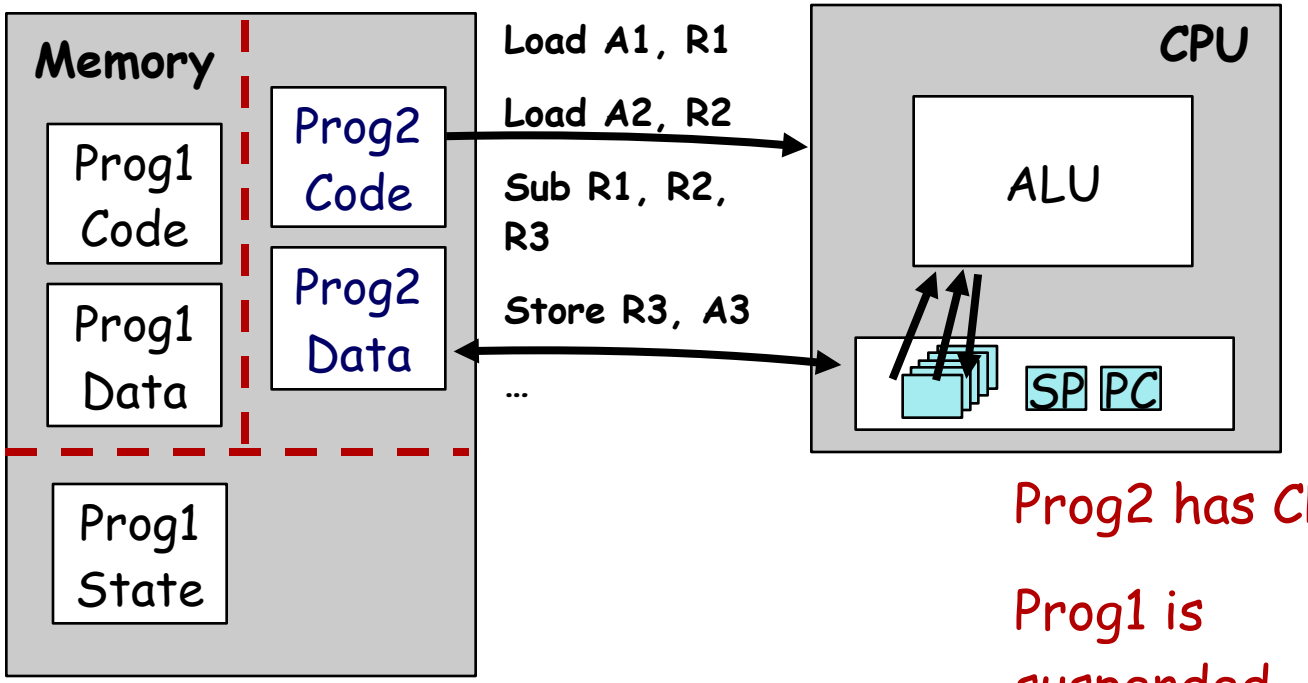
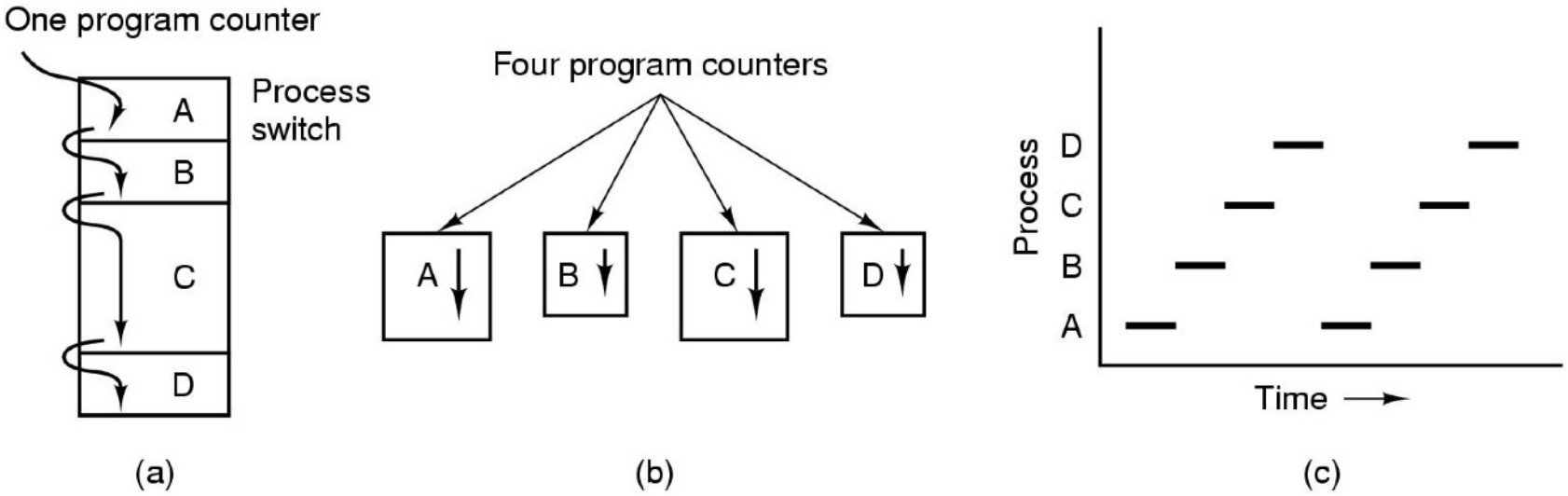
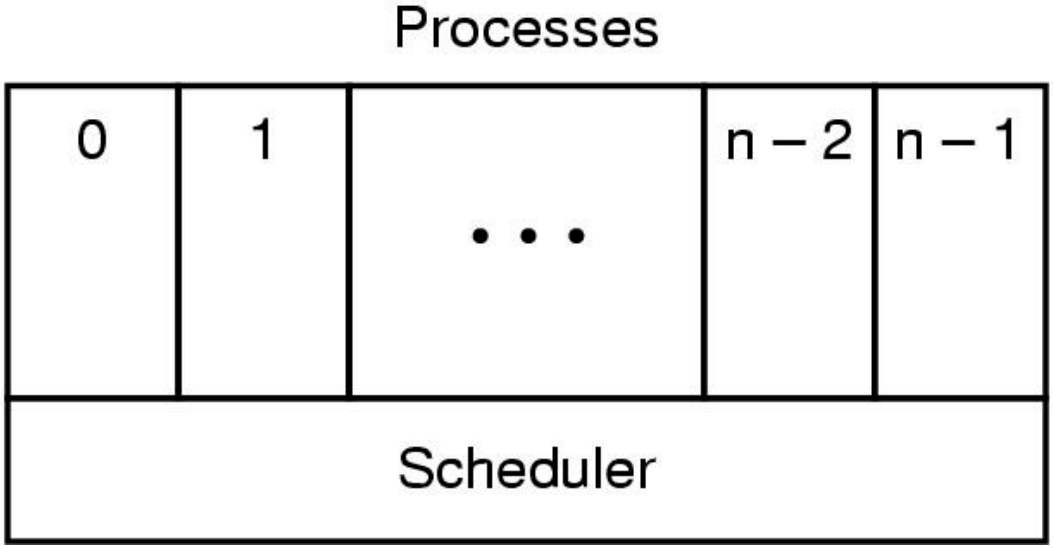


Why use the process abstraction?



- Multiprogramming of four programs in the same address space
- Conceptual model of 4 independent, sequential processes
- Only one program active at any instant

The role of the scheduler



- **Lowest layer of process-structured OS**
  - handles interrupts & scheduling of processes
- **Sequential processes only exist above that layer**