csci3411: Operating Systems

Lecture 3: **System structure and Processes**

Gabriel Parmer

Some slide material from Silberschatz and West

System Structure

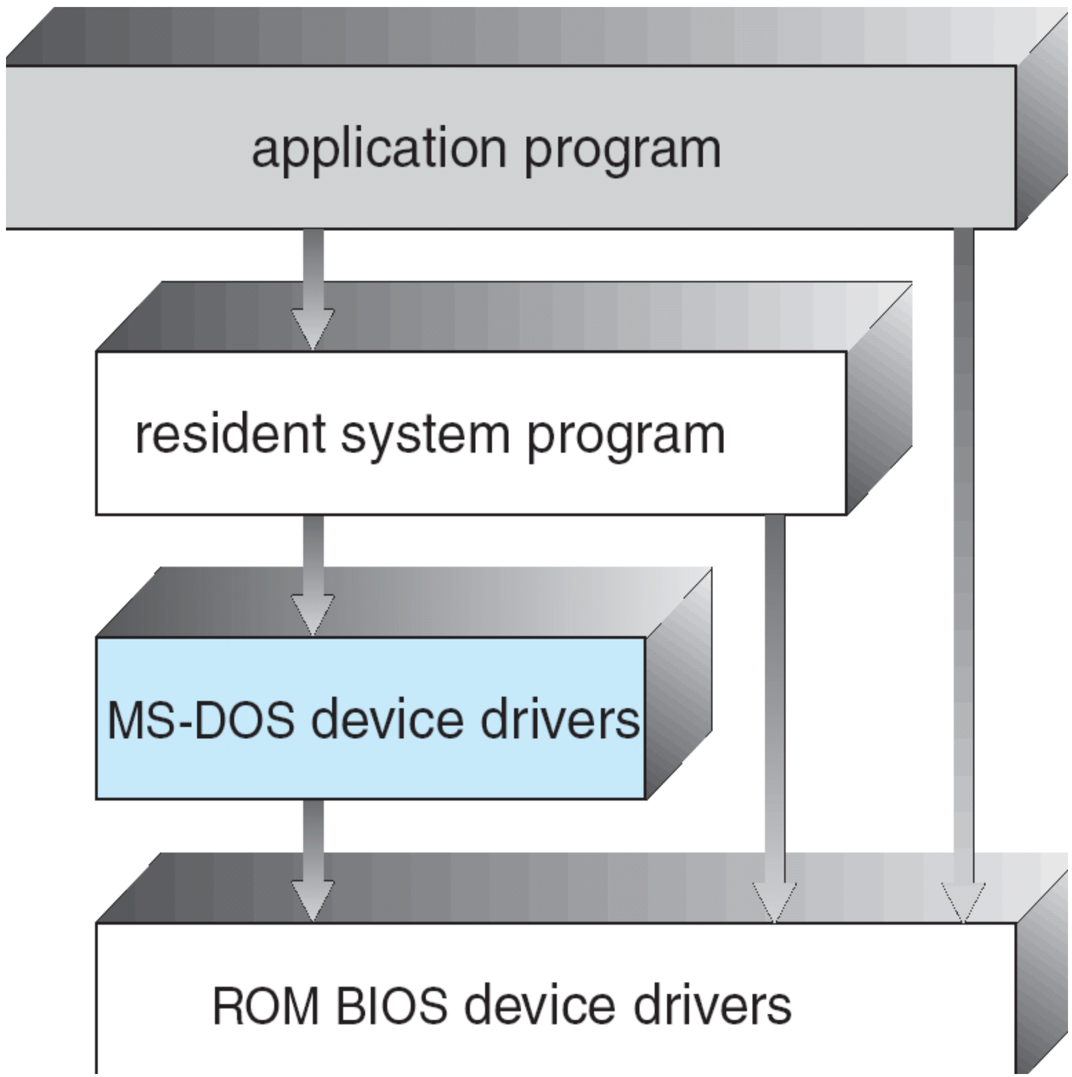
- *System Structure* – How different parts of software

  1) Are separated from each other (*Why?)*

  2) Communicate

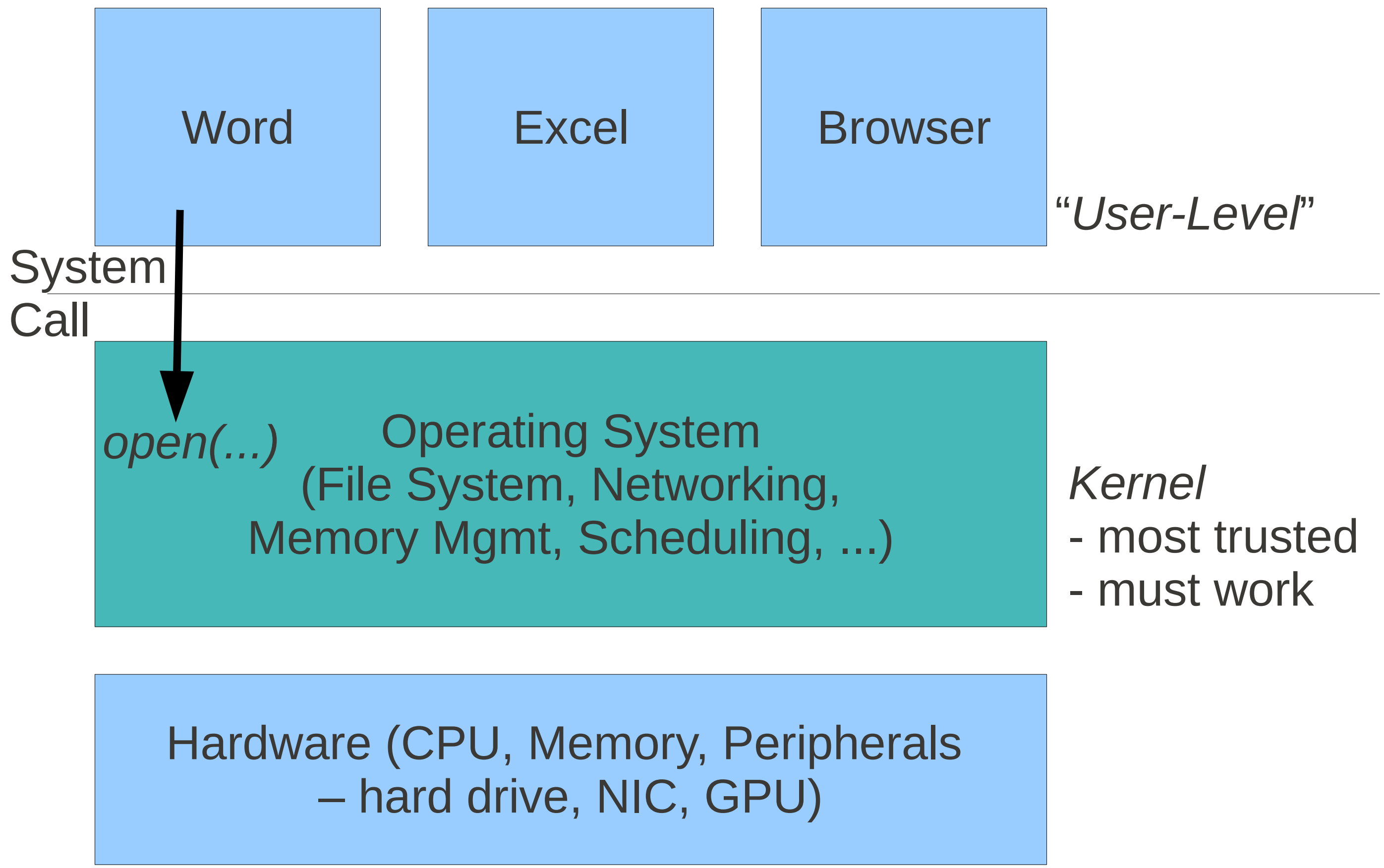
- How does a system use
  - dual mode
  - v*irtual address spaces*
- Implications on
  - Security/Reliability
  - Programming style/Maintainability

MSDOS: No Structure/Protection



Monolithic System Structure

- Includes Unix/Windows/OSX



Monolithic System Structure

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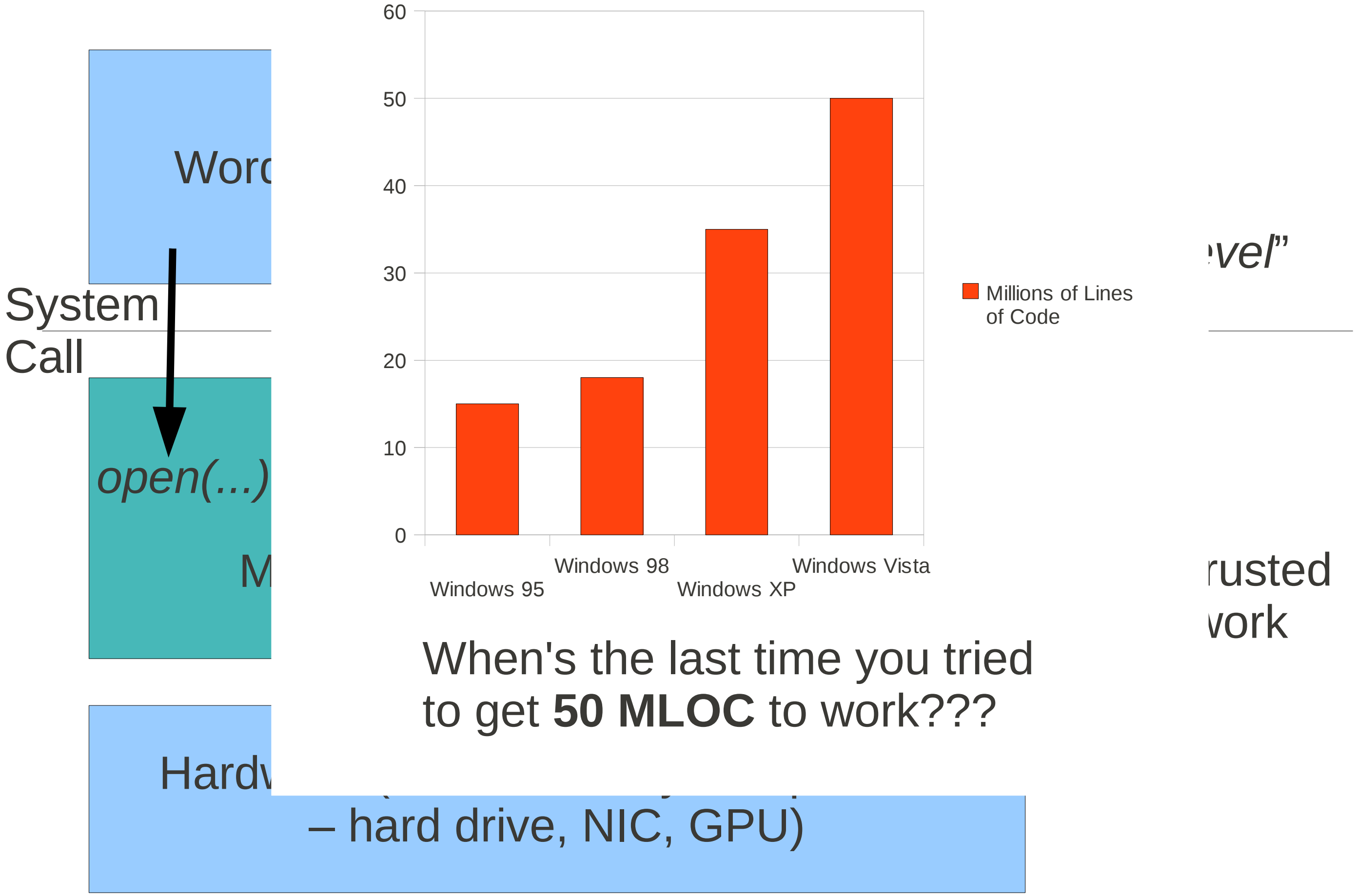
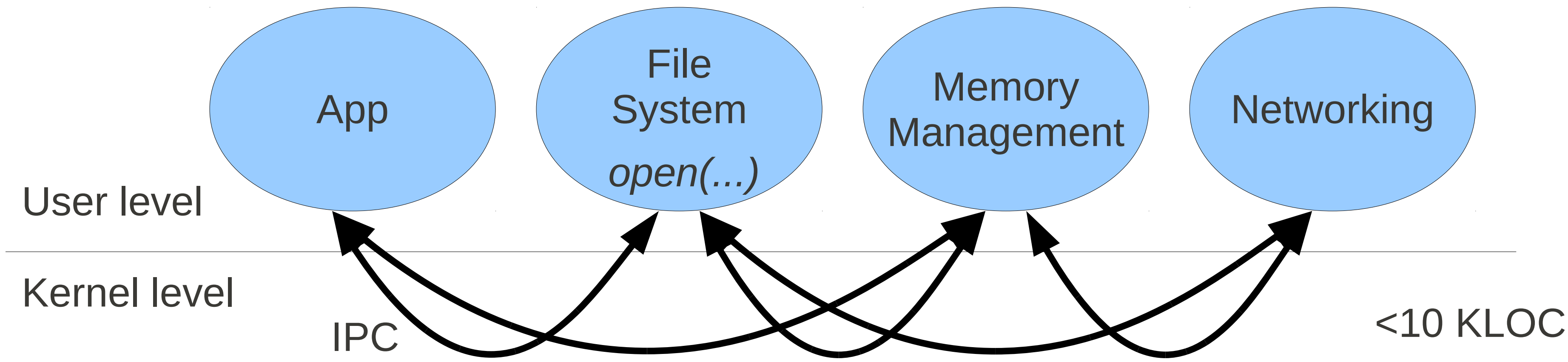


Microkernel System Structure



- Moves functionality from the kernel to "*user*" space
- Communication takes place between user *servers* using inter-process communication (IPC)
- Benefits:
  - Easier to add functionality
  - More reliable (less code is running in kernel mode)
  - More secure
- Detriments: performance! (why?)

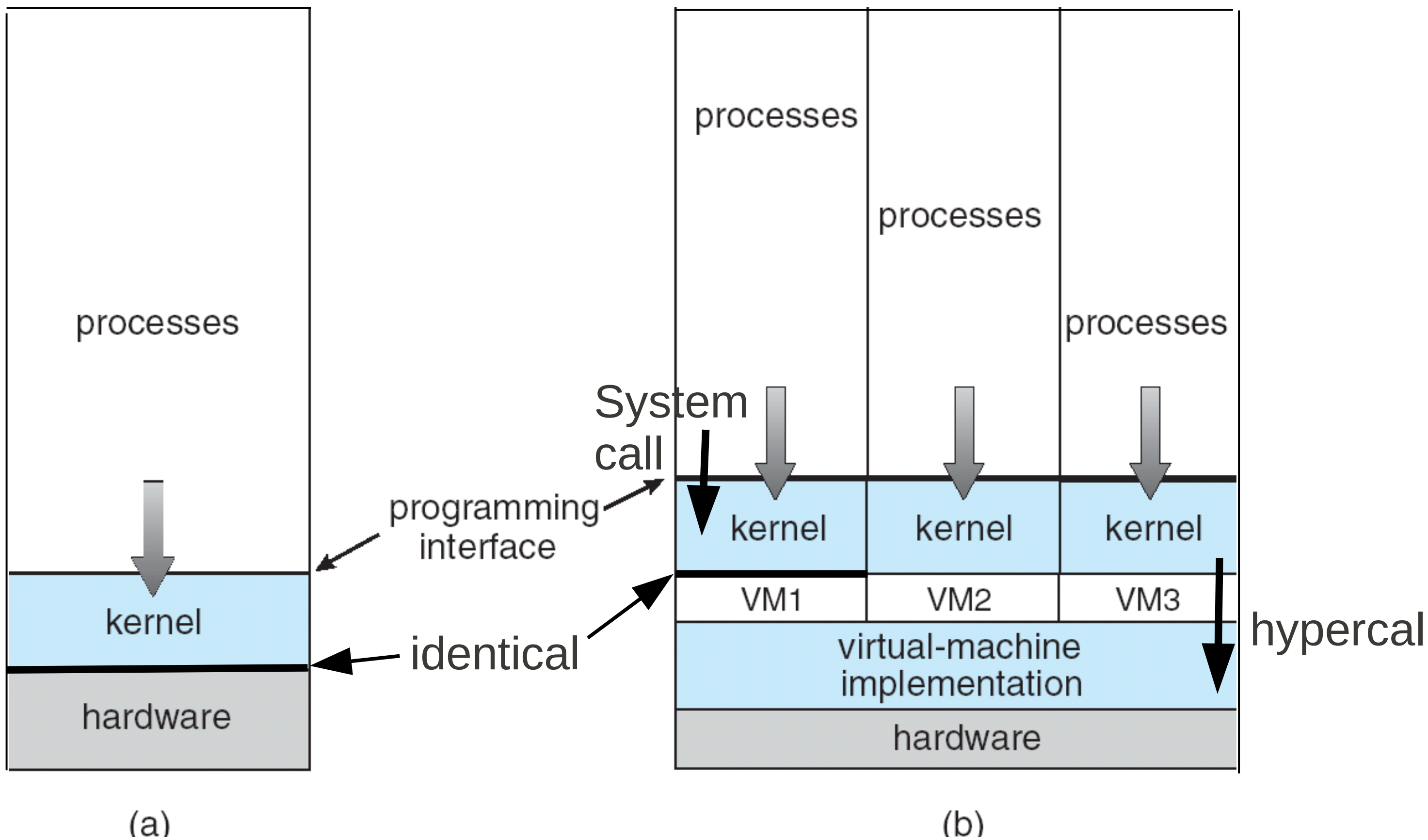
Virtual Machines I

- Do you know what these are?
- What is the structure of VMs?

Virtual Machines II

- A virtual machine *host* (the kernel) provides an interface *identical* to the underlying bare hardware
  - Other *guest* kernels execute in user-mode
  - The API for virtual machines is a copy of the machine!

Virtual Machines III



(a) non-virtual machine (b) virtual machine

Virtual Machine: Benefits

- Fundamentally, multiple operating systems share the same hardware
- Protected from each other
- Some sharing of files
- Communicate with each other via networking
- Useful for development, testing
- *Consolidation* of many low-resource use systems onto fewer busier systems

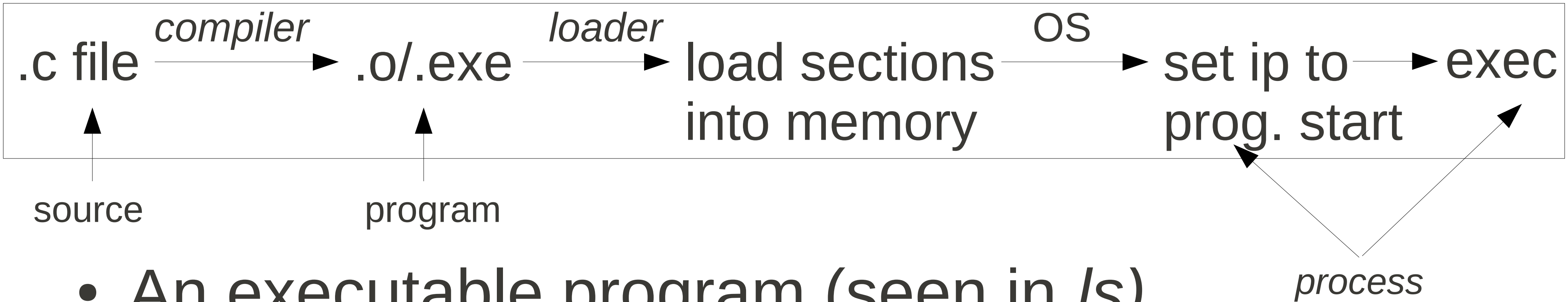
Vms vs microkernels

- Is either a *generalization* of the other?
- Why are microkernels better?
- Why are VMs better?
- Which is more commonly used?
  - Where?
  - Why?

CPU/Memory Abstraction

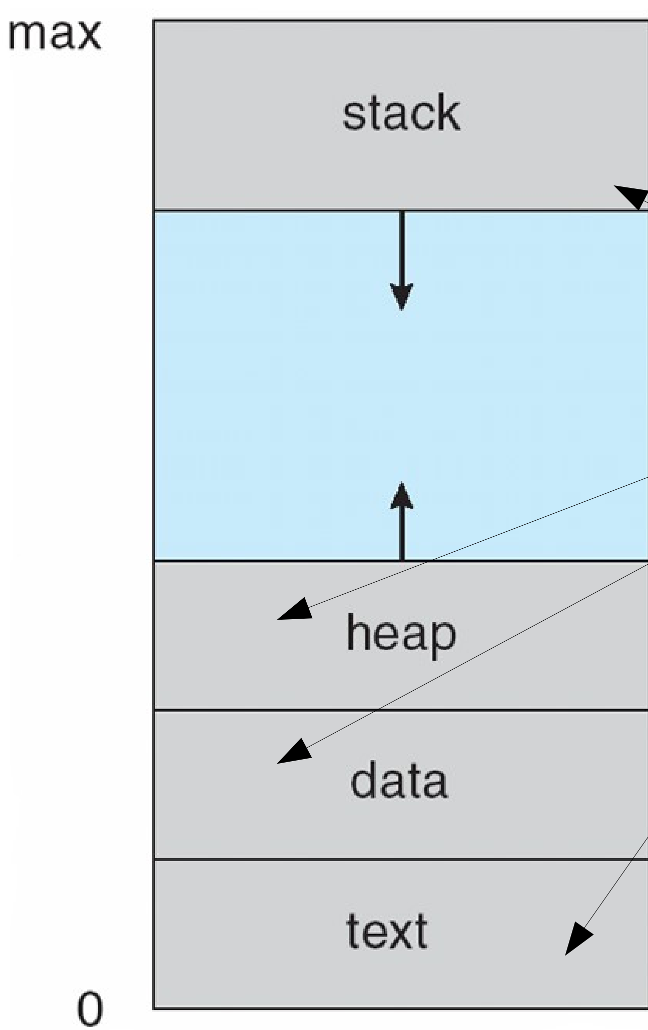
- Hardware provides
  - Sequential execution
  - Interrupts
- OS should provide
  - Multiple flows of sequential execution (diff apps)
  - Each app should have its own memory “space”
  - Protection between these applications
    - Security
    - Fault isolation

Processes



- An executable program (seen in *ls*)
  - passive collection of code and data; kept in file
- UNIX Process: active entity that includes (seen in *ps*)
  - Registers (instruction counter, stack pointer, etc..)
  - Execution stack
  - Heap
  - Data and text (code) segments

Process in Memory




```
char *s = malloc(10);
printf(”stk: %p\n”, &s);
printf(“malloc: %p\n”, s);
printf(”global: %p\n”, &global_variable);
printf(”fn: %p\n”, main);
→
stk: 0xBC87B240
malloc: 0x1070B4F0
global: 0x004C72A0
fn: 0x000BC240
```

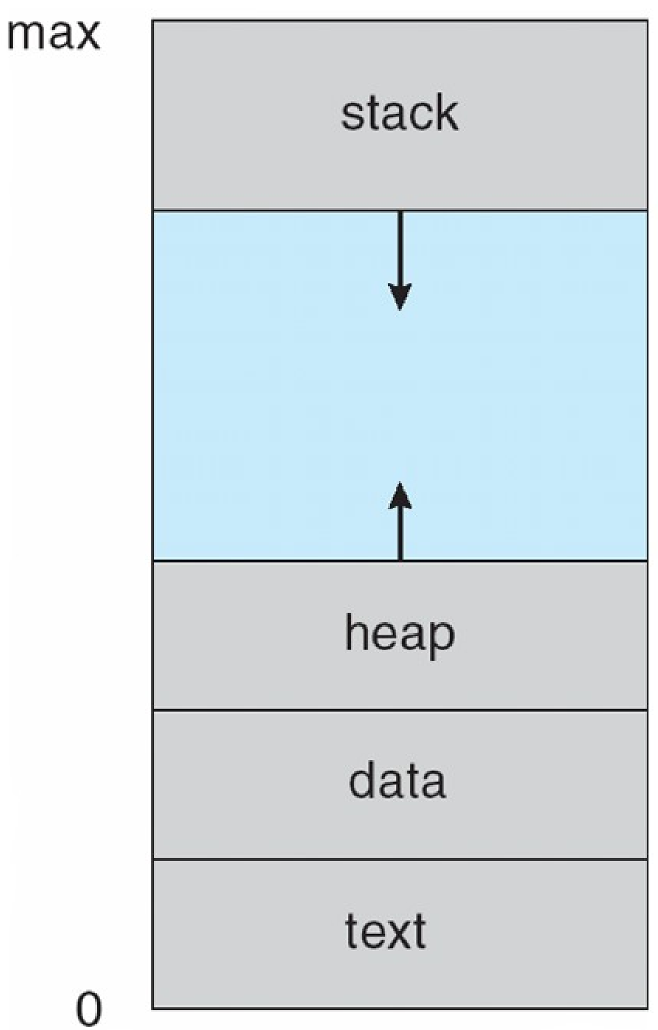
empty

malloc, free

int global_variable;

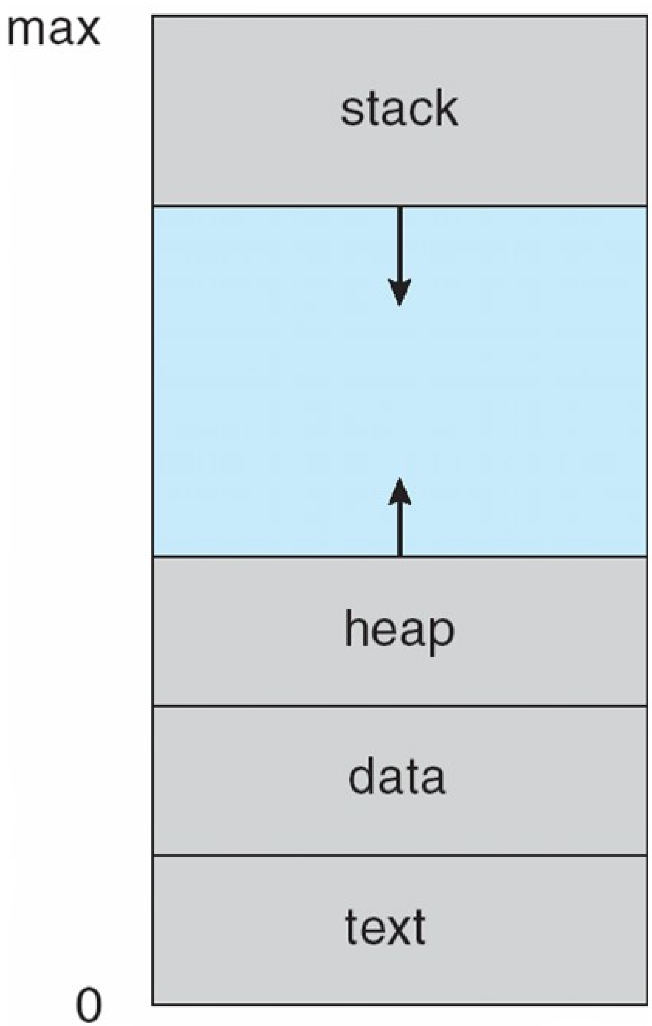
int main(void) { return 0; }

OS Support for Process Memory



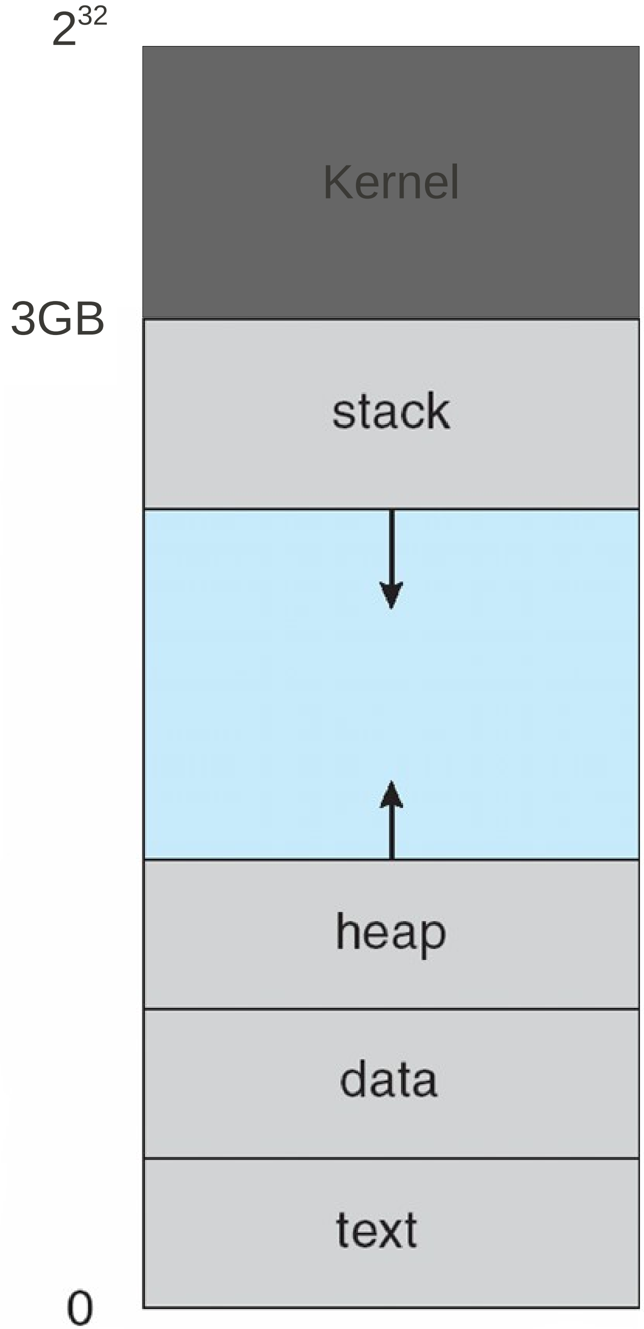
- OS uses HW to provide virtual address space (VAS)
  - Each process thinks it has all memory
    - OS abstraction!!!
  - Provides protection between processes
  - Only subset of that address space is populated by actual memory

OS Support for Process Memory II



- Kernel must manage virtual address spaces
  - Create mapping between virtual and actual memory
  - Switch between apps == switch between VAS
    - Only mode 0 can switch VAS!

Kernel vs. Process Memory



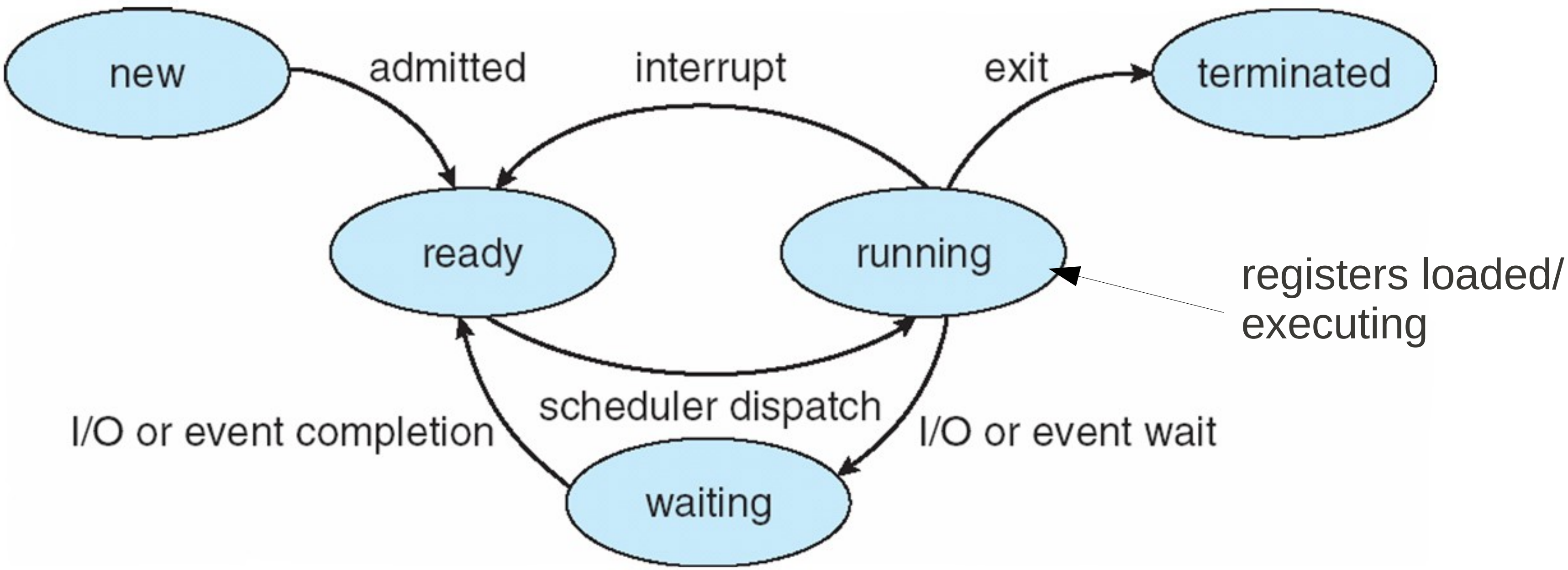
- Kernel mapped into *each* AS
  - kernel data-structure storage
- Questions
  - *Why no separate kernel AS?*
  - *How is the kernel protected?*
  - *Revisit system call flow?*
- *Blue pill:*
  - *switching AS → same kernel mem*

Process Control Block (PCB)

- Kernel, per-process, data-structure includes:
  - CPU registers (including instruction counter)
  - Scheduling state (priority)
  - Memory management information (amount of memory allocated, virtual address space mapping, stack location)
  - CPU accounting info (exec time at user/kernel level)
  - File info (open files)
  - Process state

Process States

- As process executes, the kernel changes its state

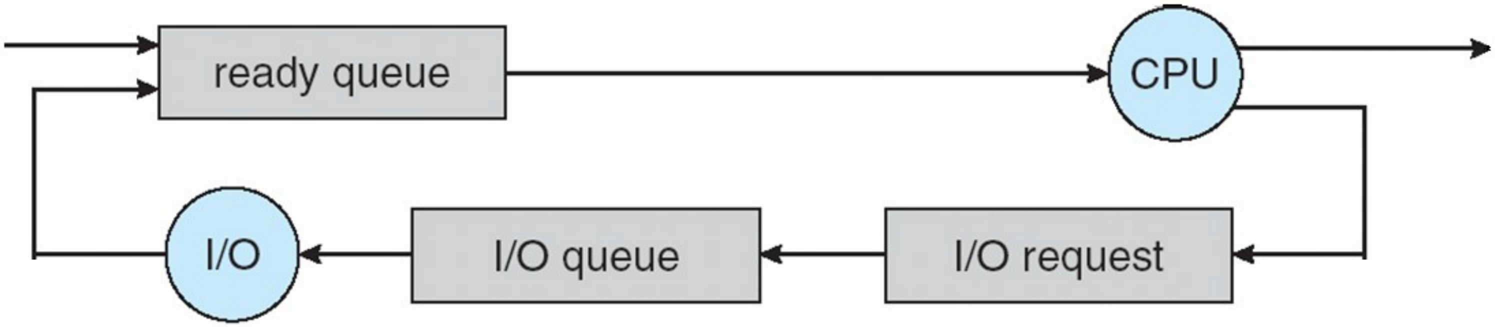


- Many processes in system
  - If one is in *running*, what states are the others in?
  - Give an example of why a process would go from *running* → *waiting*
  - Why would *running* + interrupt → waiting

Process Queues

- Process/Job queue – all processes in system
- Scheduling runqueue – procs in *ready* state
  - Waiting to execute
  - Scheduler chooses next process to run
- Device queues – processes waiting for I/O completion (interrupts)
  - Typically one queue per device
- Processes migrate between queues

Process Migration between Queues



Process Scheduling

- Choose which process to *dispatch* next given
  - Process priority (compared to other ready/runnable processes)
  - Remaining process timeslice (CPU allocation)
- Two general types of processes
  1) CPU bound: most time on CPU, not waiting for I/O
  2) I/O bound: short bursts of CPU usage, most time spent waiting on I/O

- *What keeps a single CPU-bound process from monopolizing the CPU?*

Timer Interrupts

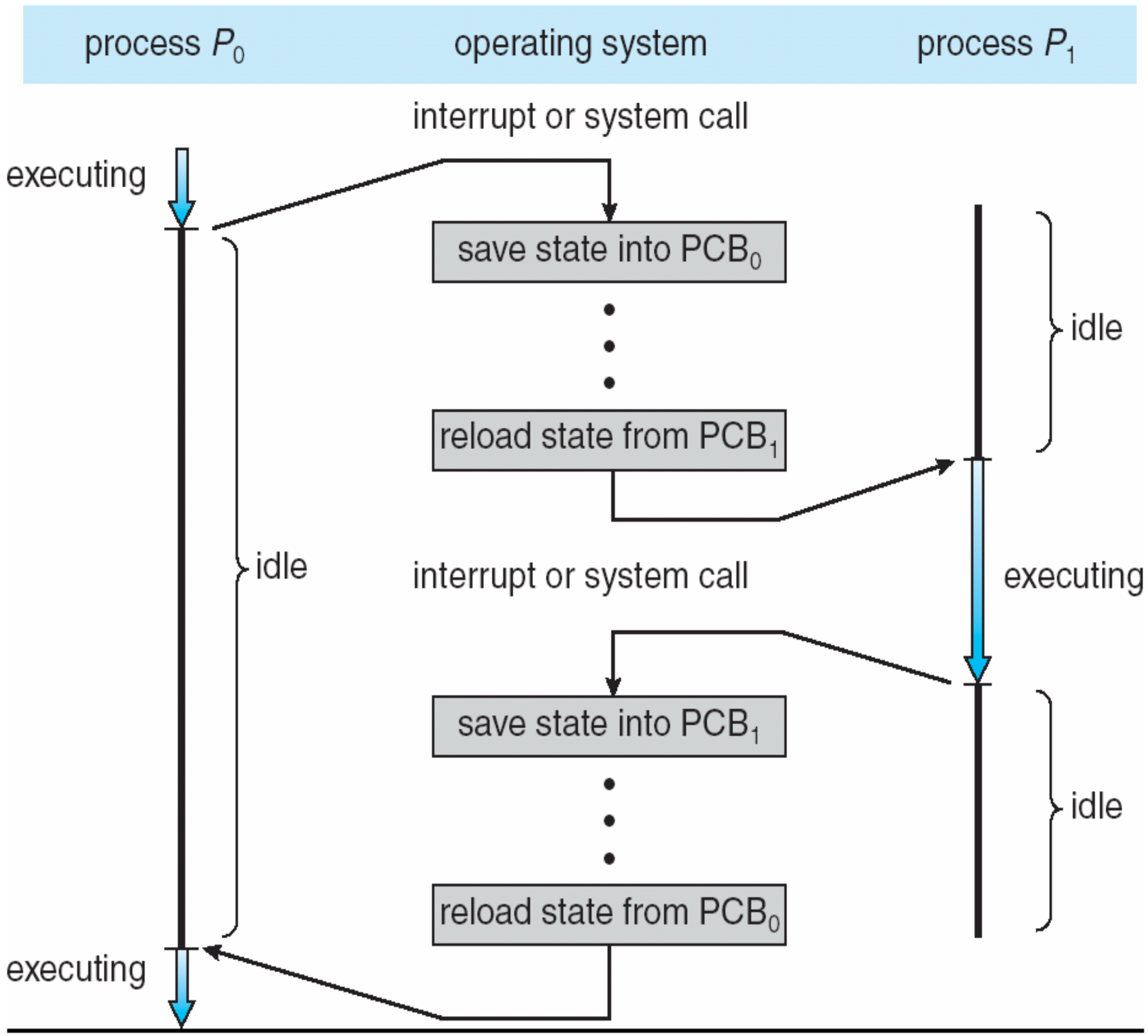
- Interrupt from on-processor time keeping device
  - e.g. 100 times a second in Linux, every 10 milliseconds
- Allows kernel to “keep time”
  - Track amount of execution of different processes
  - Schedule accordingly
- Process' *timeslice* typically a multiple of a timer interrupt's inter-arrival time

Single CPU → Many Processes

- Scheduler decides which process to run next
- *Dispatcher* actually switches from the current process, to the next (chosen by the scheduler)
  - Ready state → running state
- *Context switch* time is overhead; should be minimal

- *What is involved in a context switch? What needs to be saved and restored?*

Single CPU → Many Processes II



Context Switch Implementation

```
struct thread *current, *next;
switch_regs(current, next)
```

```
switch_regs:
	/* save first thread's registers */
	mov %a, current->regs.a
	…
	mov %sp, current->regs.sp
	mov post_switch, current->regs.ip

	/* load next thread's registers! */
	mov next->regs.a, %a
	…
	mov next->regs.sp, %sp
	jmp next->regs.ip
post_switch:
	ret
```

%a is the first register
%sp is the stack pointer