Operating Systems

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What is an OS?

What is an OS?

- Application view
- System view
- Implementation view

Application View

- Provides an execution environment for running programs
- Provides an abstract view of the underlying computer system
  - Processors → Processes, Threads
  - Memory → Address space (virtual memory)
  - Storage → Volumes, Directories, Files
  - I/O Devices → Files
  - …

System View

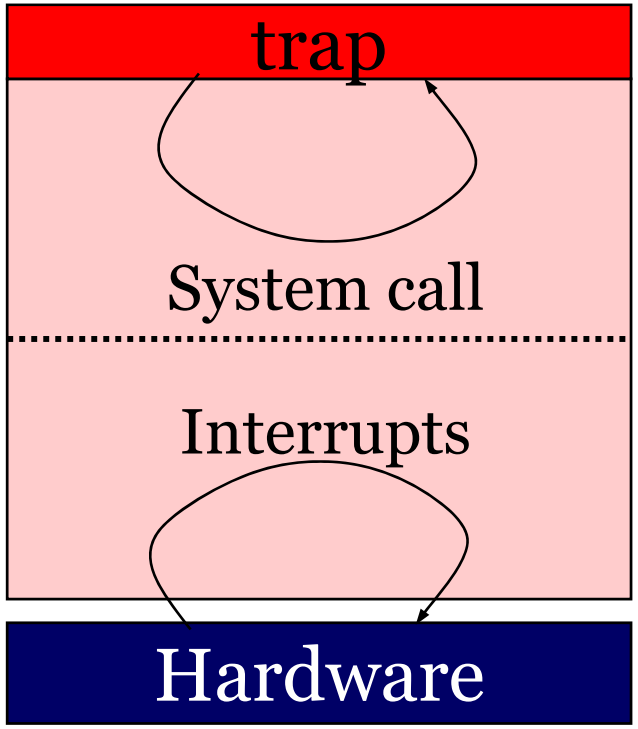
- Manages various resources of a computer system
- Goals
  - Sharing
  - Protection
  - Fairness
  - Efficiency
  - …

Resources

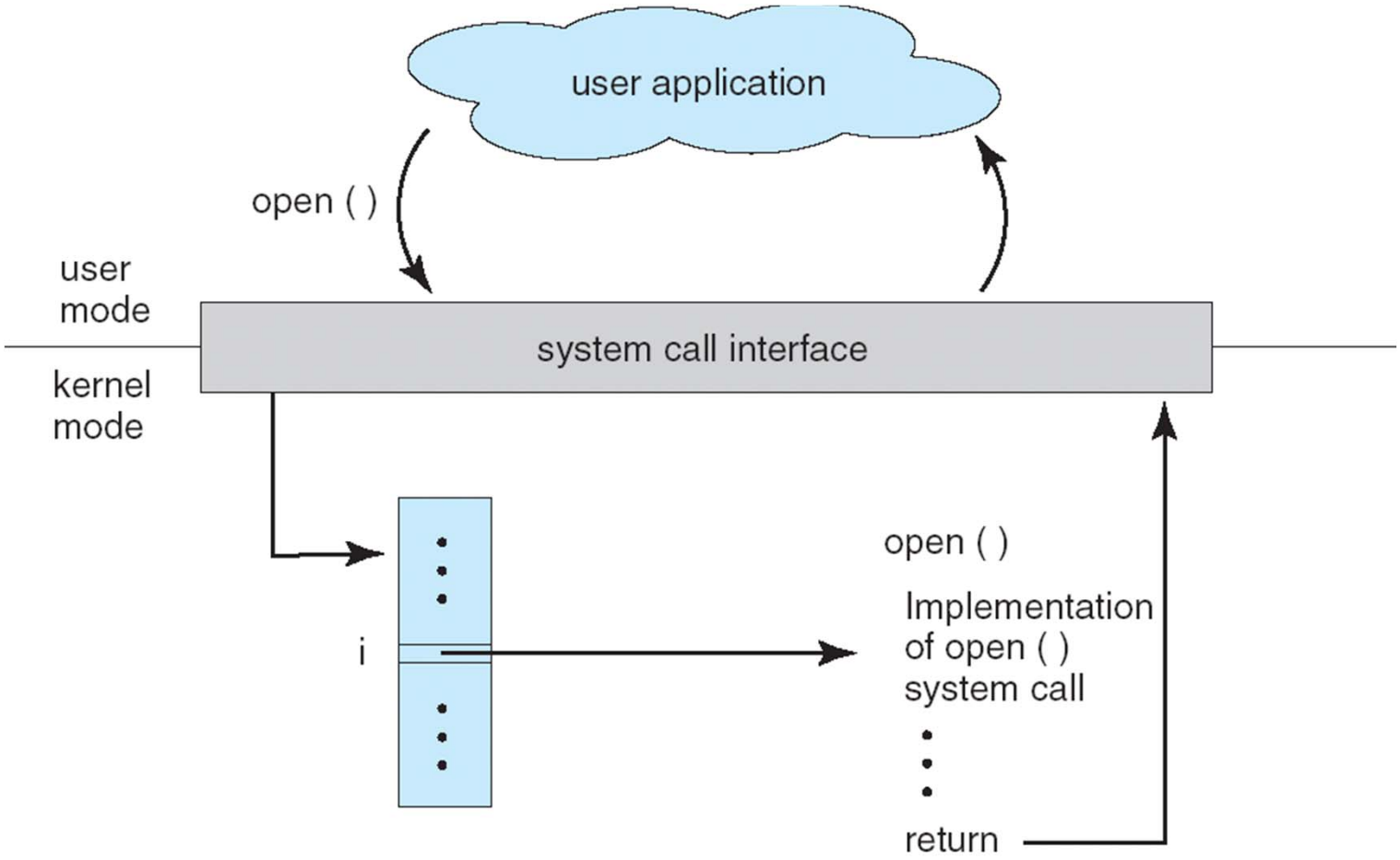
- CPU
- Memory
- I/O devices
- Queues
- Energy
- …

Implementation View

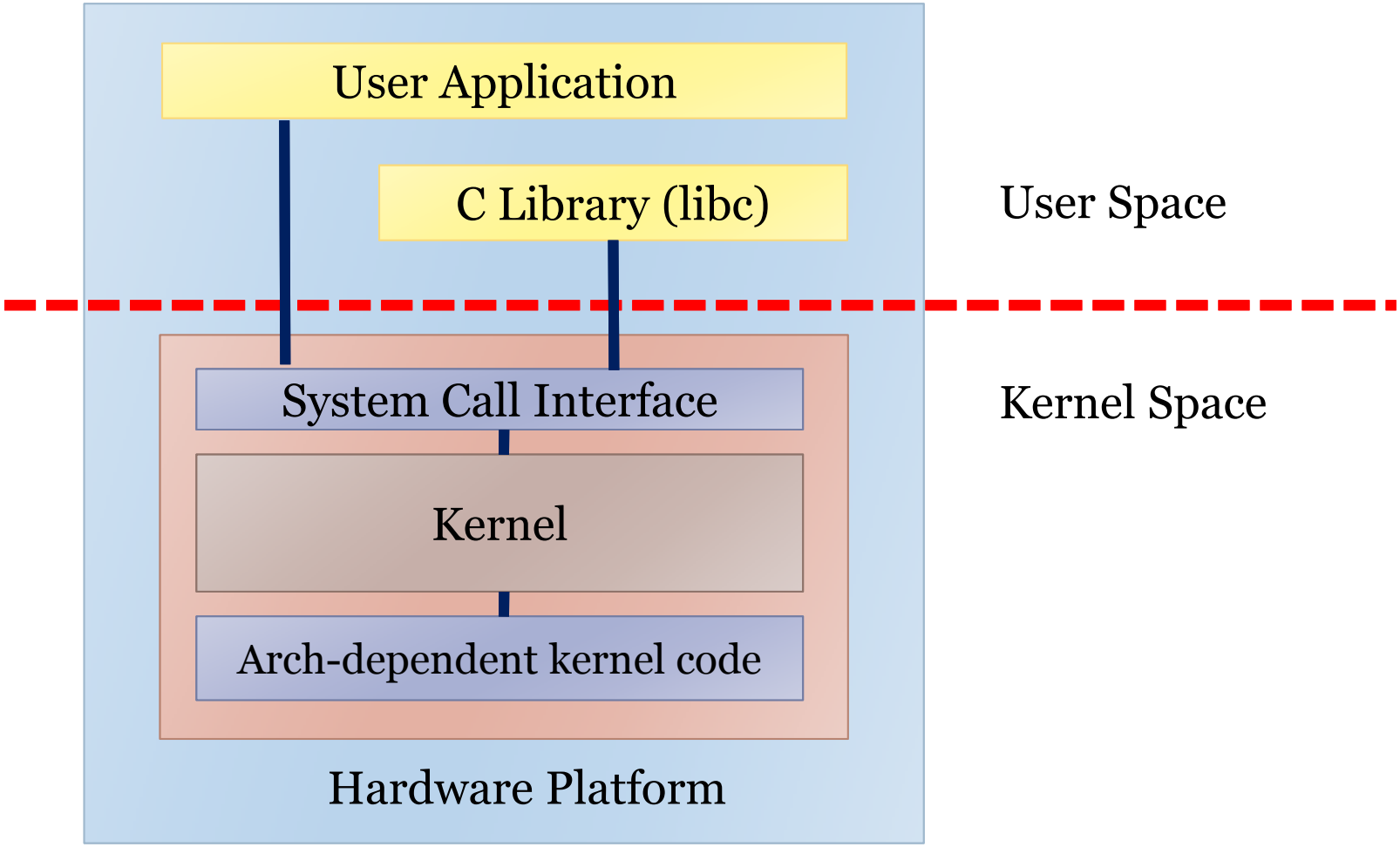
- Highly-concurrent, event-driven software



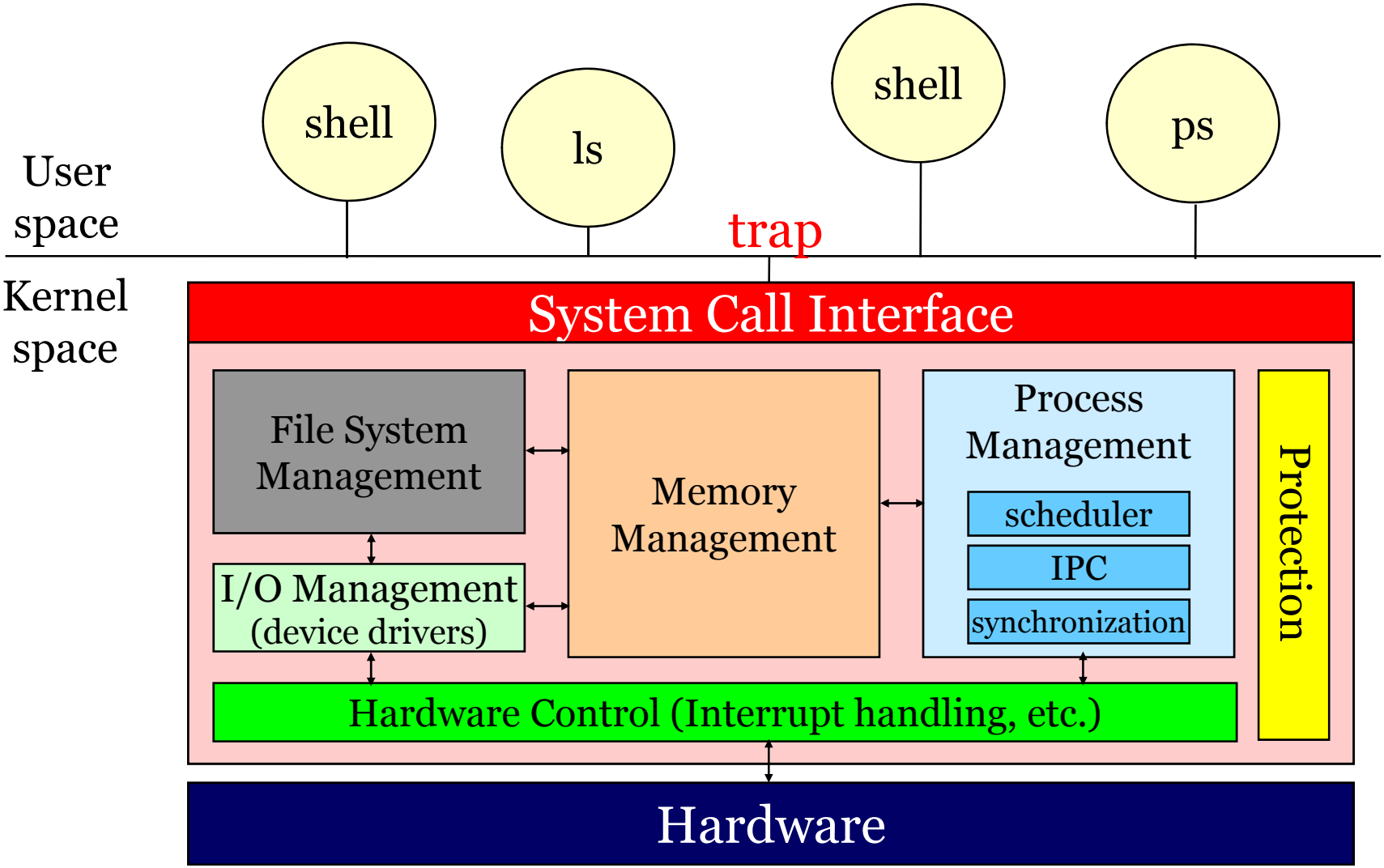
System Calls



OS Structure



Kernel Internals



Processes and Threads

Abstracting CPUs

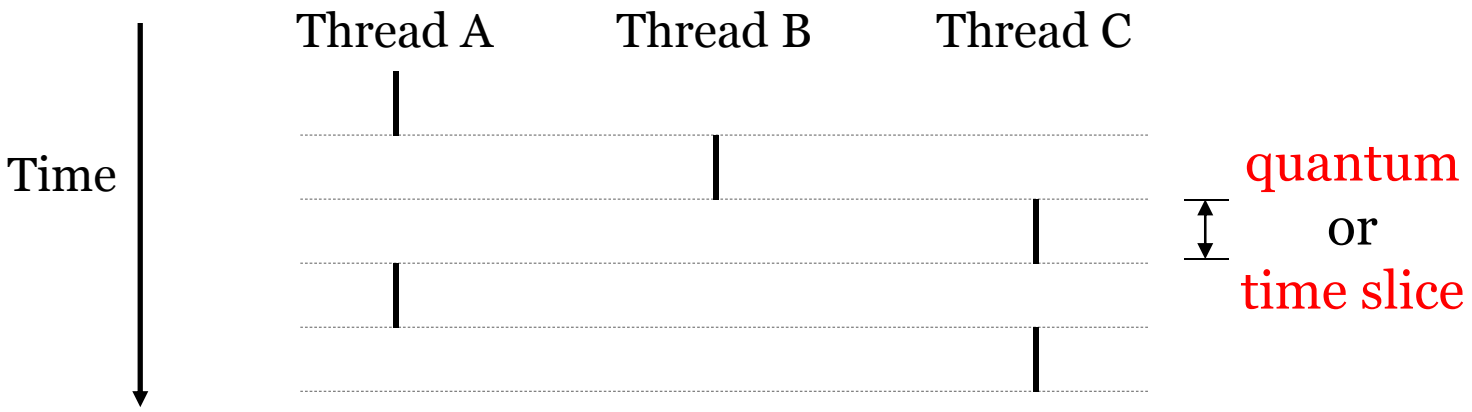
- Process
  - An instance of a program in execution
  - Resource allocation unit
- Thread
  - A sequential flow of control
  - Scheduling unit
- Task
  - Process or thread

Thread (1)

- A thread of control
- Usually consists of
  - A program counter (PC)
  - A stack to keep track of local variables and return addresses
  - Registers
- Threads share the instructions and most of its data

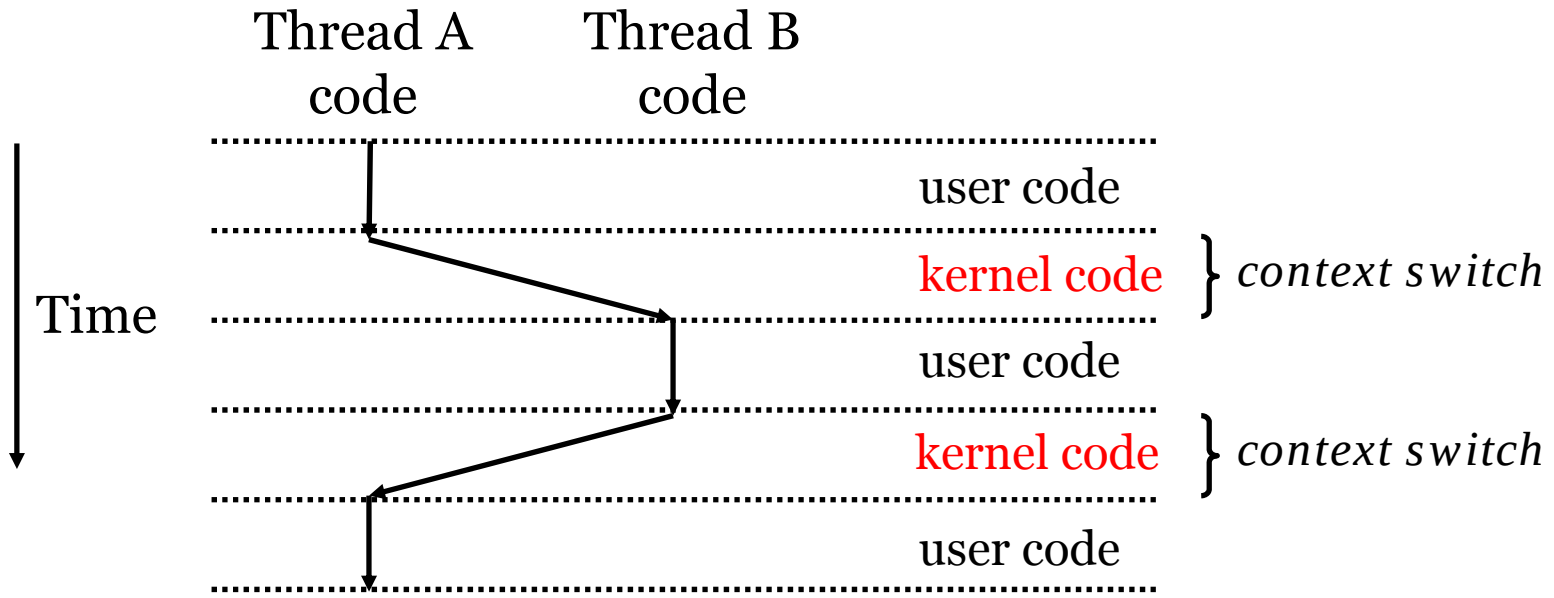
Thread (2)

- Key abstraction
  - Each thread has its own logical control flow.
  - Thread executions interleaved by the scheduler
  - What is running a thread?

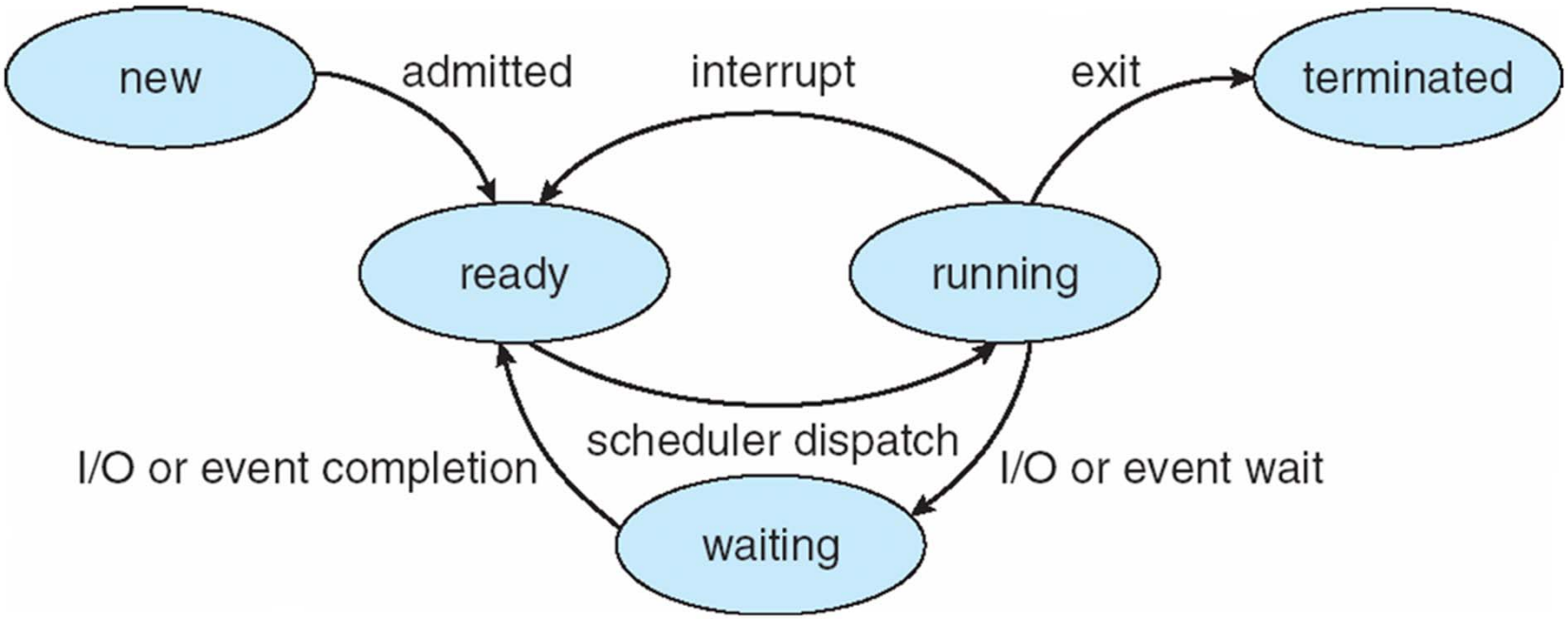


Thread (3)

- Context switching
  - Control flow passes from one thread to another via a context switch.



Thread State Transition



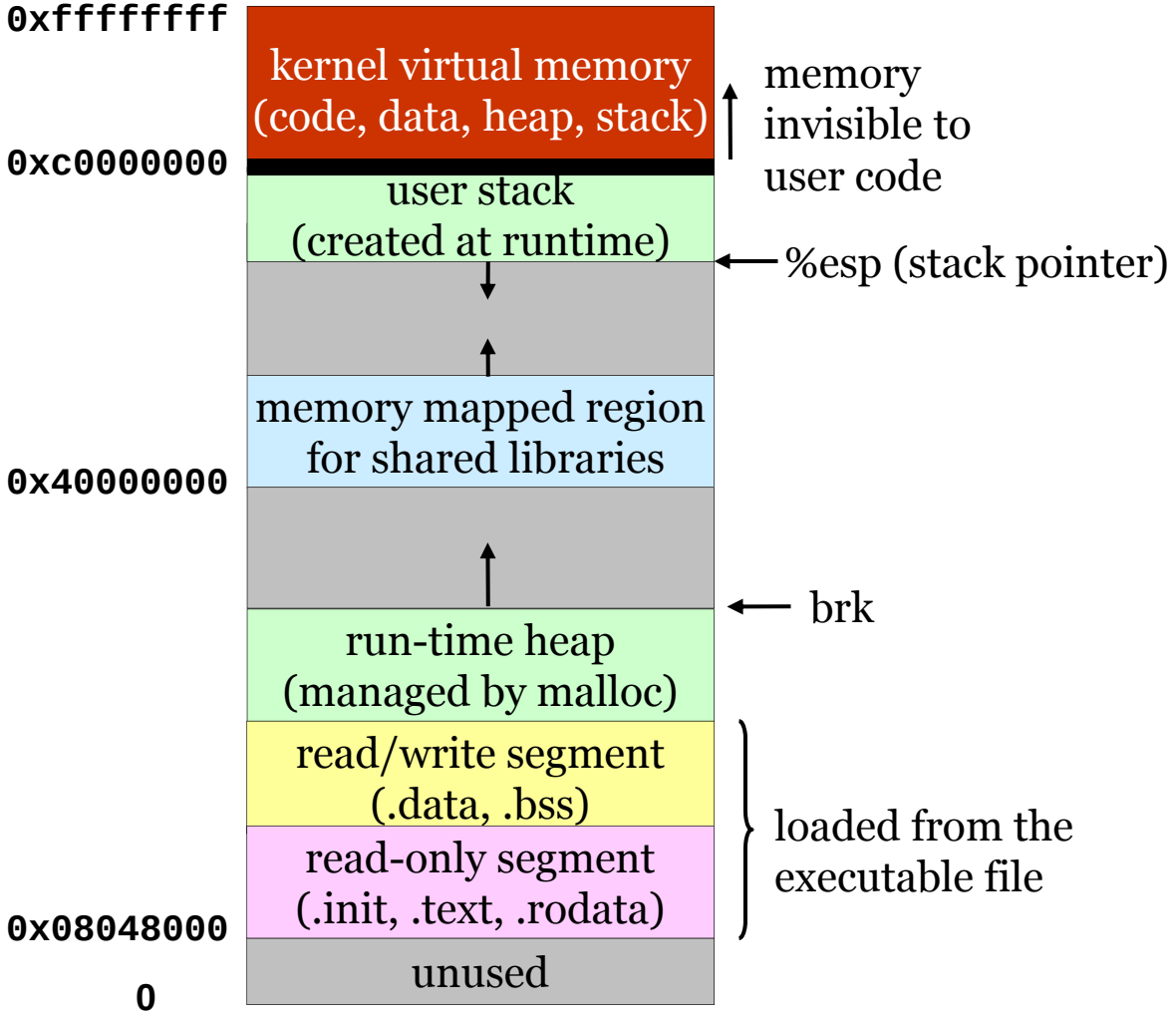
Process (1)

- An instance of a program in execution
- A process includes
  - Hardware execution state (PC, SP, registers, …)
  - OS resources (e.g., memory, open files)
  - Other information (PID, state, owner, …)
- Two key abstractions
  - Logical control flow (virtual CPU)
  - Private address space (virtual memory)

Process (2)

- Used to run a user program
- Protection domain
- Creating a new process is costly
- Inter-process communication is costly, since it must usually go through the OS

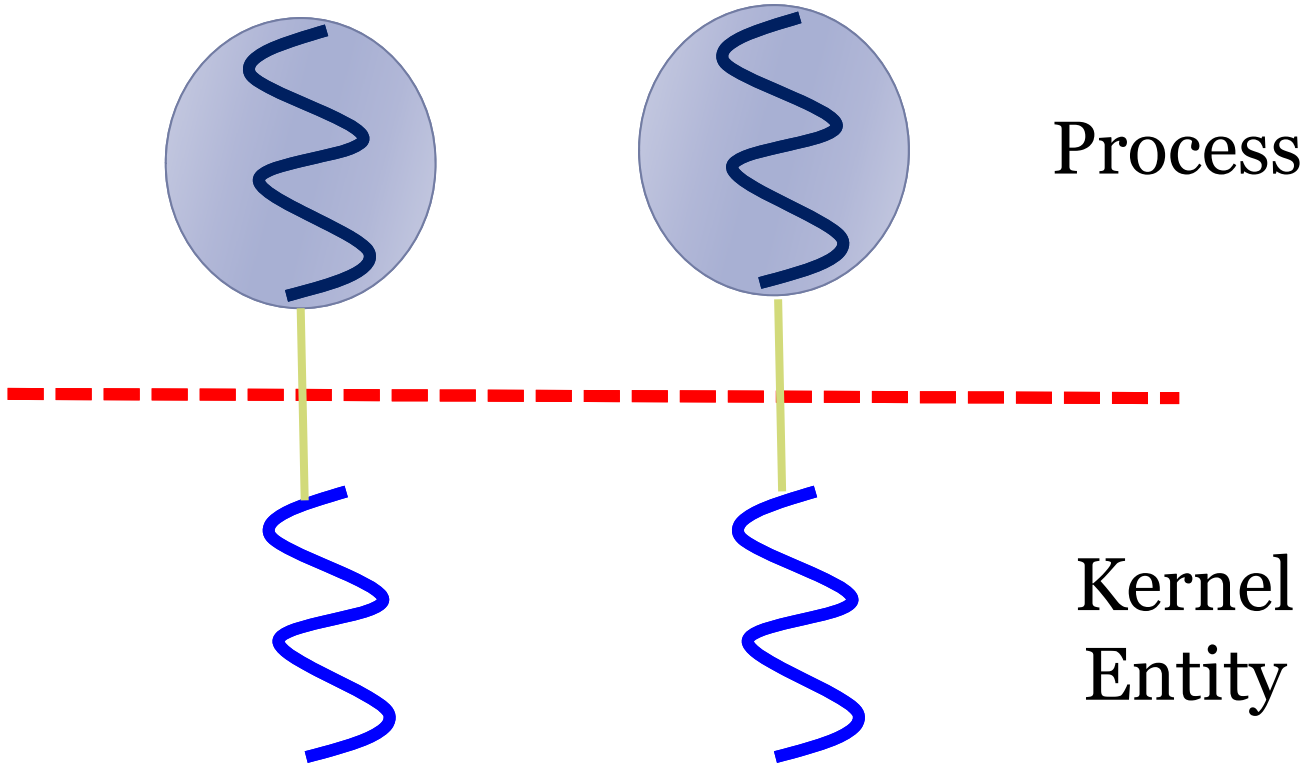
Private Address Spaces



Virtual Memory

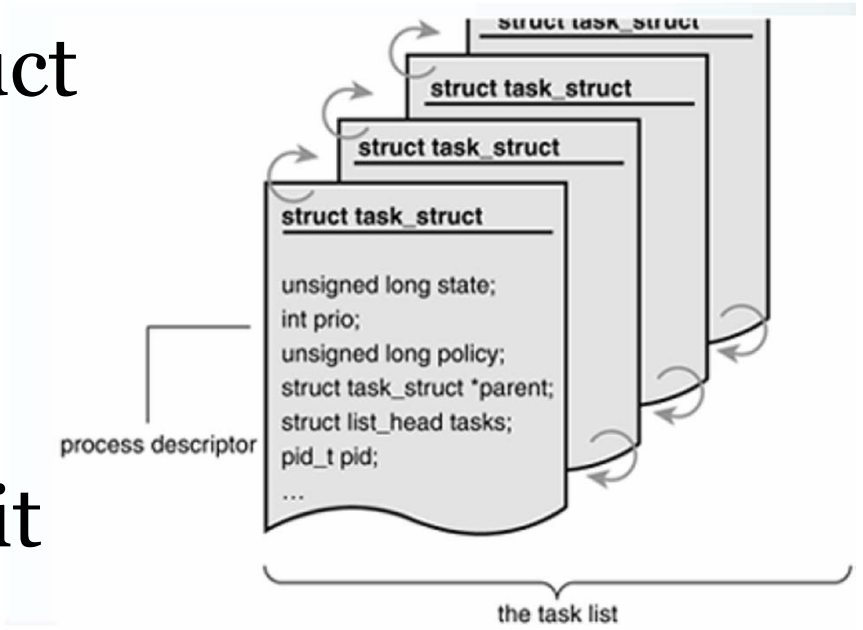
- Allows to run programs much larger than the available physical memory size
- Simplifies memory management
- Provides memory protection

Implementing Processes



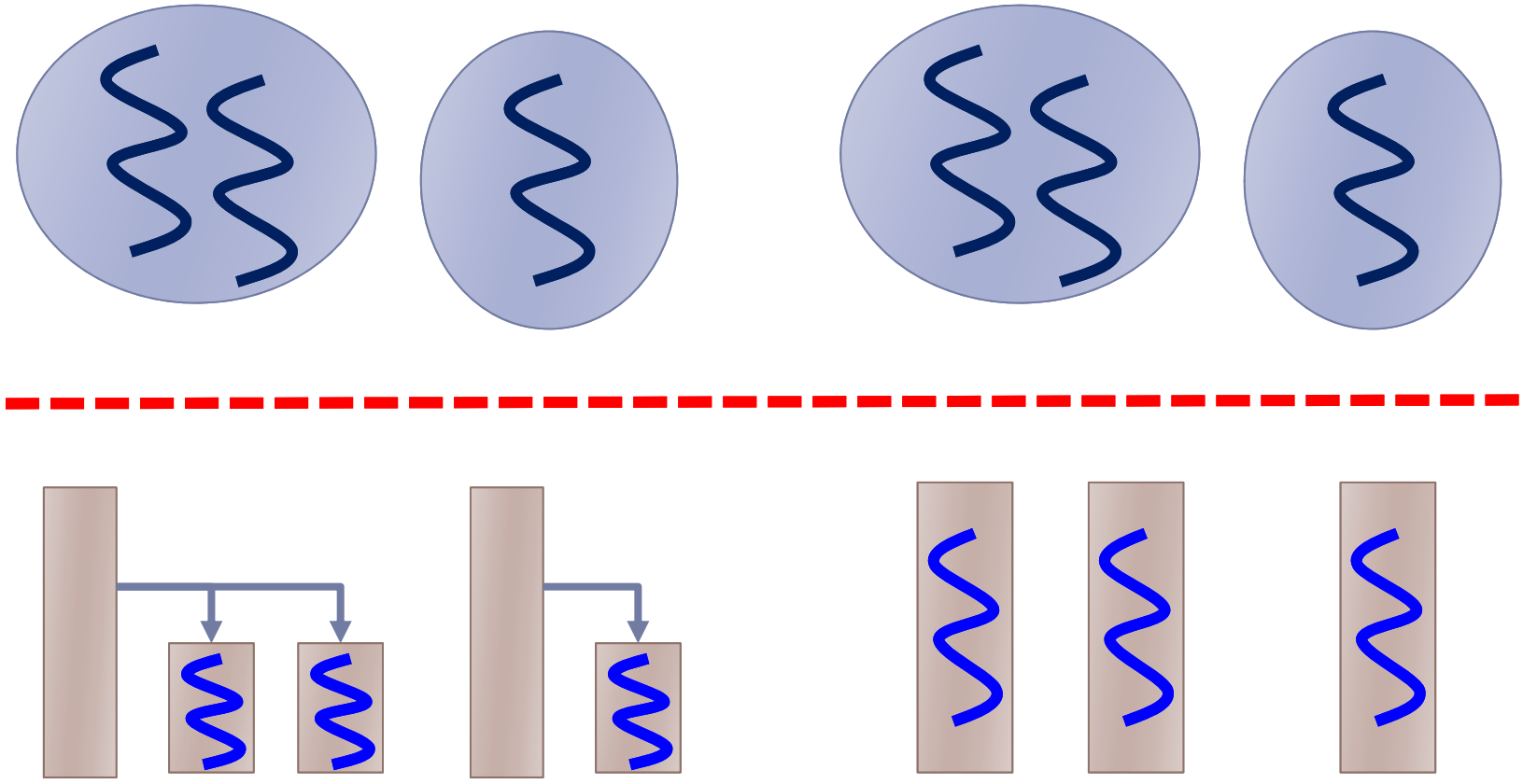
Process Descriptor

- Linux: struct task_struct
- Everything the kernel has to know about a process or a thread
- About 1.7KB on a 32-bit machine
- Task list: the list of task structures in a circular doubly linked list



Processes with Threads

- 1:1 model



Threads vs. Processes

- A thread is bound to a single process (or a single address space)
- A process can have multiple threads
- Sharing data between threads is cheap: all see the same address space
- Threads are the unit of scheduling
- Processes are containers in which threads execute
- Processes become static, threads are the dynamic entities

Classification

# threads per addr space: / # of addr spaces:	One	Many
One	MS/DOS Early Macintosh	Traditional UNIX
Many	Many embedded Oses (VxWorks, uClinux, ..)	Mach, OS/2, Linux, Windows, Mac OS X, Solaris, HP-UX