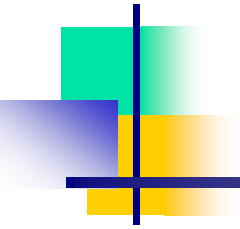


Operating Systems

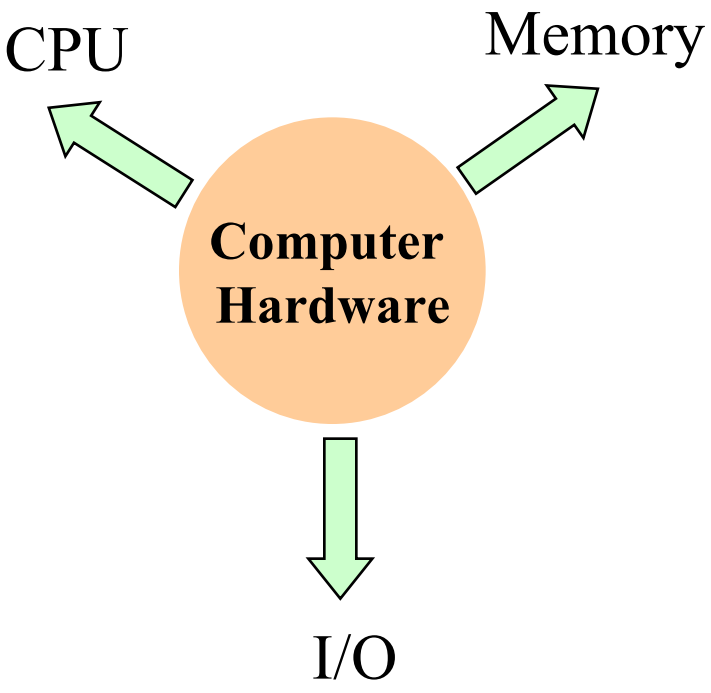
Lecture3.1: Input / Output Management

Golestan University

Hossein Momeni
momeni@iust.ac.ir

Computer Hardware

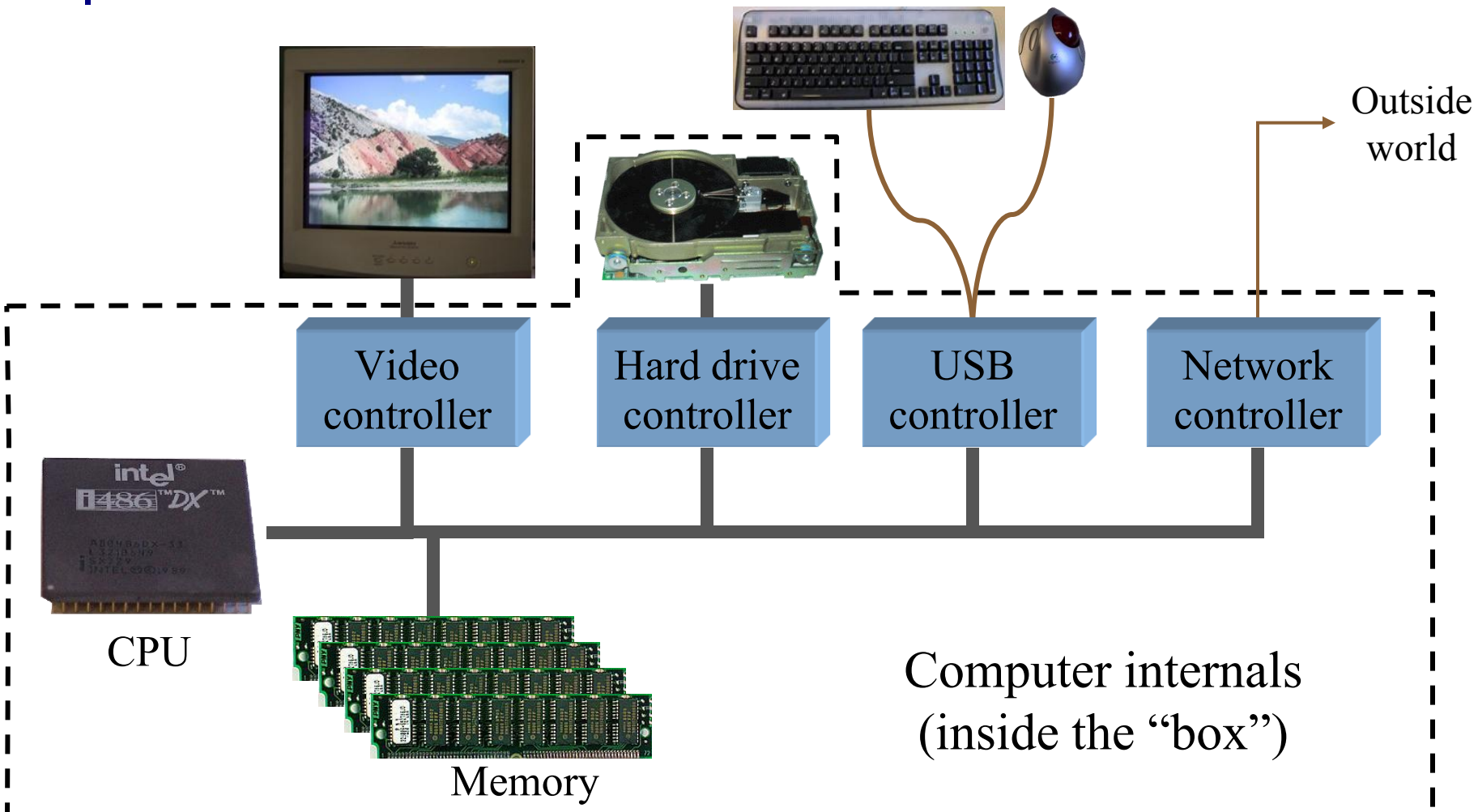
- The computer hardware has been composed of three main components: CPU, I/O and memory.



I/O Devices

- From one point of view, I/O devices can be divided into two categories:
  - **Block devices**: A device in which reads and writes data in fixed size blocks, like disks and tapes.
    - Addressing
  - **Character devices:** A device in which delivers or accepts a stream of characters, regardless of any block structure, like printers or networks.
    - No addressing
    - No search

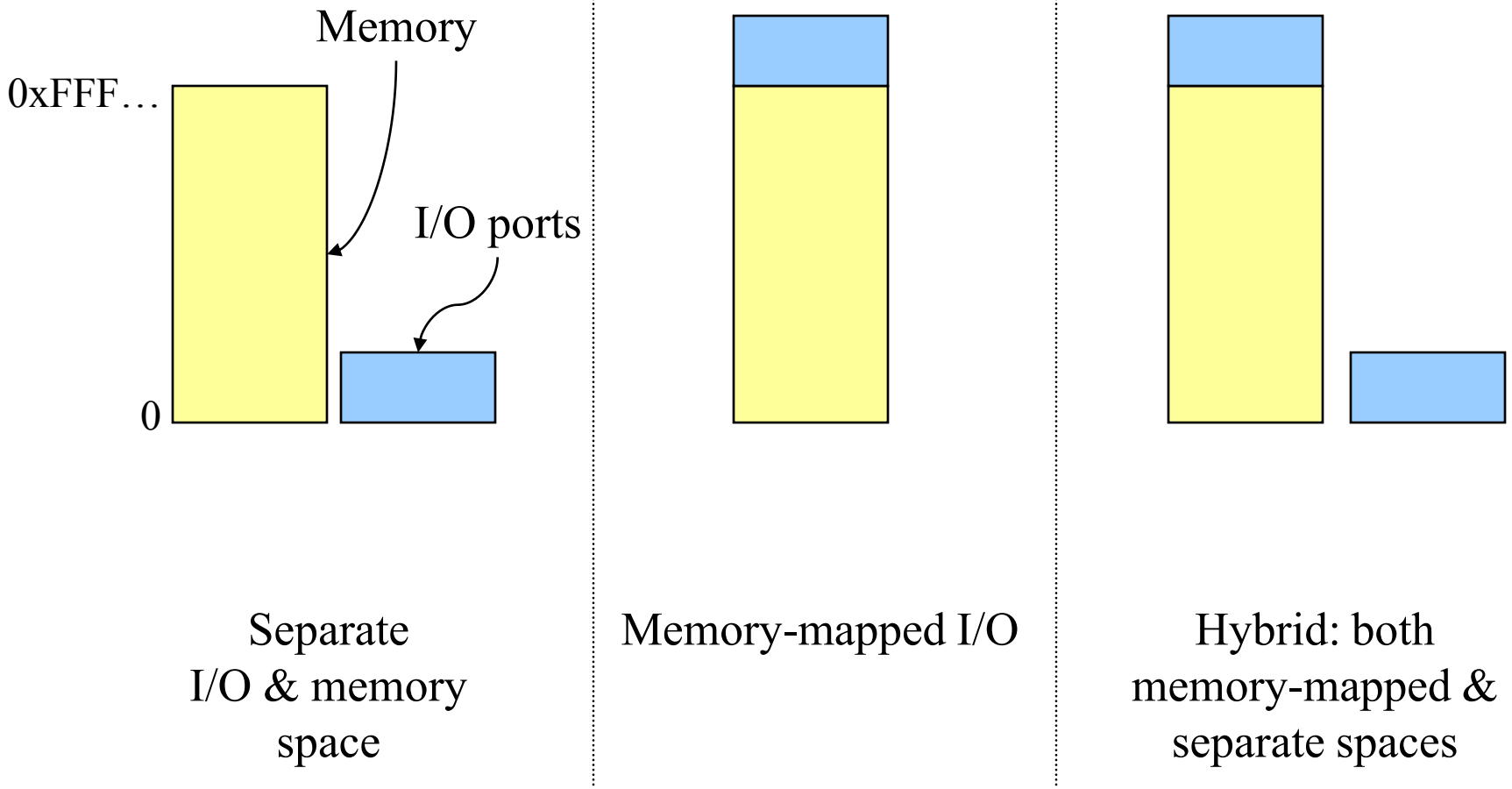
I/O Hardware


Outside world
Video controller
Hard drive controller
USB controller
Network controller
CPU
Memory
Computer internals (inside the "box")

Device controllers

- I/O devices have components
  - Mechanical component
  - Electronic component
- The electronic component is the device controller
  - May be able to handle multiple devices
- Controller's tasks
  - Convert serial bit stream to block of bytes
  - Perform error correction as necessary
  - Make available to main memory

Memory-Mapped I/O



Intercommunication between I/O devices & CPU

- Pooling
  - CPU check controller registers periodically
- Interrupt

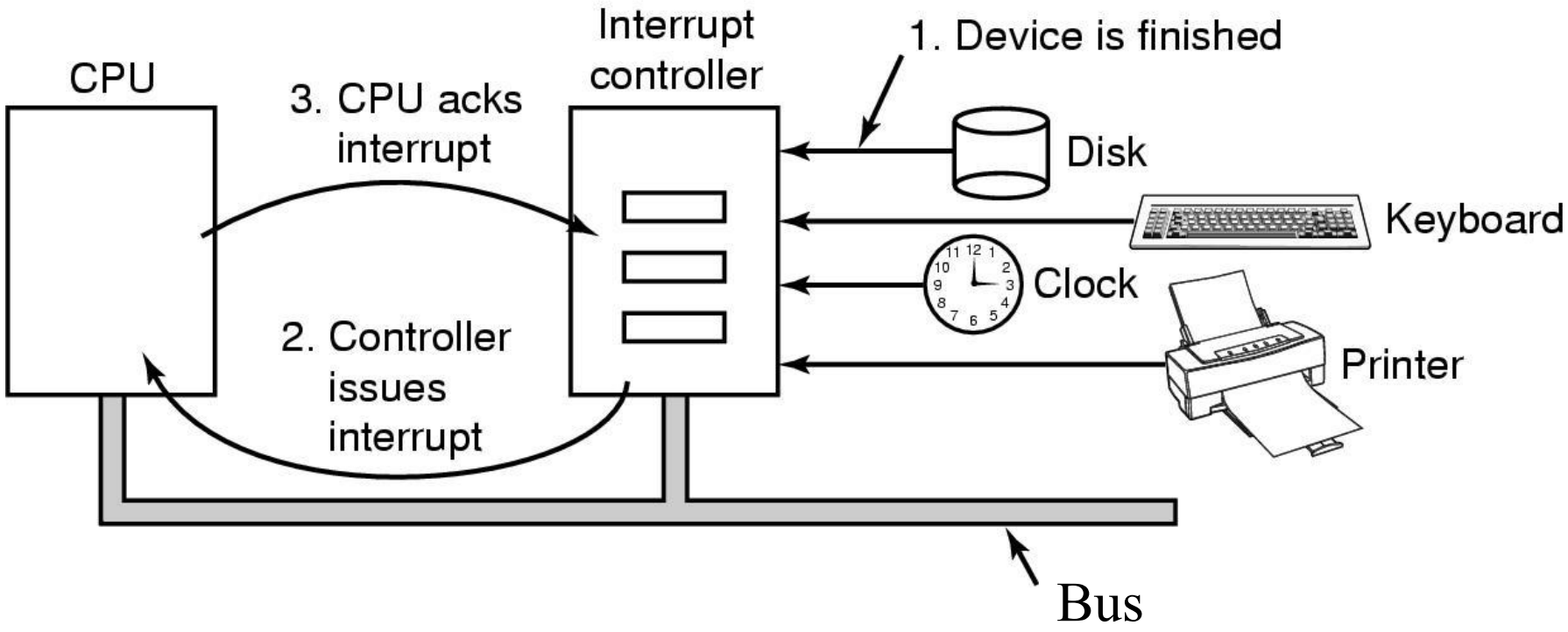
Polling

- Determines state of device
  - command-ready
  - busy
  - Error
- **Busy-wait** cycle to wait for I/O from device

Interrupts

- CPU **Interrupt-request line** triggered by I/O device
- **Interrupt handler** receives interrupts
- **Maskable** to ignore or delay some interrupts
- Interrupt vector to dispatch interrupt to correct handler
  - Based on priority
  - Some **nonmaskable**
- Interrupt mechanism also used for exceptions

Hardware's view of interrupts

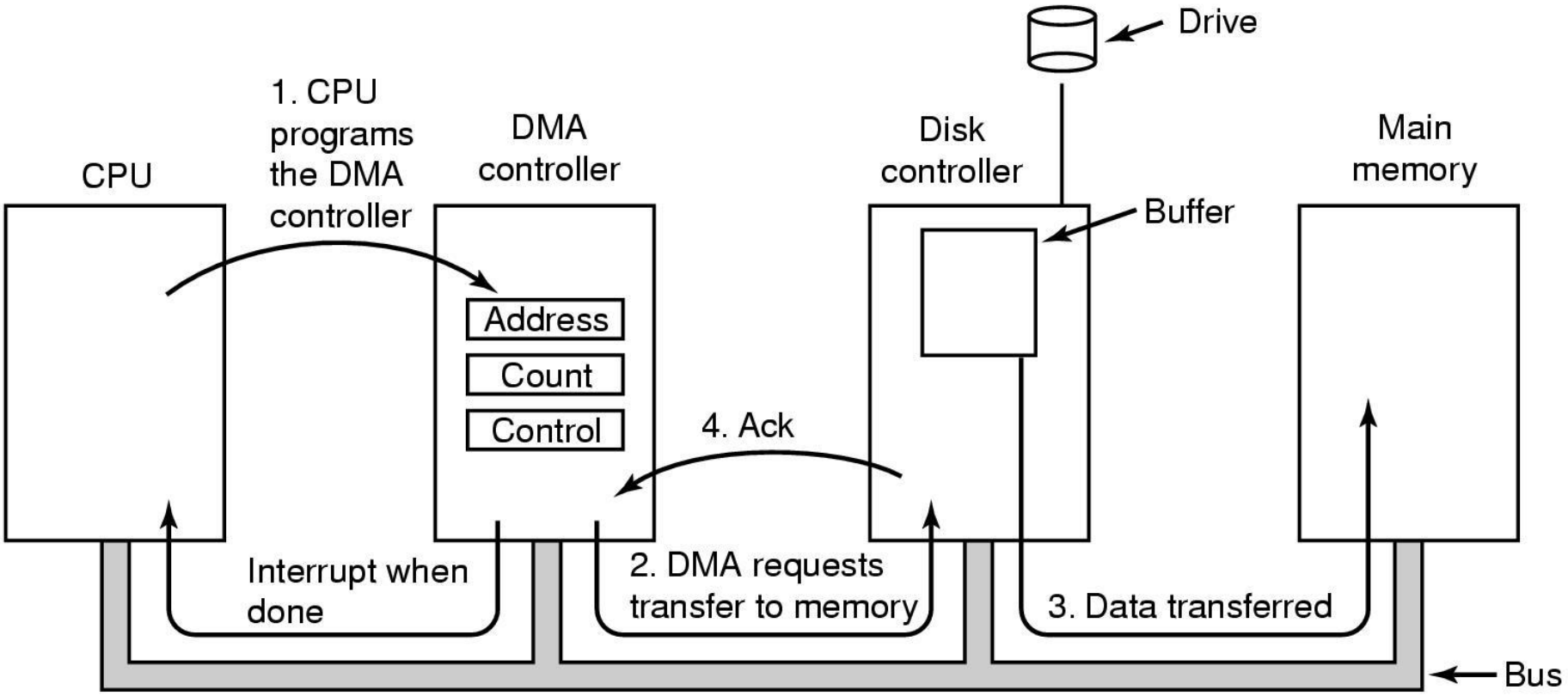


How interrupts happens. Connections between devices and interrupt controller actually use interrupt lines on the bus rather than dedicated wires

Direct Memory Access

- Used to avoid **programmed I/O** for large data movement
- Requires **DMA** controller
- Bypasses CPU to transfer data directly between I/O device and memory

Direct Memory Access (DMA) operation

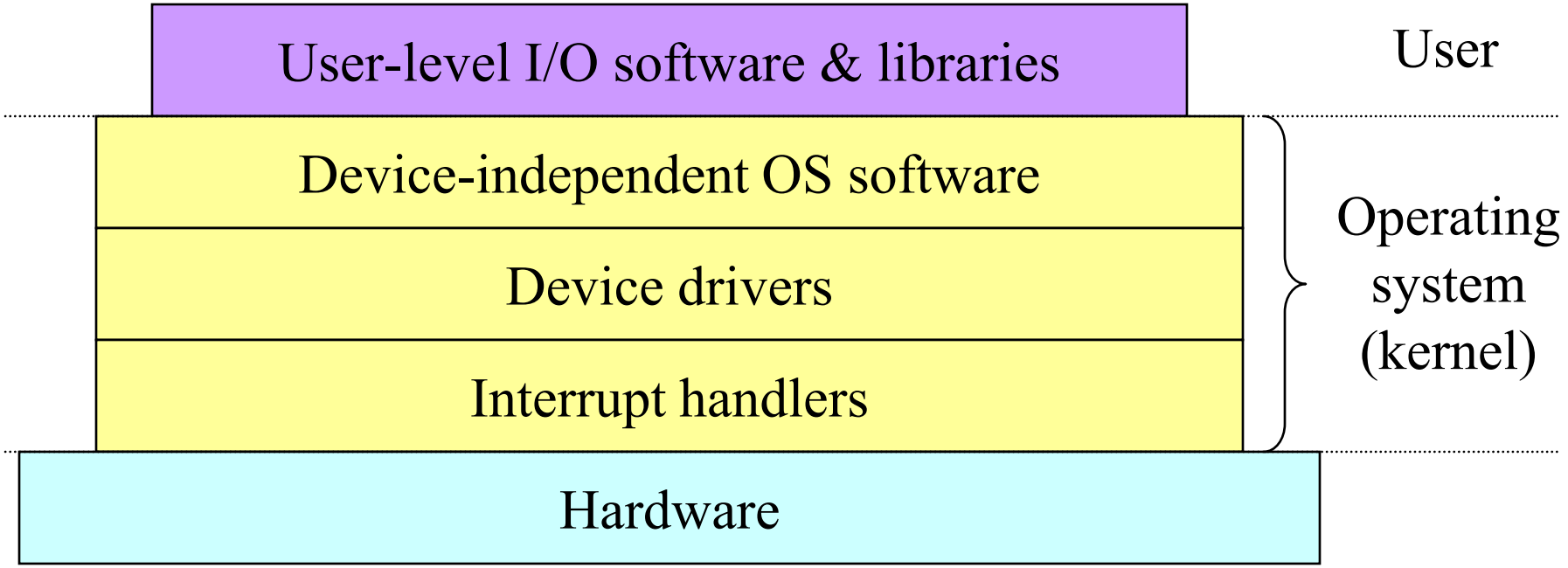


Principles of I/O Software

I/O software: goals

- Device independence
  - Programs can access any I/O device
  - No need to specify device in advance (floppy, hard drive, or CD-ROM)
- Uniform naming
  - Name of a file or device is a string or an integer
  - Doesn't depend on the machine (underlying hardware)
- Error handling
  - Done as close to the hardware as possible
  - Isolate higher-level software
- Synchronous vs. asynchronous transfers
  - Blocked transfers vs. interrupt-driven
- Buffering
  - Data coming off a device cannot be stored in final destination
- Sharable vs. dedicated devices
  - disks are sharable
  - tape drives would not be

Layers of I/O software

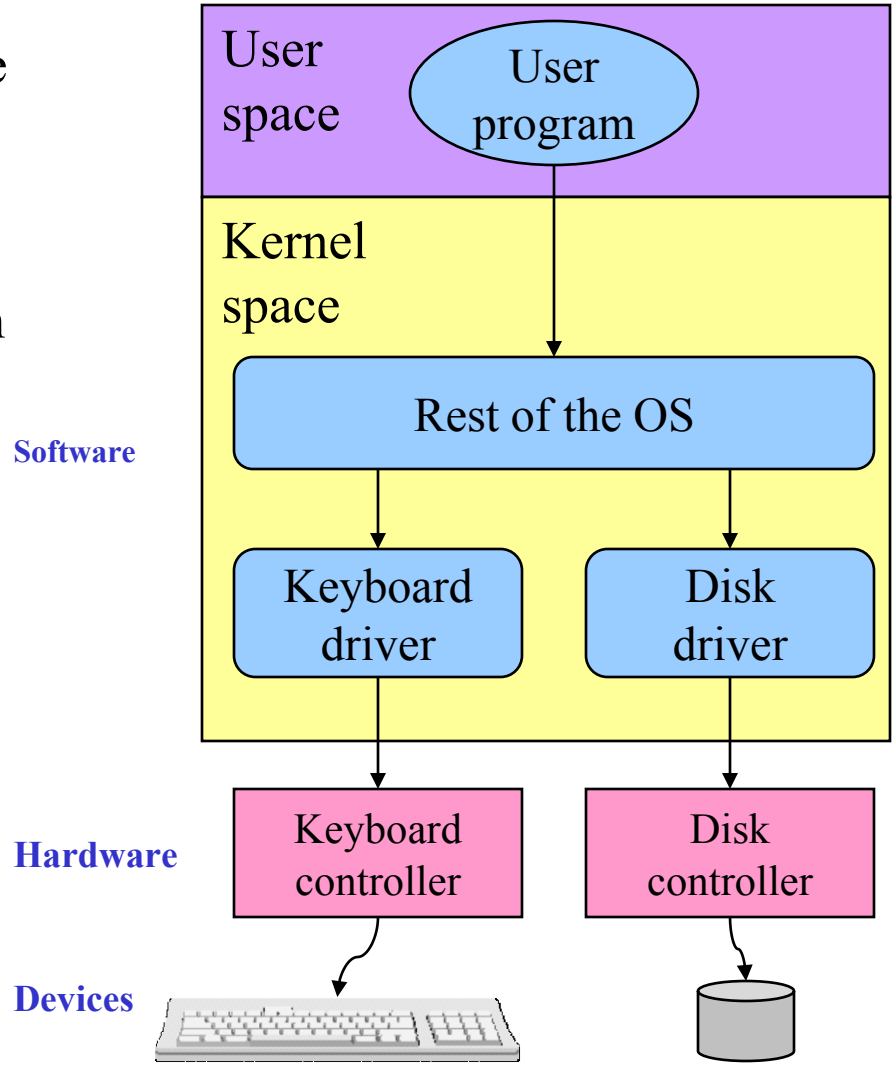


Interrupt handlers

- Interrupt handlers are best hidden
  - Driver starts an I/O operation and blocks
  - Interrupt notifies of completion
- Interrupt procedure does its task
  - Then unblocks driver that started it
  - Perform minimal actions at interrupt time
    - Some of the functionality can be done by the driver after it is unblocked
- Interrupt handler must
  - Save regs not already saved by interrupt hardware

Device drivers

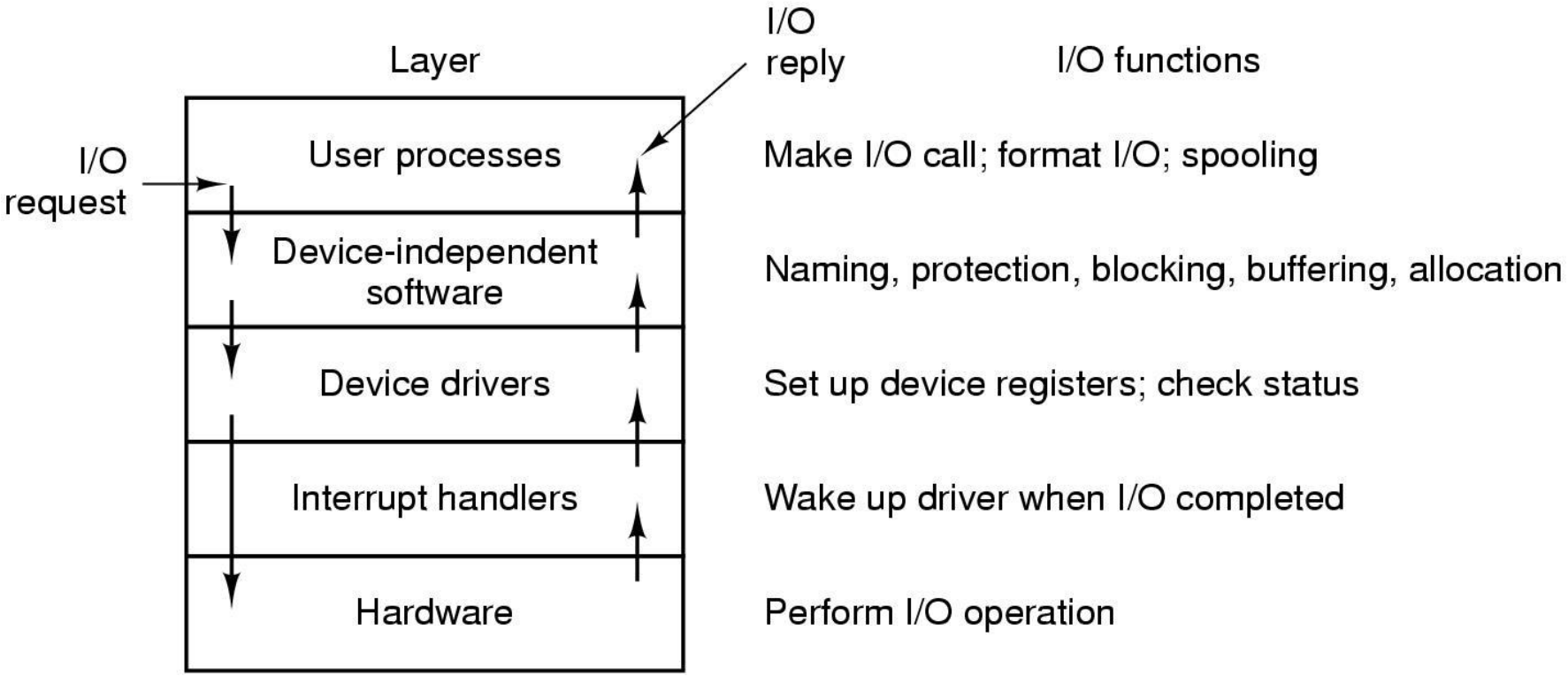
- Device drivers go between device controllers and rest of OS
  - Drivers standardize interface to widely varied devices
- Device drivers communicate with controllers over bus
  - Controllers communicate with devices themselves



Device-independent I/O software

- Device-independent I/O software provides common "library" routines for I/O software
- Helps drivers maintain a standard appearance to the rest of the OS
- Uniform interface for many device drivers for
  - Buffering
  - Error reporting
  - Allocating and releasing dedicated devices
  - Suspending and resuming processes
- Common resource pool
  - Device-independent block size (keep track of blocks)

Anatomy of an I/O request



Layers of the I/O system and the main functions of each layer