2020春

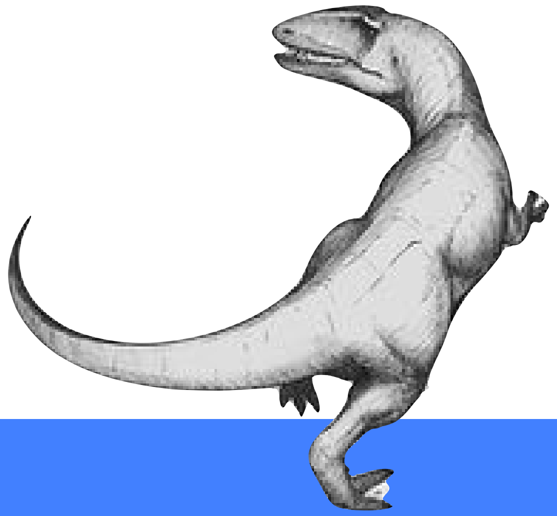
LINUX OPERATING SYSTEM

YANG

LINUX操作系统（双语）

双语课→课件内容中英混排

Final Lecture



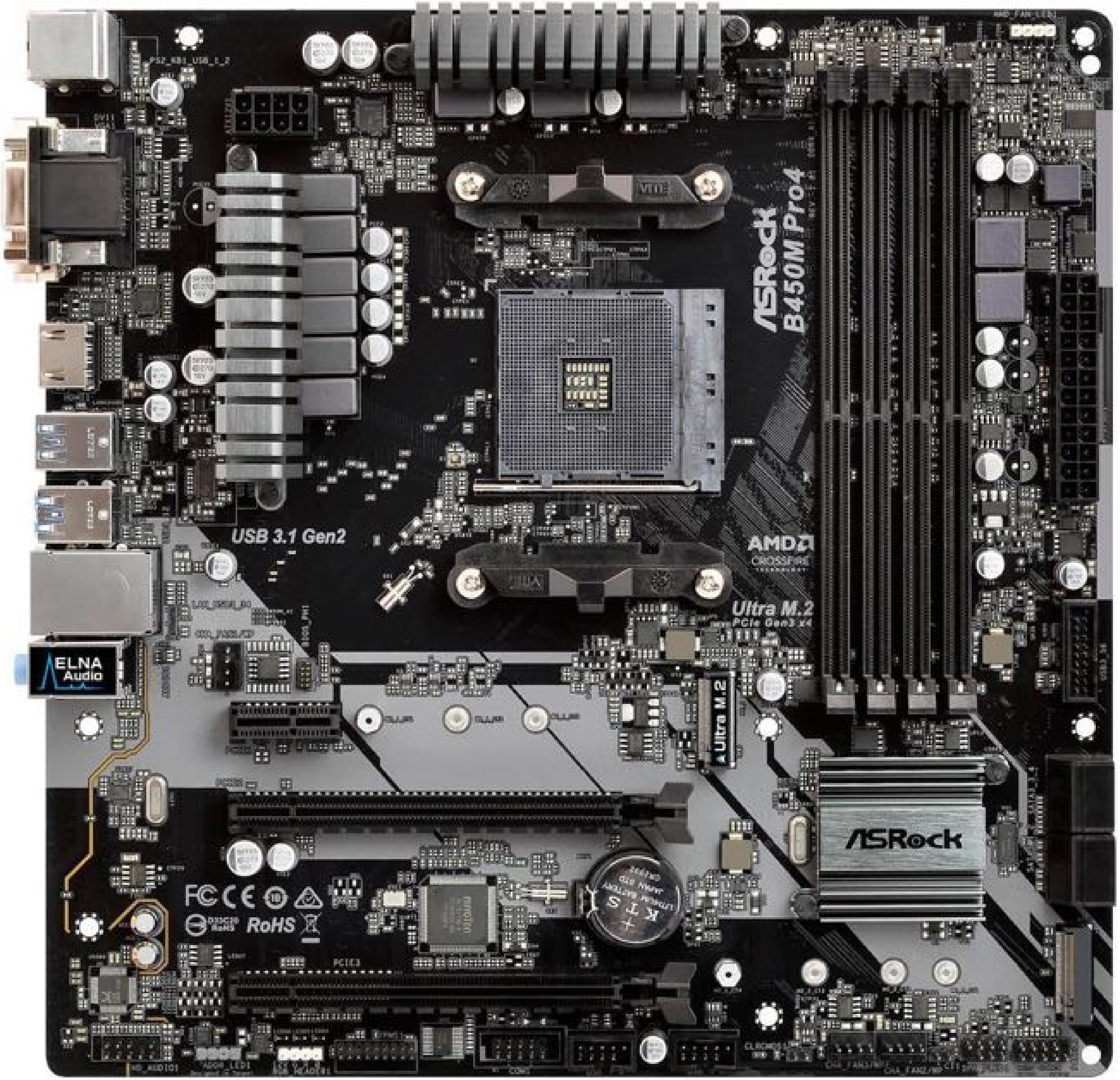
I/O Systems

本讲内容

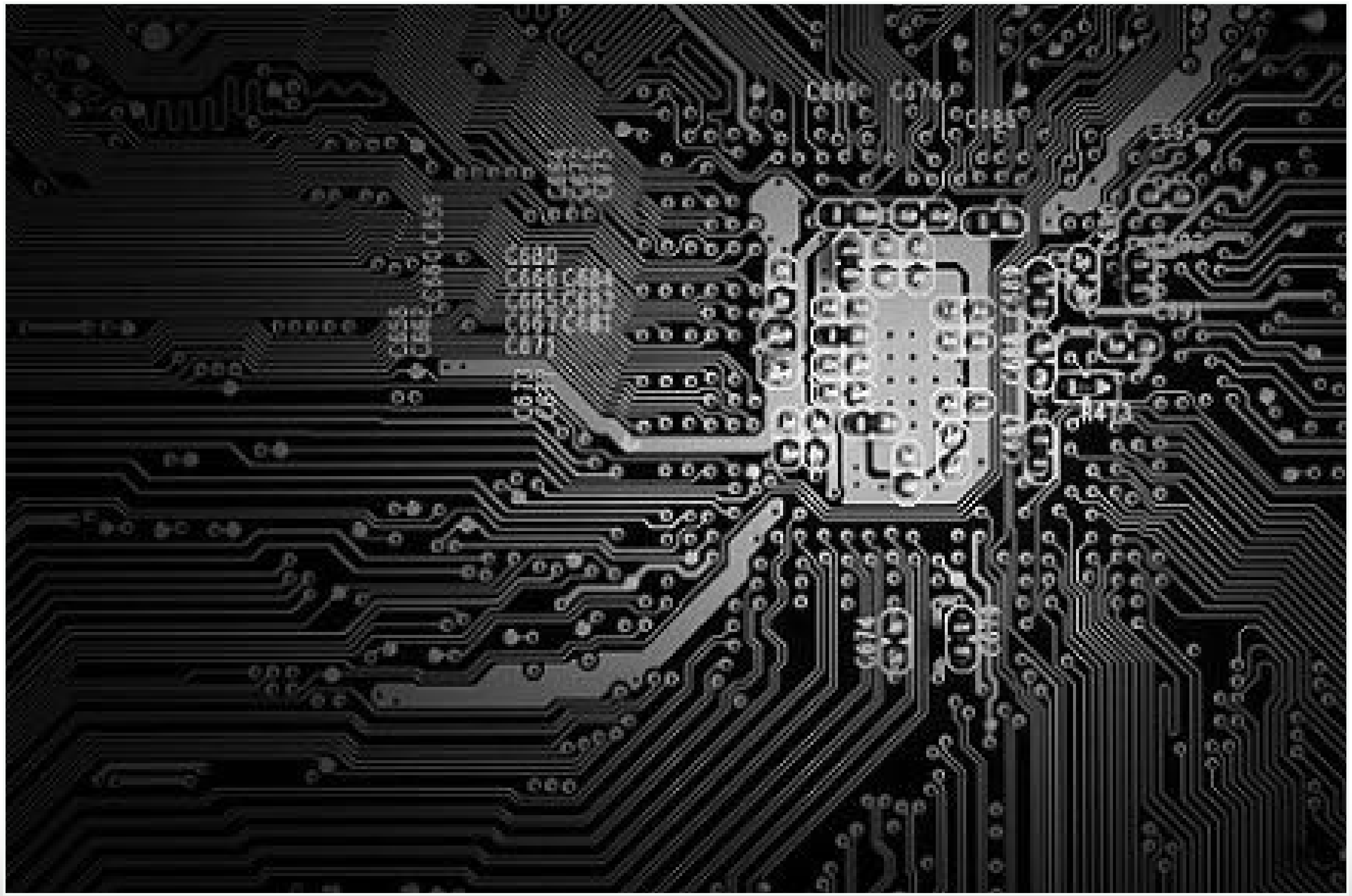
- I/O硬件
  - I/O设备
  - 控制方式
- 内核I/O结构

I/O硬件

MOTHER BOARD

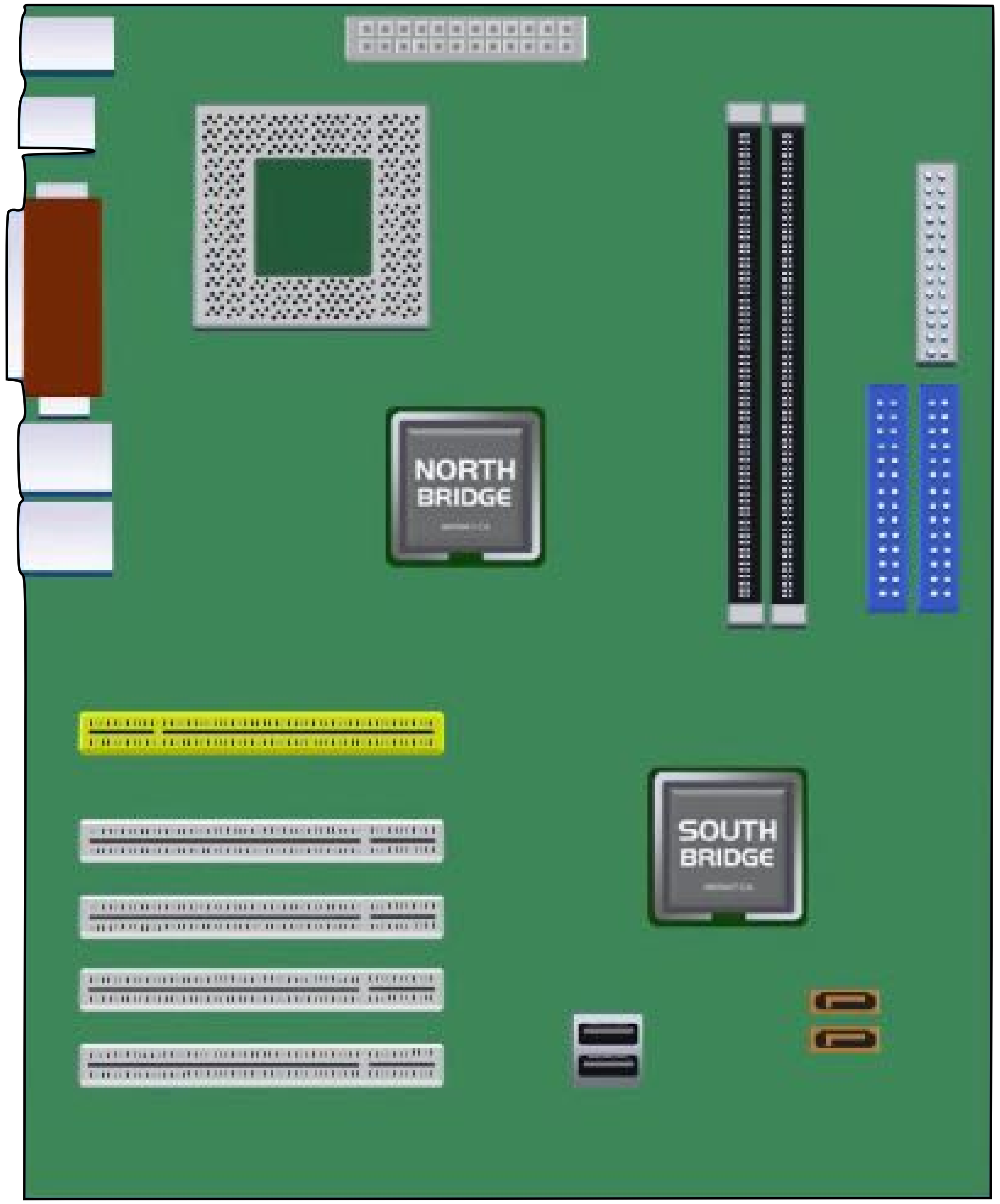


BUS

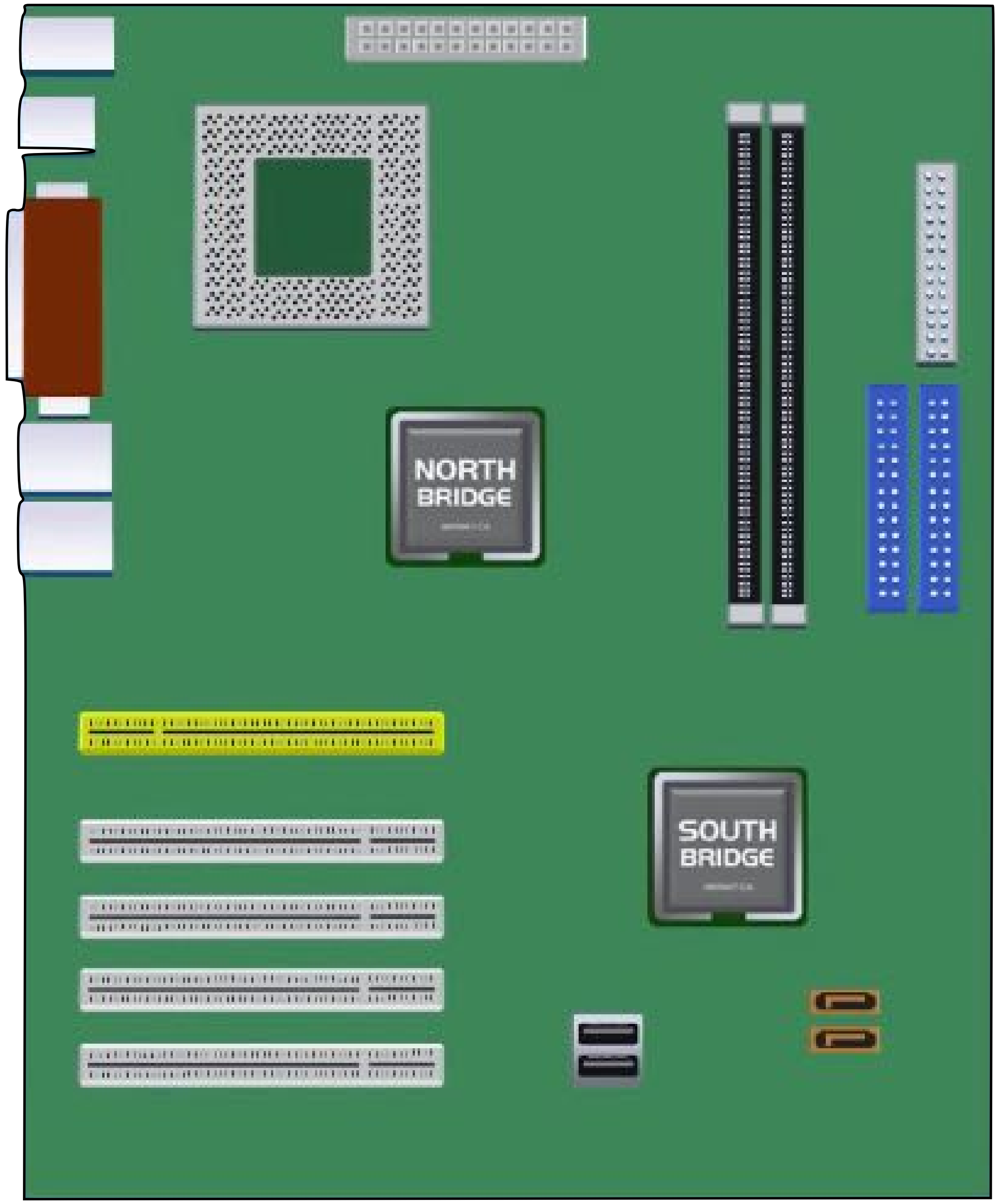


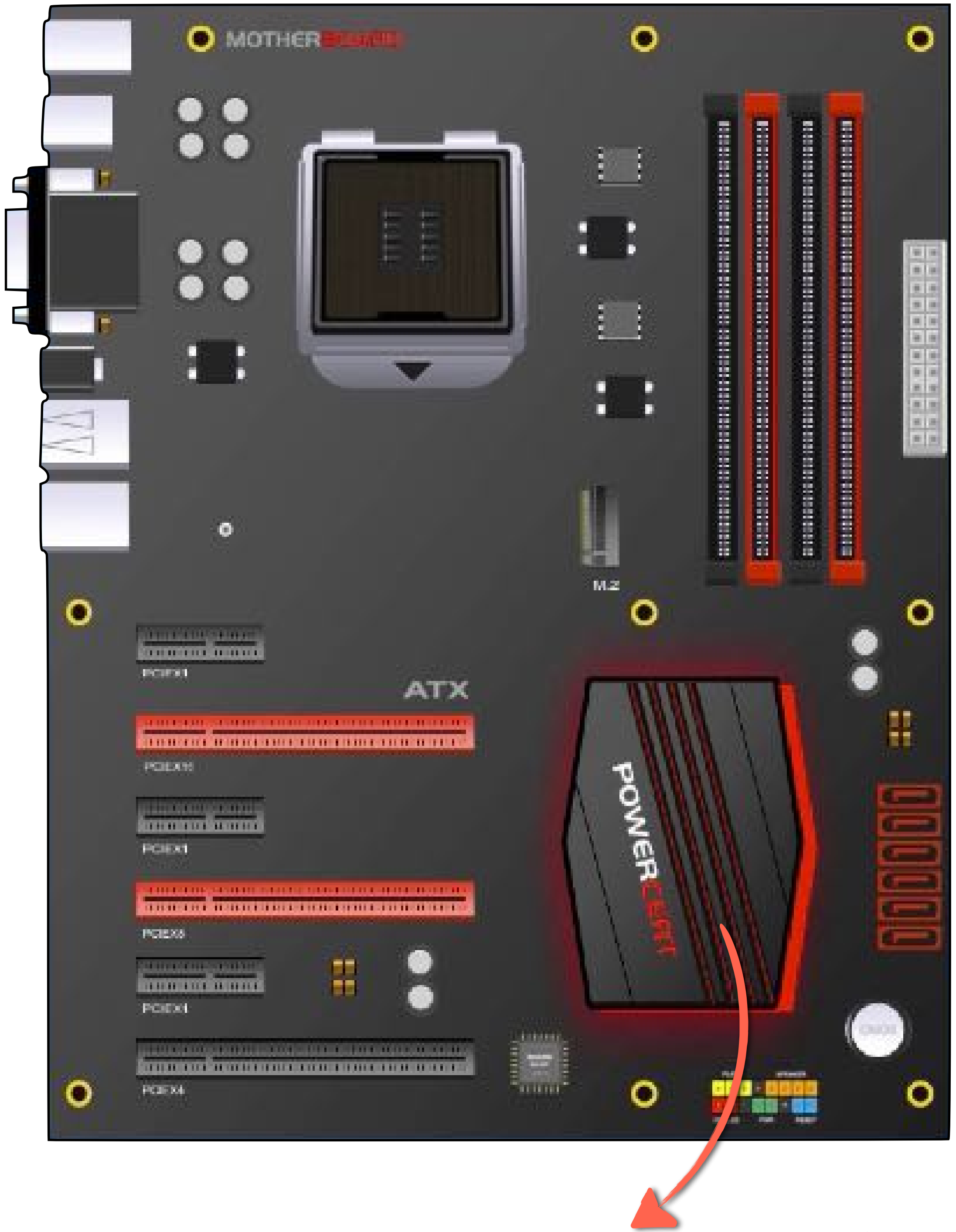
- 总线：一组线路和通过线路传输信息的一个协议。
  - 并行：Multiple Lane
  - 串行：Single Lane

PERIPHERALS COMPONENT INTERCONNECT



PERIPHERALS COMPONENT INTERCONNECT

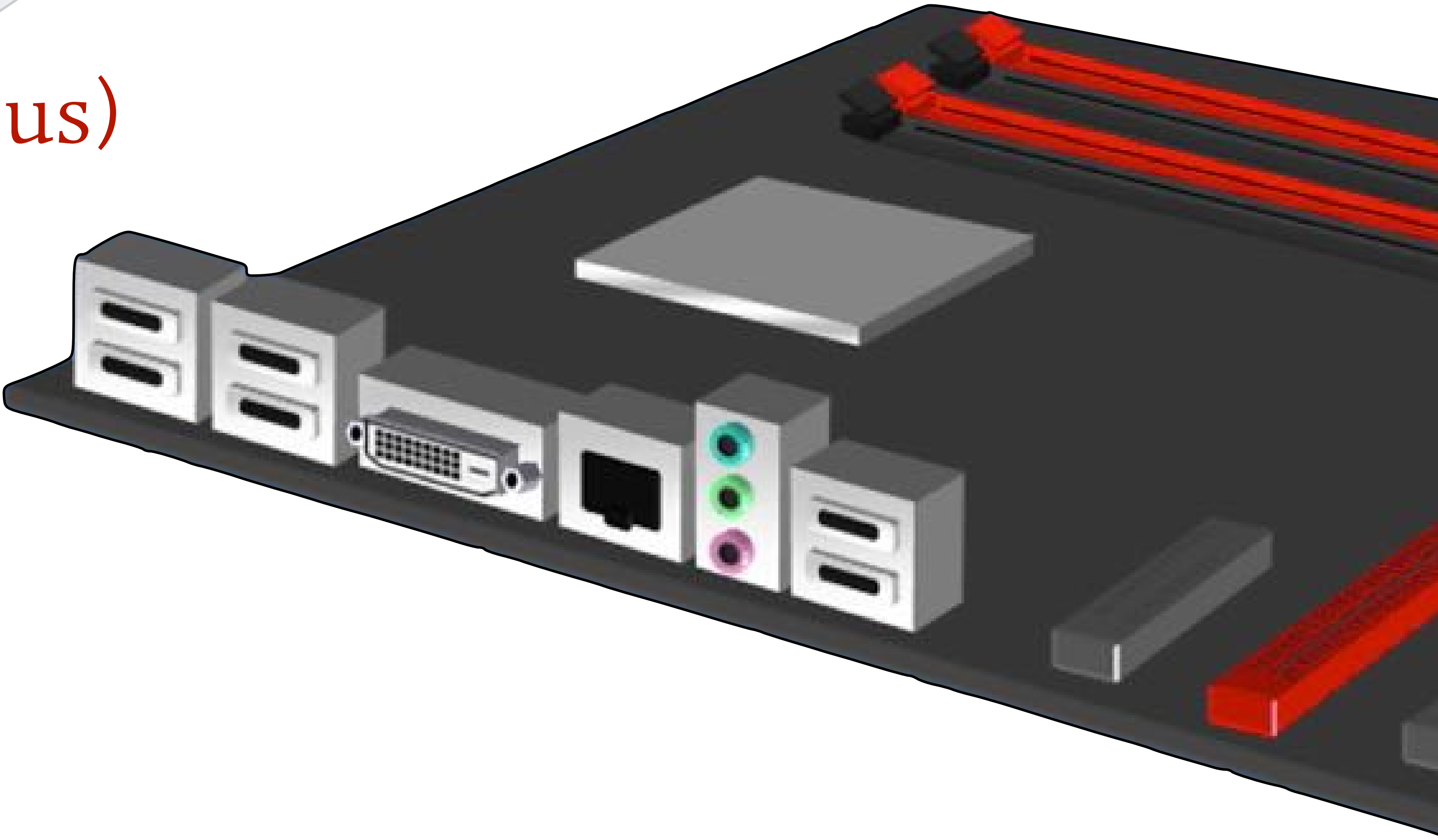




Platform Controller Hub

PORTS

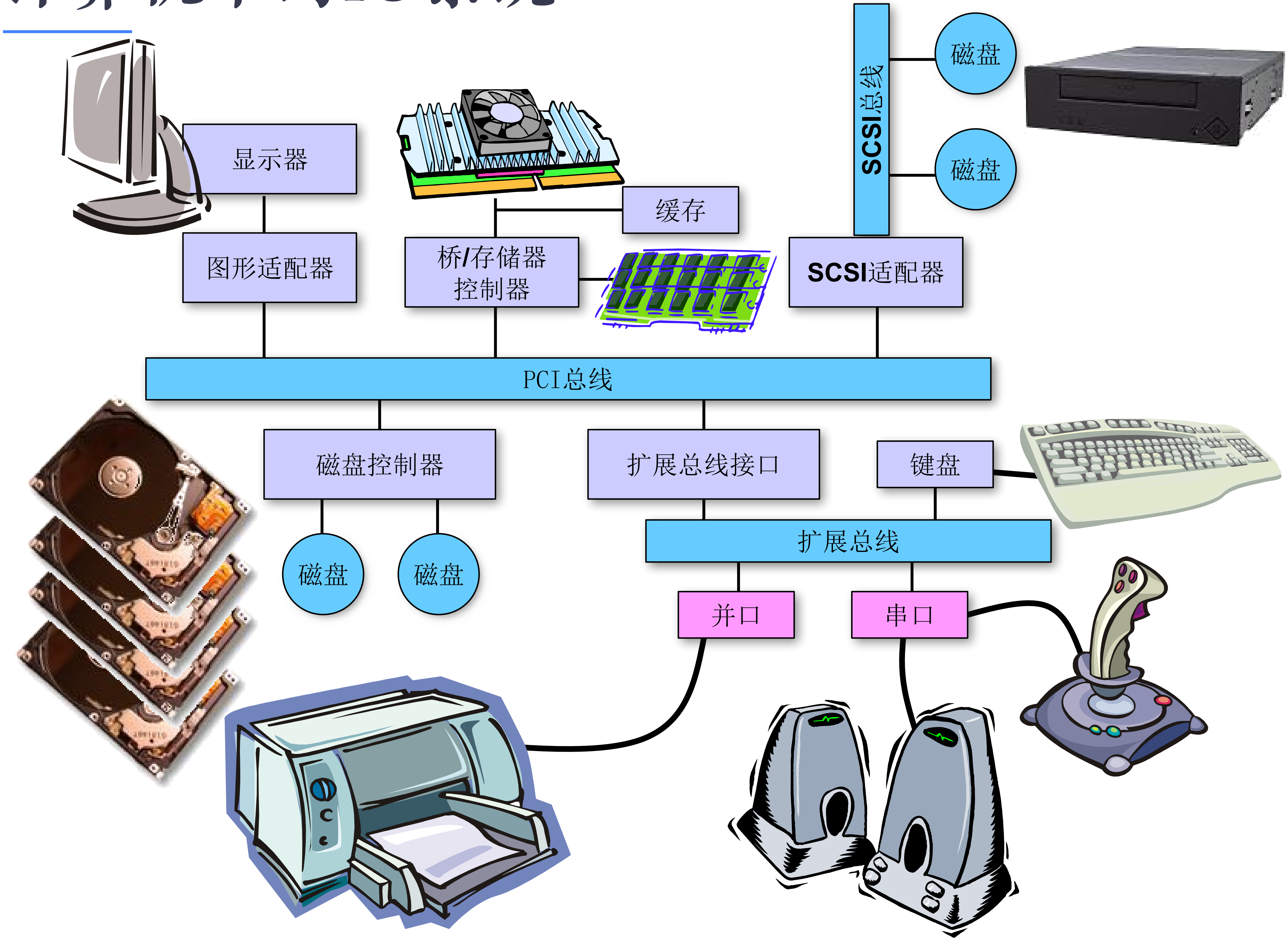
- PCIe
- SATA
- USB (Universal Serial Bus)
- VGA
- HDMI
- DVI
- Thunder Blot



设备类型

- 块设备（block device）
  - 存取单位是一个block
  - 如磁盘、磁带、DVD等
- 字符设备（character device）
  - 存取单位是一个字符
  - 如显示器、键盘、鼠标等

计算机中的IO系统

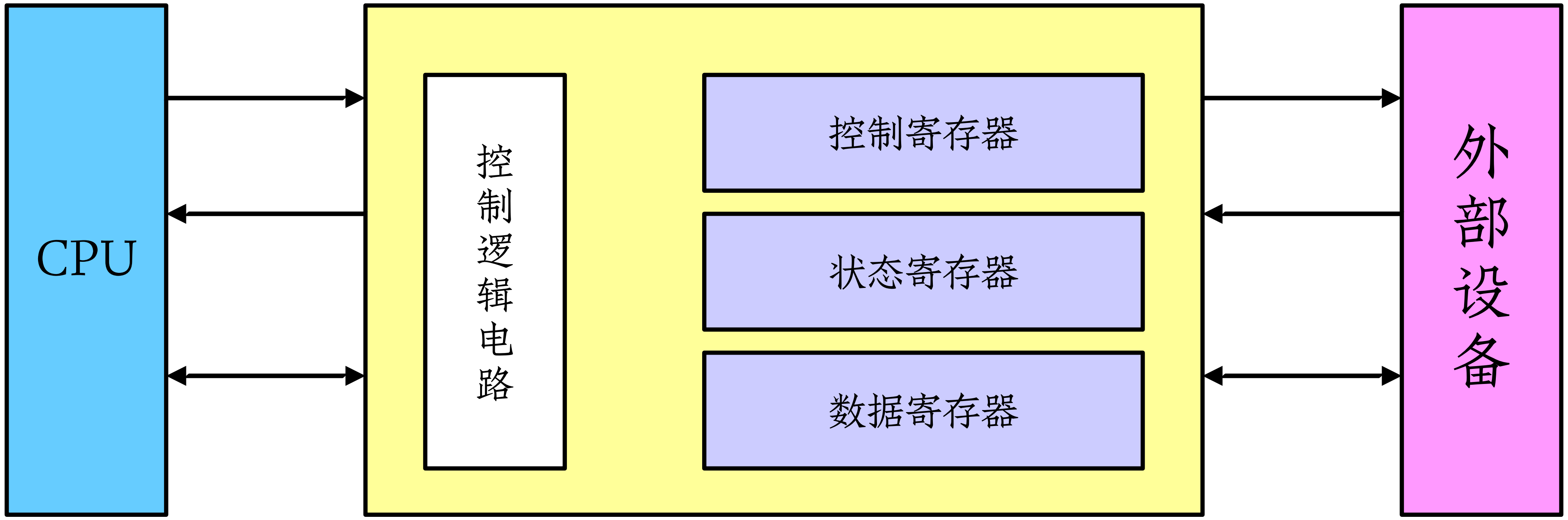

显示器
图形适配器
缓存
桥/存储器
控制器
SCSI总线
磁盘
磁盘
SCSI适配器
PCI总线
磁盘控制器
扩展总线接口
键盘
磁盘
磁盘
扩展总线
并口
串口

CONTROLLER

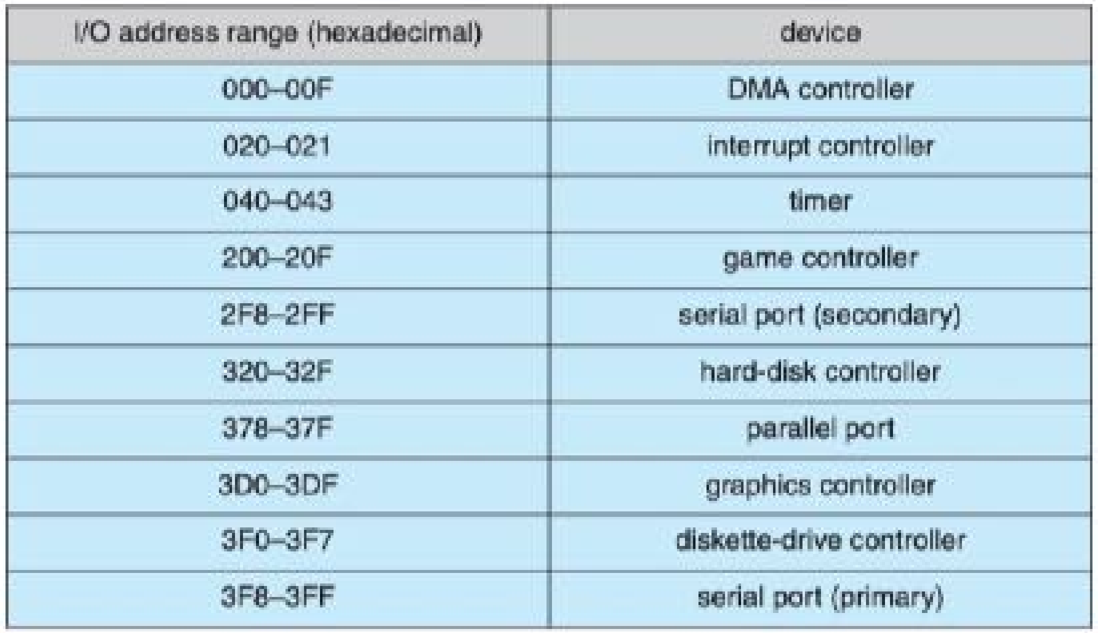
- A controller is a collection of electronics that can operate a port, a bus, or a device.
  - A serial-port controller is a simple device controller. It is a single chip (or portion of a chip) in the computer that controls the signals on the wires of a serial port.
  - A SCSI bus controller is NOT simple because the SCSI protocol is complex. It typically contains a processor, microcode, and some private memory to enable it to process the SCSI protocol messages.
  - Some devices have their own built-in controllers. You will see a circuit board attached to one side of a disk drive. This board is the disk controller. It implements the disk side of the protocol for some kind of connection— SCSI or Serial Advanced Technology Attachment (SATA), for instance. It has microcode and a processor to do many tasks, such as bad-sector mapping, prefetching, buffering, and caching.

如何对控制器发布命令

- 控制器有一个或多个用于数据和控制信号的寄存器。CPU 通过读写这些寄存器来控制通信。
  - 控制寄存器：可以被主机发布命令或改变设备状态
  - 状态寄存器：包含一些主机可读的位信息
  - 数据寄存器：记录主机可读或写入的数据

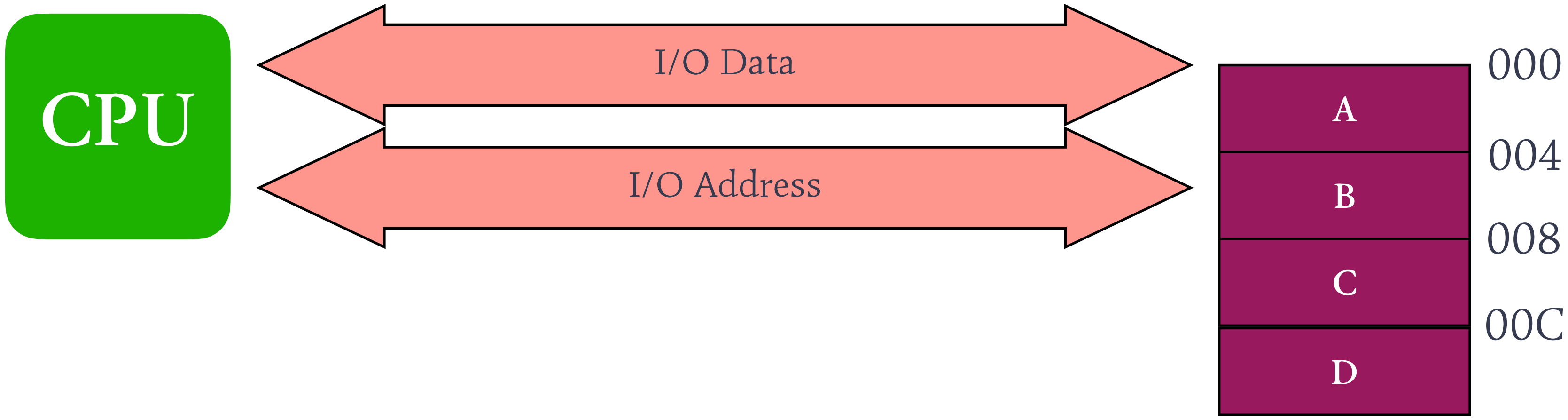


I/O地址



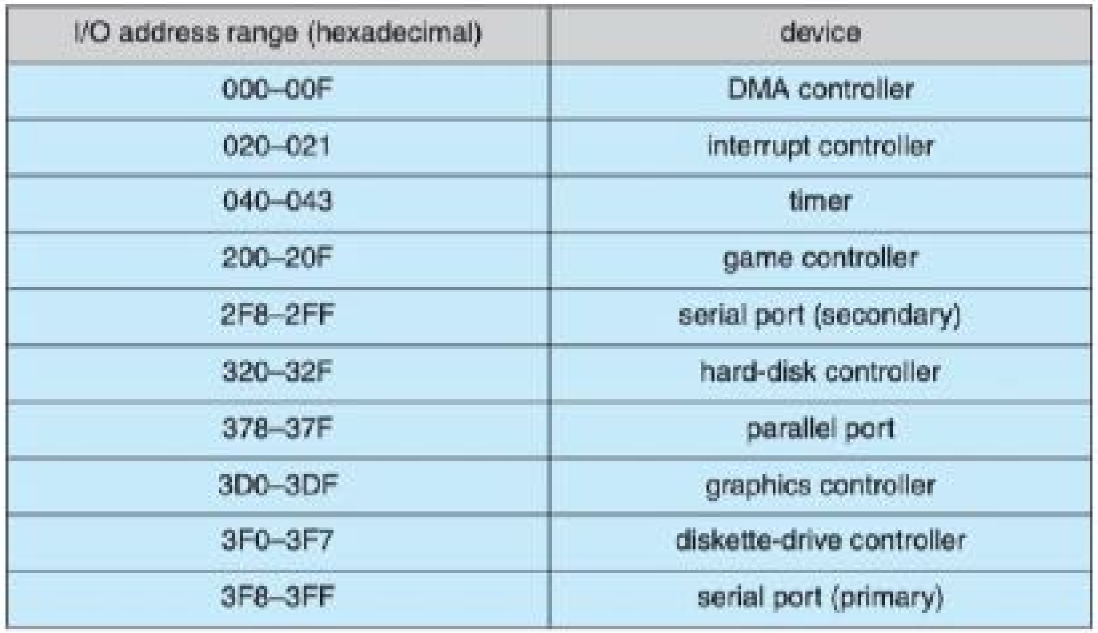
I/O address range (hexadecimal)	device
000–00F	DMA controller
020–021	interrupt controller
040–043	timer
200–20F	game controller
2F8–2FF	serial port (secondary)
320–32F	hard-disk controller
378–37F	parallel port
3D0–3DF	graphics controller
3F0–3F7	diskette-drive controller
3F8–3FF	serial port (primary)

- I/O地址：控制寄存器地址
- 编址方式
  - I/O独立编址：使用独立的I/O指令，如IN、OUT；
  - 内存映射编址：划出一块内存地址，将I/O的端口地址映射进来，这样就可以使用访问内存指令对控制寄存器进行读写。



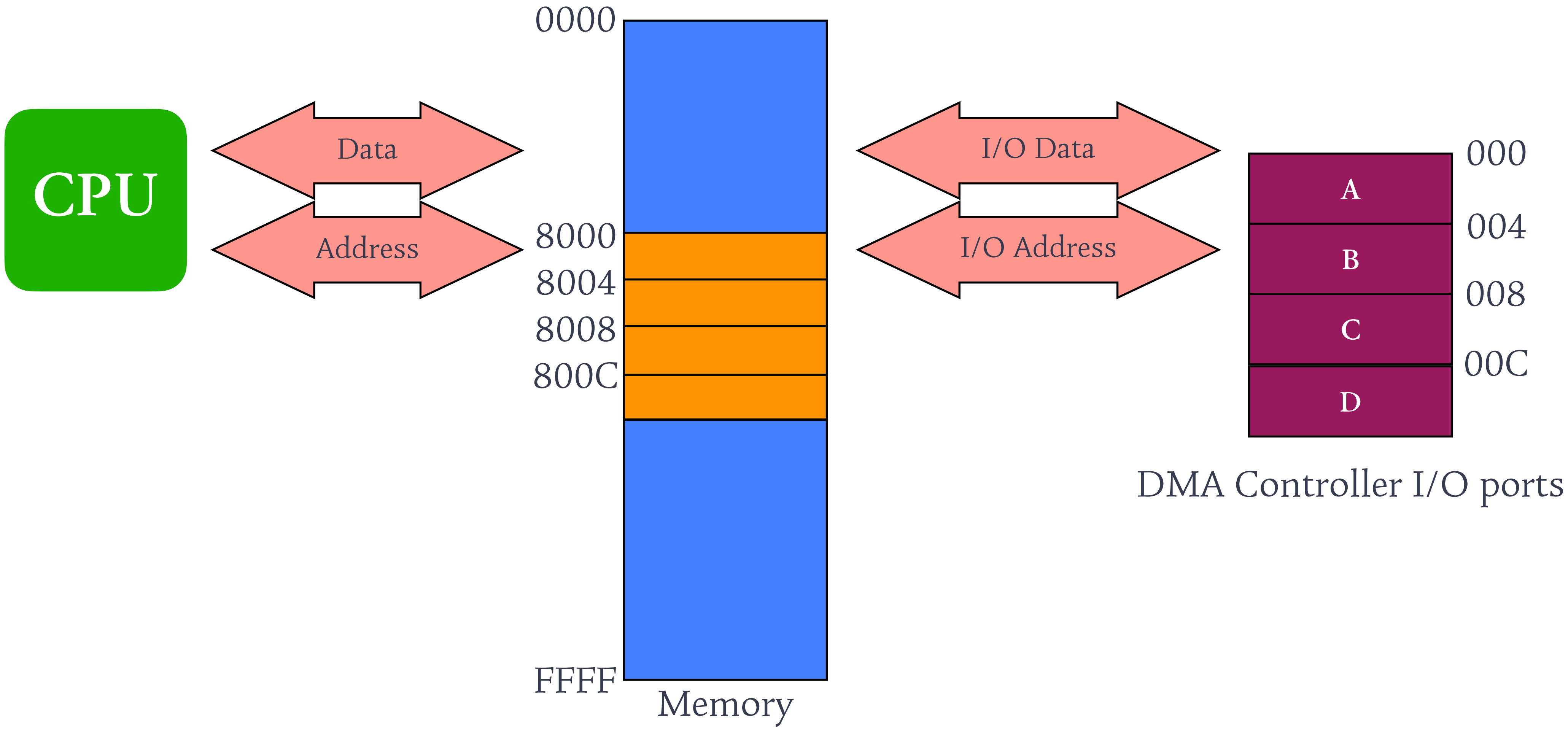
DMA Controller I/O ports

I/O地址



I/O address range (hexadecimal)	device
000–00F	DMA controller
020–021	interrupt controller
040–043	timer
200–20F	game controller
2F8–2FF	serial port (secondary)
320–32F	hard-disk controller
378–37F	parallel port
3D0–3DF	graphics controller
3F0–3F7	diskette-drive controller
3F8–3FF	serial port (primary)

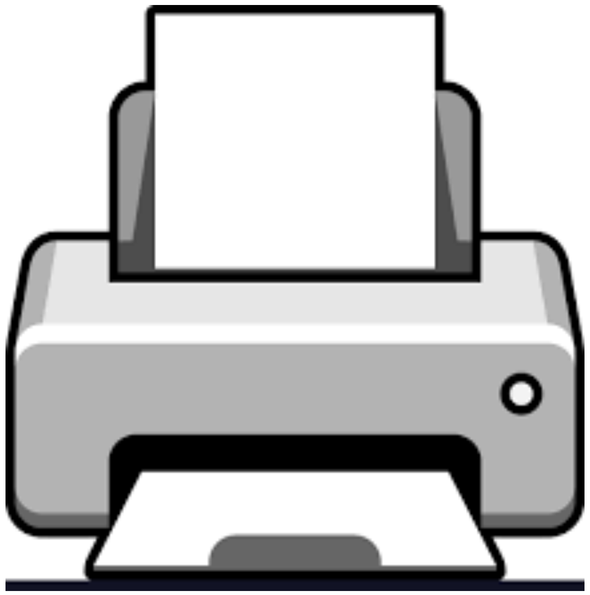
- I/O地址：控制寄存器地址
- 编址方式
  - I/O独立编址：使用独立的I/O指令，如IN、OUT；
  - 内存映射编址：划出一块内存地址，将I/O的端口地址映射进来，这样就可以使用访问内存指令对控制寄存器进行读写。

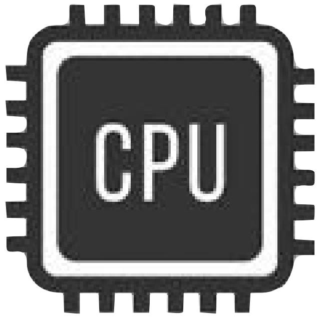


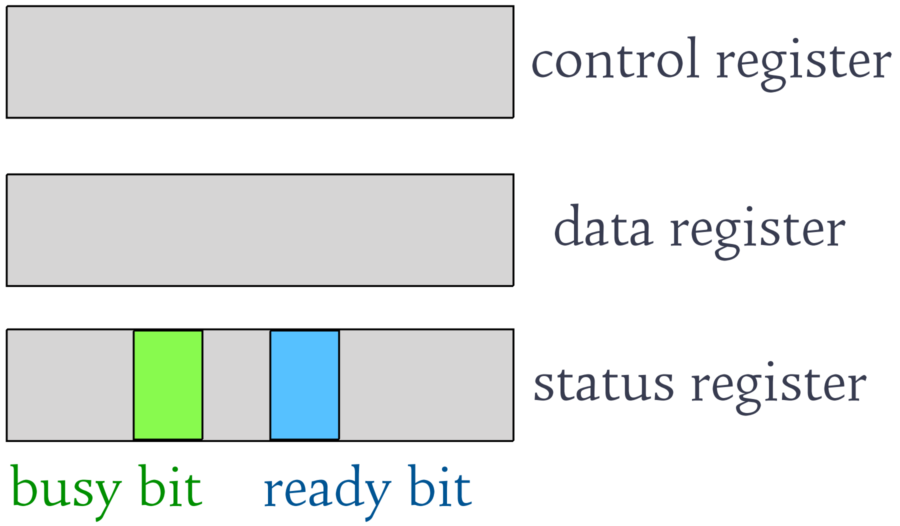
I/O控制方式

轮询

- 步骤
  - 重复测试busy位，直到清零；
  - 设置控制寄存器为write操作，并将要写入的字节X存入数据寄存器；
  - 设置ready位
  - 若ready位为1，则设置busy位
  - 执行write命令，将字节X写入设备
  - 清除ready位和busy位
- 评价
  - 优点
  - 缺点







control register

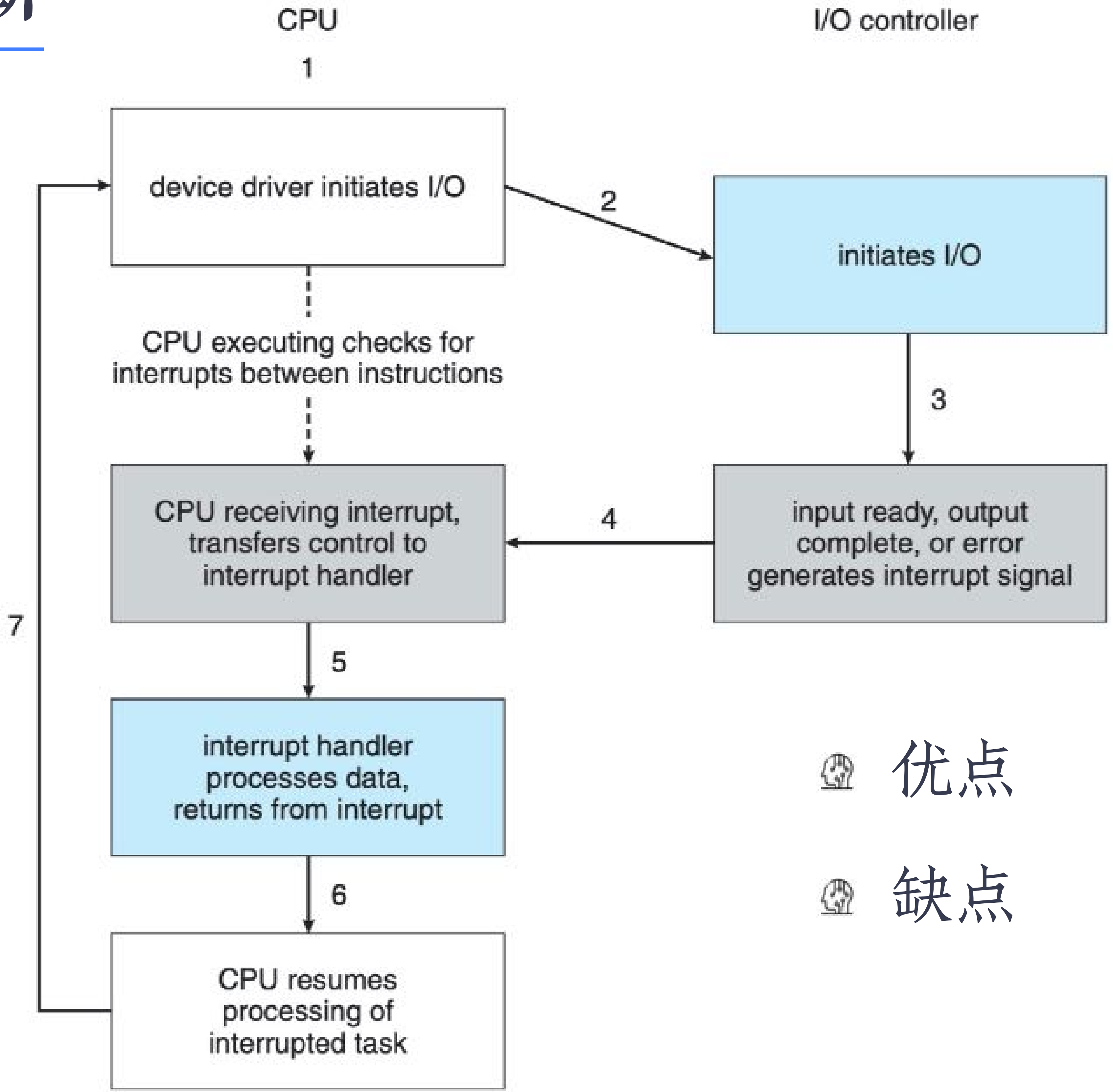
data register

status register

busy bit

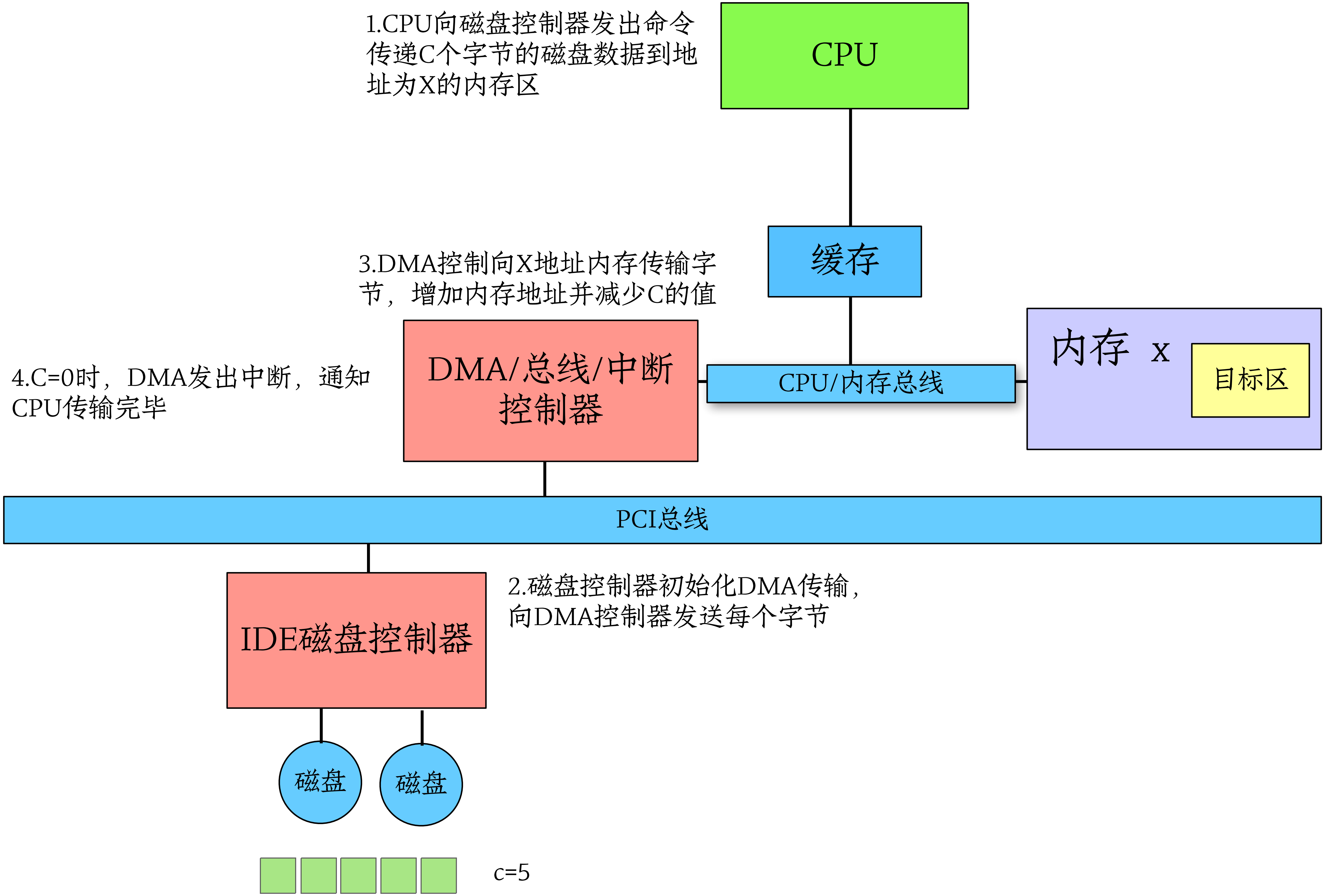
ready bit

中断


CPU
I/O controller
1
device driver initiates I/O
2
initiates I/O
CPU executing checks for interrupts between instructions
3
CPU receiving interrupt, transfers control to interrupt handler
4
input ready, output complete, or error generates interrupt signal
7
5
interrupt handler processes data, returns from interrupt
6
CPU resumes processing of interrupted task

- 优点
- 缺点

DMA直接内存访问



1.CPU向磁盘控制器发出命令传递C个字节的磁盘数据到地址为X的内存区

2.磁盘控制器初始化DMA传输，向DMA控制器发送每个字节

3.DMA控制向X地址内存传输字节，增加内存地址并减少C的值

4.C=0时，DMA发出中断，通知CPU传输完毕

CYCLE STEALING

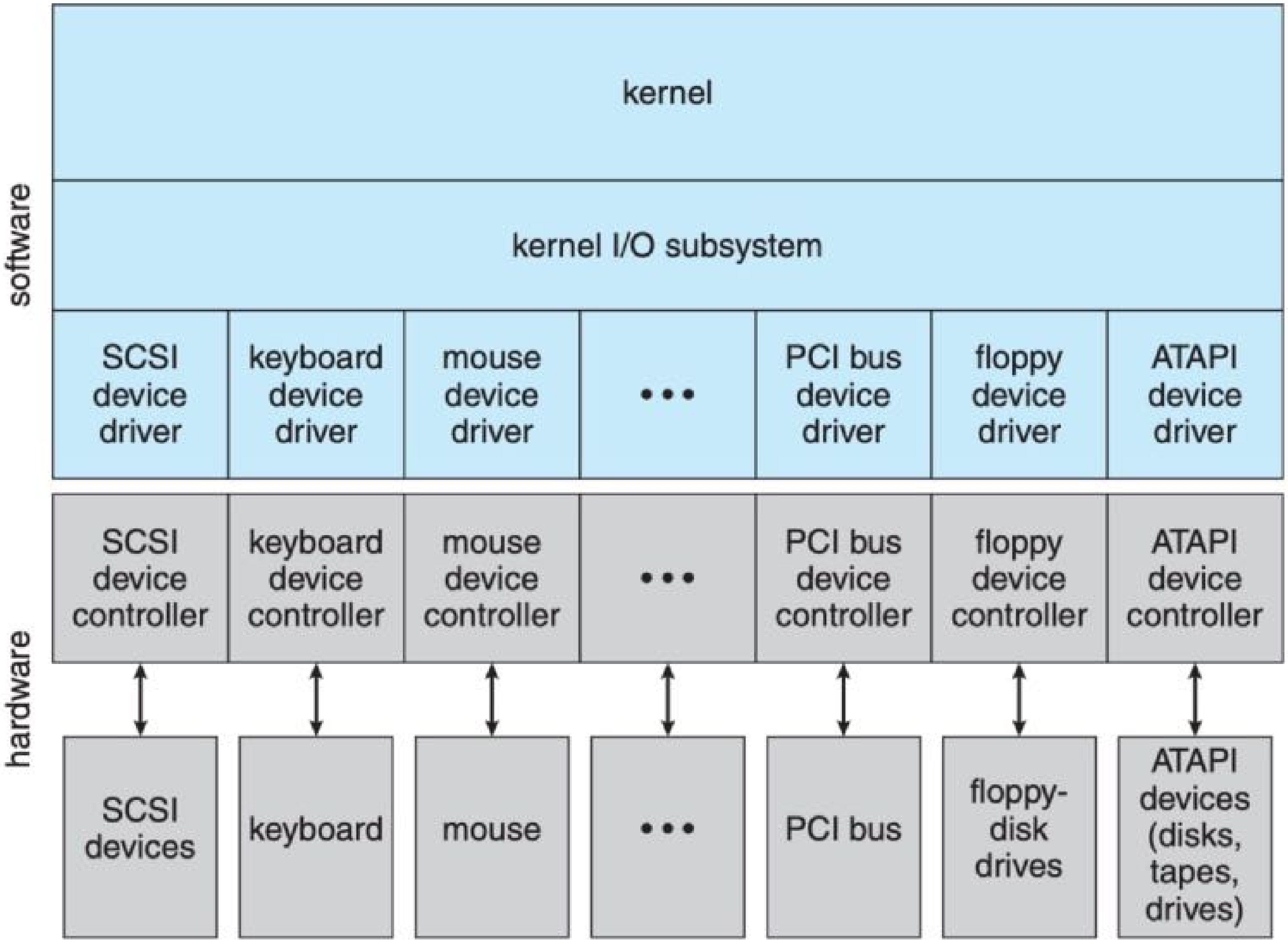
- When the DMA controller seizes the memory bus, the CPU is momentarily prevented from accessing main memory. We call the DMA steals the CPU's cycle.
- Although this cycle stealing can slow down the CPU computation, offloading the data-transfer work to a DMA controller generally improves the total system performance.

内核I/O结构

内核I/O结构

- 内核I/O结构包括I/O硬件和I/O软件两个部分，I/O软件的设计目标主要体现在：
  - 高效率（efficiency）：通过一些手段提高I/O设备的访问效率。
  - 通用性（generality）：屏蔽硬件细节，让用户使用统一的接口方便地使用不同的硬件。

内核I/O结构图



software

hardware

kernel

kernel I/O subsystem

SCSI device driver

keyboard device driver

mouse device driver

• • •

PCI bus device driver

floppy device driver

ATAPI device driver

SCSI device controller

keyboard device controller

mouse device controller

• • •

PCI bus device controller

floppy device controller

ATAPI device controller

SCSI devices

keyboard

mouse

• • •

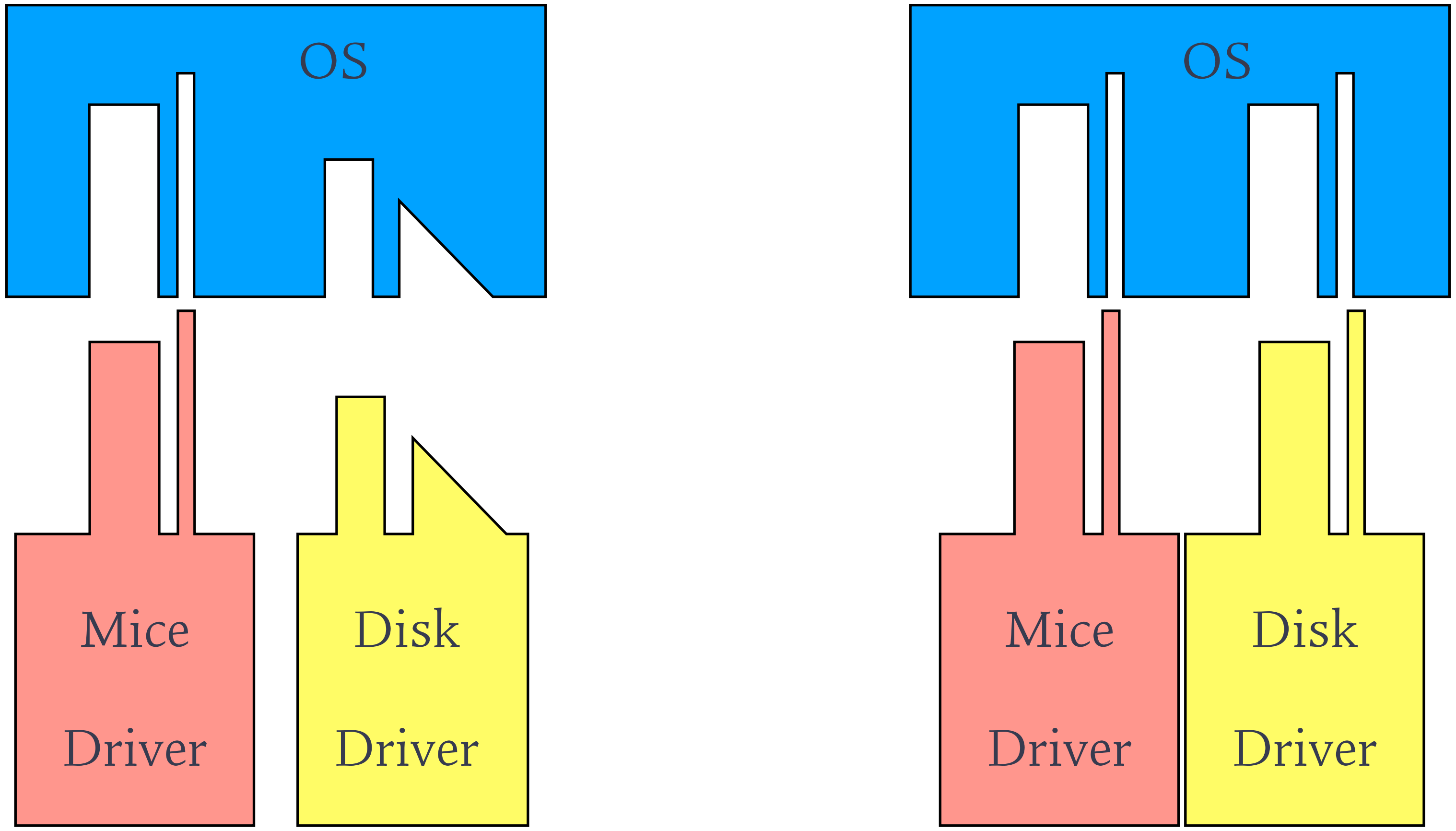
PCI bus

floppy-disk drives

ATAPI devices (disks, tapes, drives)

设备驱动层

- Device-driver layer makes the I/O subsystem independent of the hardware through hiding the differences among device controllers.



内核I/O子系统

- Several services—scheduling, buffering, caching, spooling, device reservation, and error handling—are provided by the kernel's I/O subsystem and build on the hardware and device-driver infrastructure.
- The I/O subsystem is also responsible for protecting itself from errant processes and malicious users.

BUFFERING

- 缓冲主要用于处理数据流的生产者和消费者速度不匹配问题。

BUFFERING

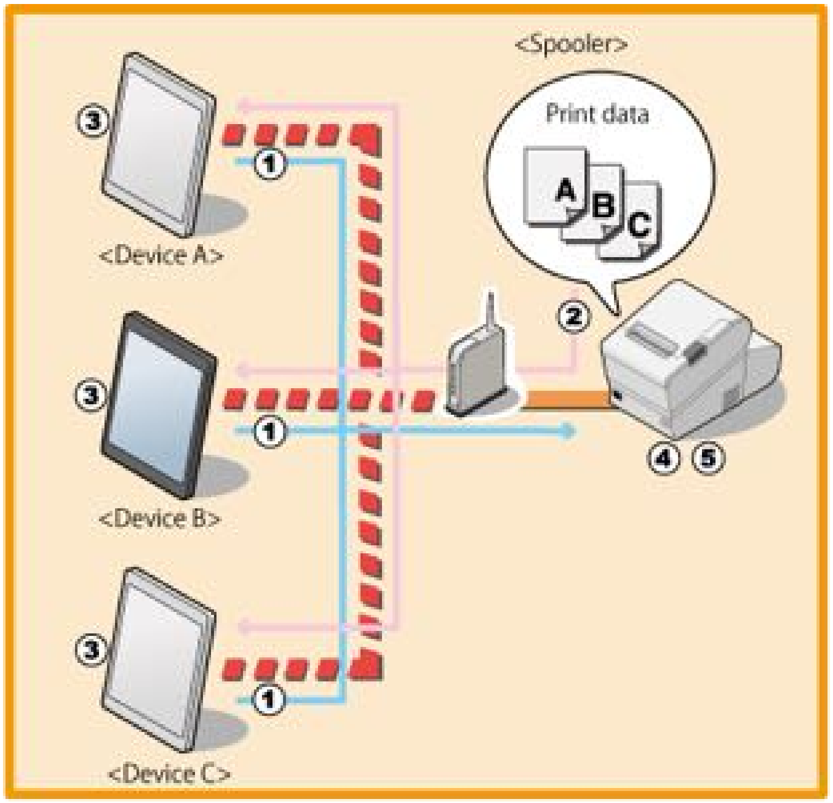
- 缓冲主要用于处理数据流的生产者和消费者速度不匹配问题。

BUFFER & CACHE

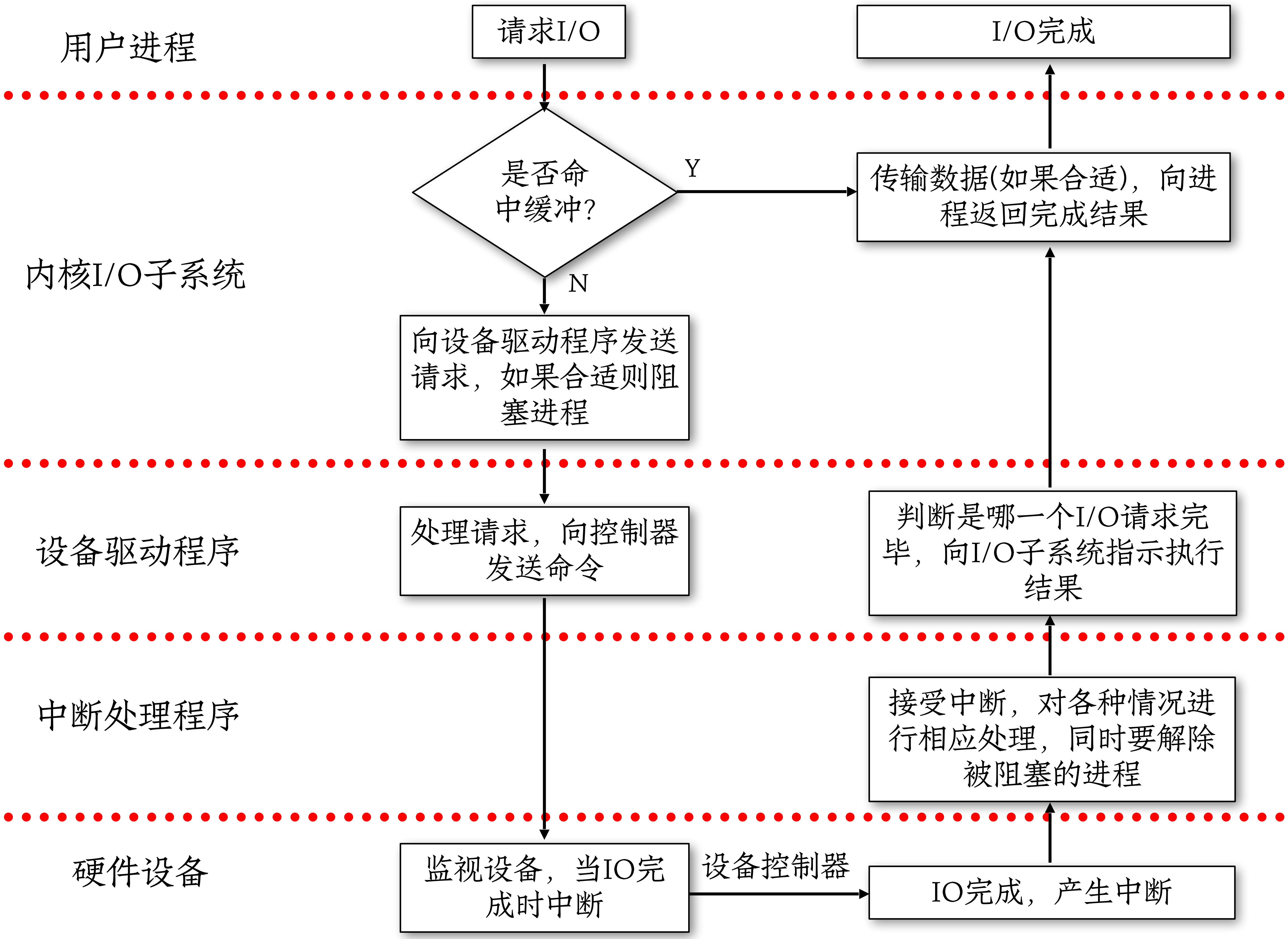
- The difference between a buffer and a cache is that a buffer may hold the only existing copy of a data item, whereas a cache, by definition, holds a copy on faster storage of an item that resides elsewhere.

SPOOLING

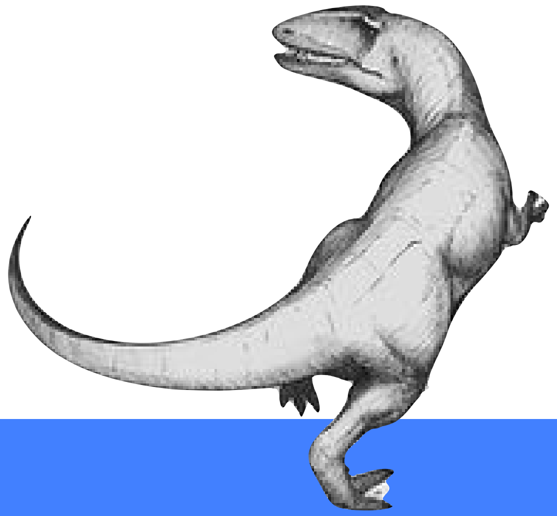
- A spool (Simultaneous Peripheral Operations On-Line) is a buffer that holds output for a device, such as a printer, that cannot accept interleaved data streams. Although a printer can serve only one job at a time, several applications may wish to print their output concurrently, without having their output mixed together.



I/O请求生命周期


用户进程
请求I/O
I/O完成
内核I/O子系统
是否命中缓冲?
Y
N
传输数据(如果合适)，向进程返回完成结果
向设备驱动程序发送请求，如果合适则阻塞进程
设备驱动程序
处理请求，向控制器发送命令
判断是哪一个I/O请求完毕，向I/O子系统指示执行结果
中断处理程序
接受中断，对各种情况进行相应处理，同时要解除被阻塞的进程
硬件设备
监视设备，当IO完成时中断
设备控制器
IO完成，产生中断

Final Lecture



The End