Example : IDE disk read with DMA

1. device driver is told to transfer disk data to buffer at address X

2. device driver tells disk controller to transfer C bytes from disk to buffer at address X

5. DMA controller transfers bytes to buffer X, increasing memory address and decreasing C until C = 0

6. when C = 0, DMA interrupts CPU to signal transfer completion

3. disk controller initiates DMA transfer

4. disk controller sends each byte to DMA controller

CPU

cache

DMA/bus/ interrupt controller

CPU memory bus

memory   X buffer

PCI bus

IDE disk controller

disk disk
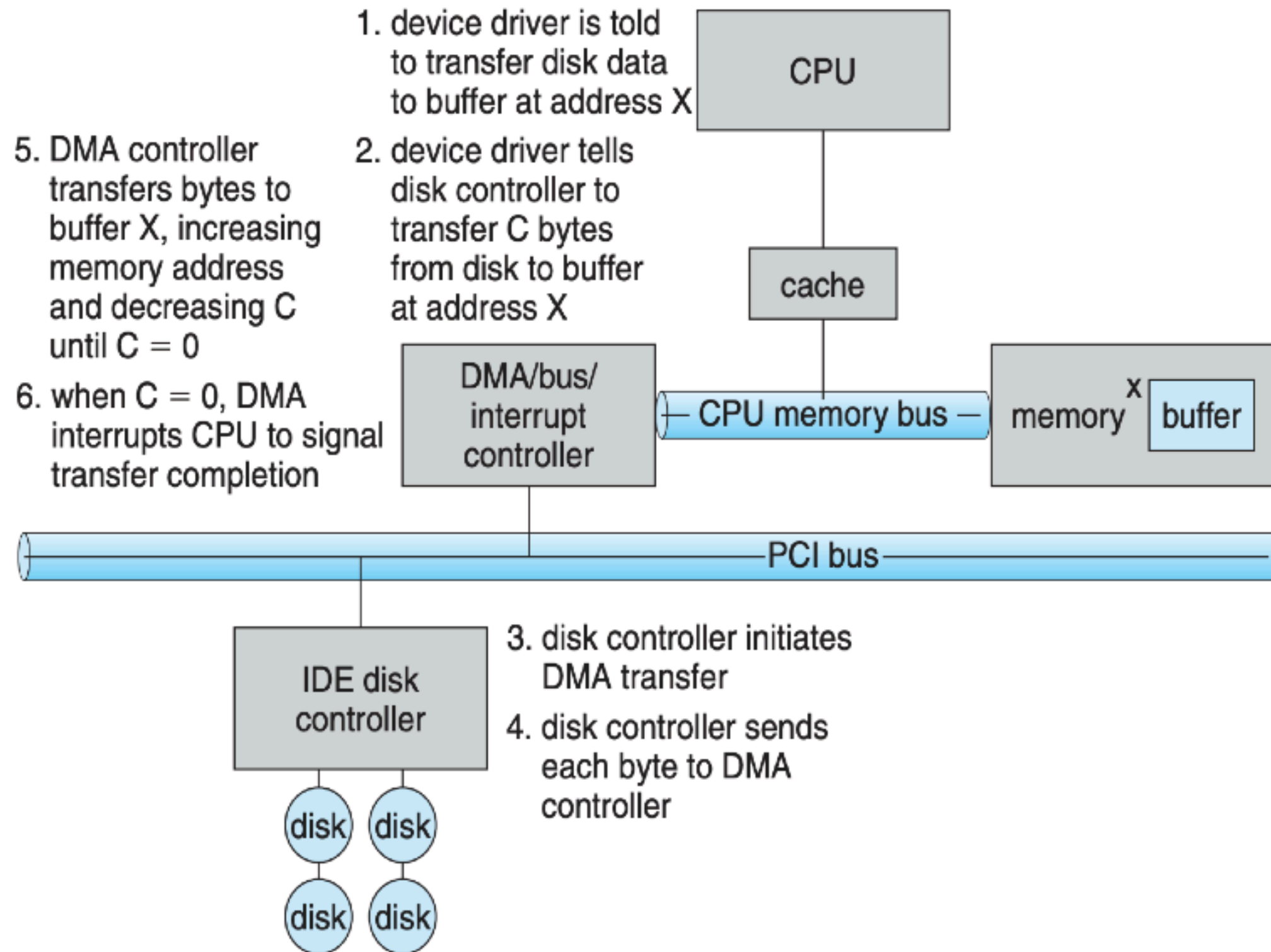
disk disk

I/O instruction using DMA

Pintos `threads/io.h`

```c
static inline void insw (uint16_t port, void *addr, size_t cnt)
{
  asm volatile ("rep insw" : "+D" (addr), "+c" (cnt)
                : "d" (port) : "memory");
}
```