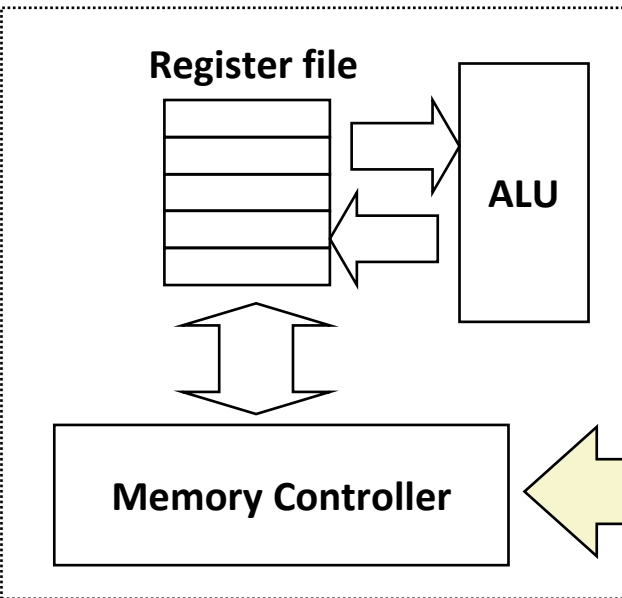
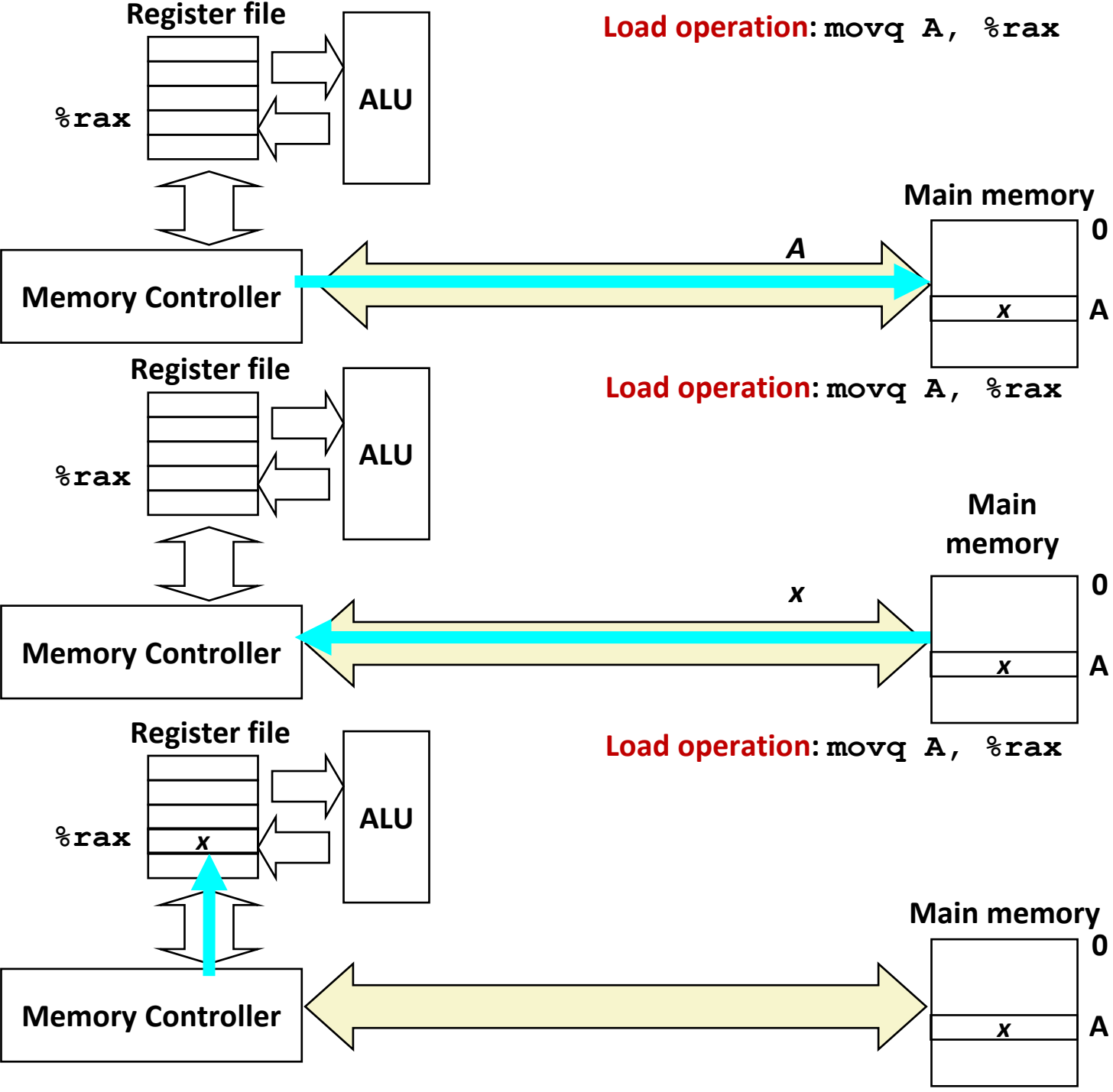


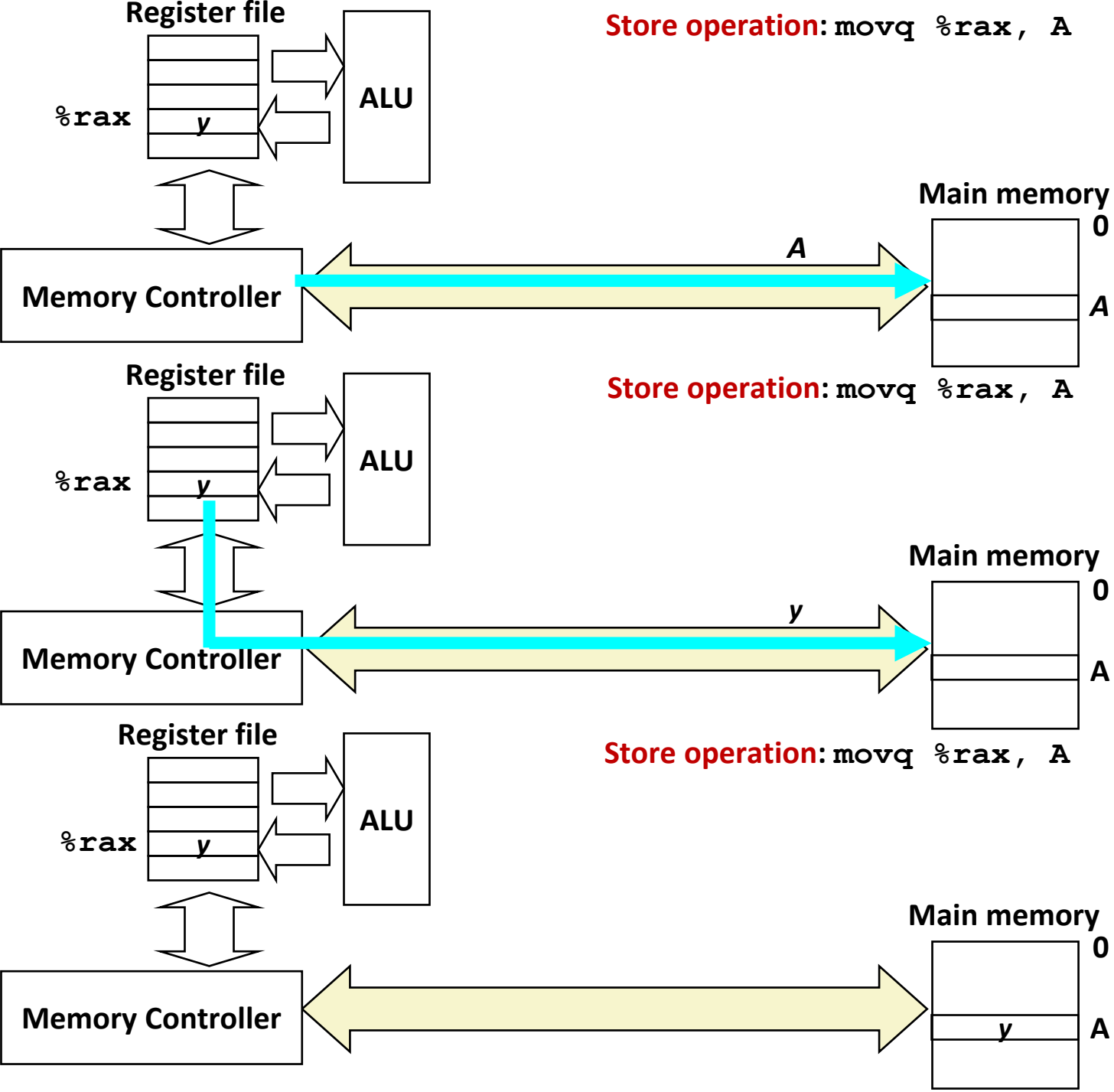
CPU chip

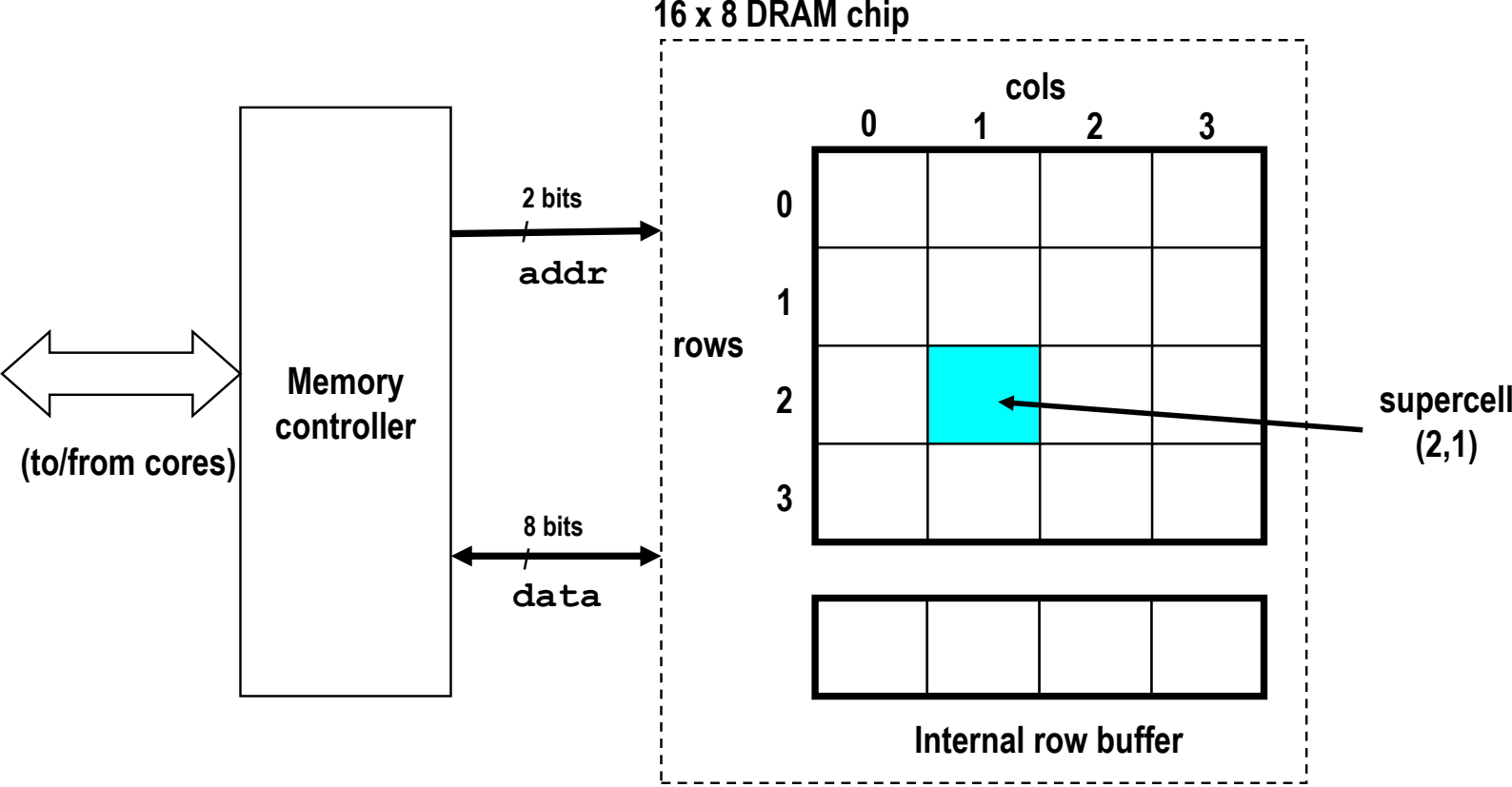


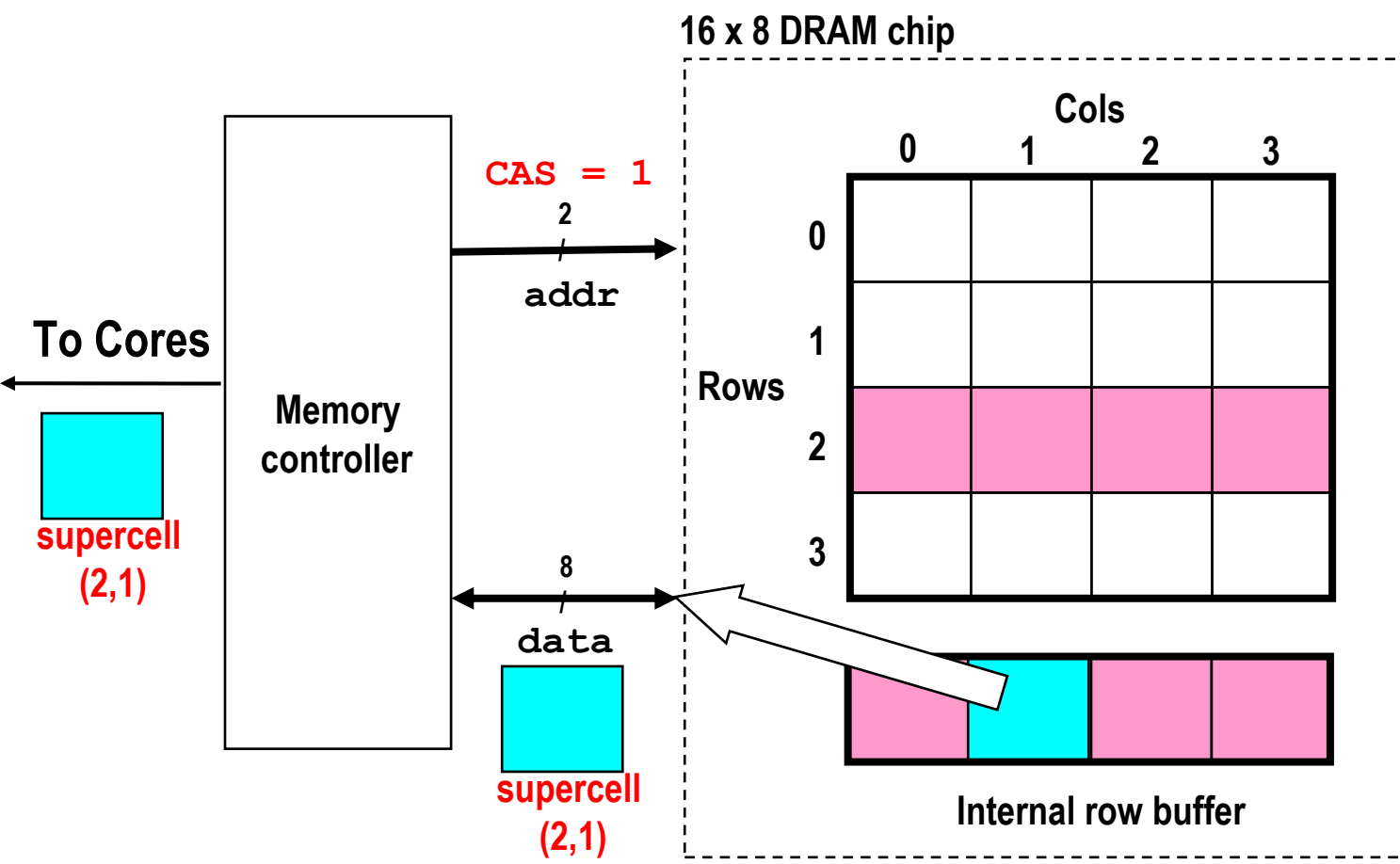
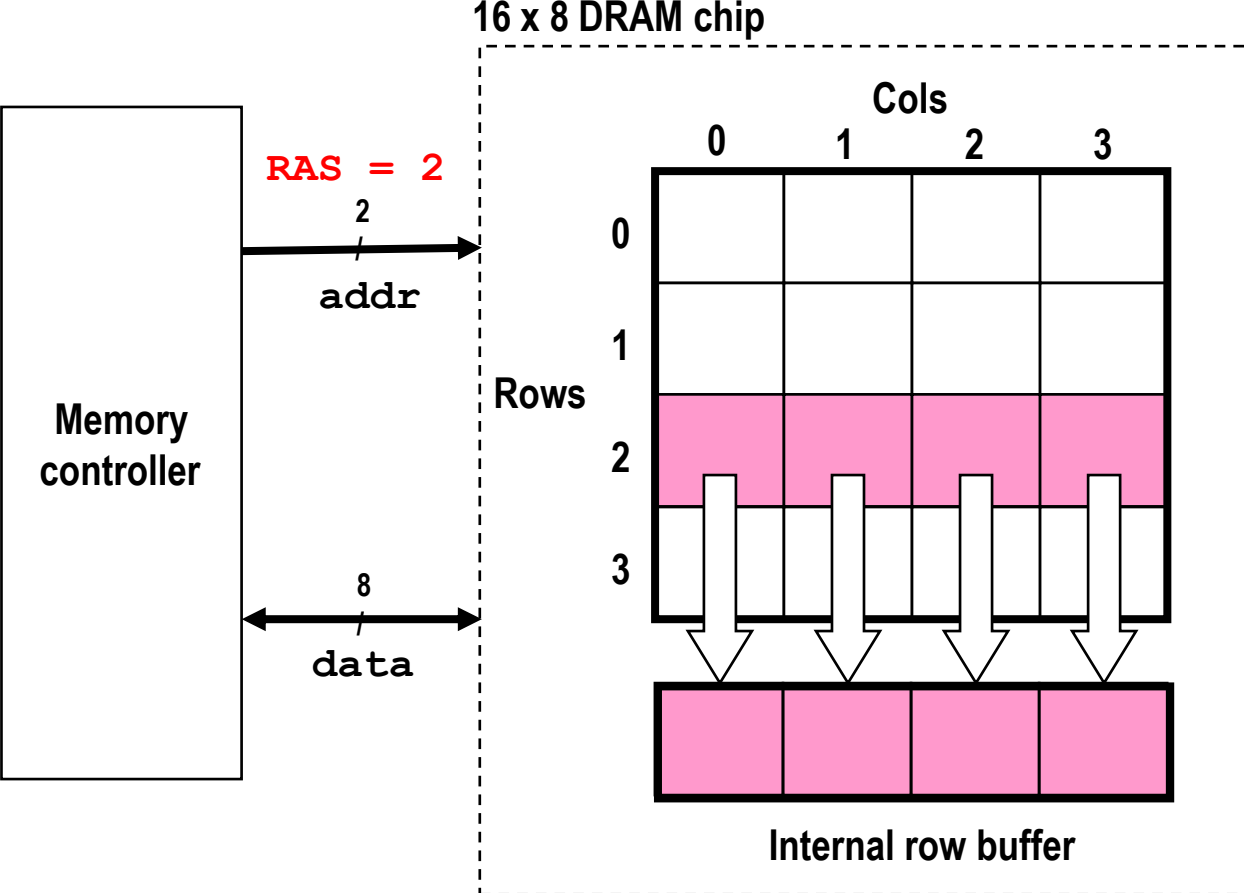
Memory bus

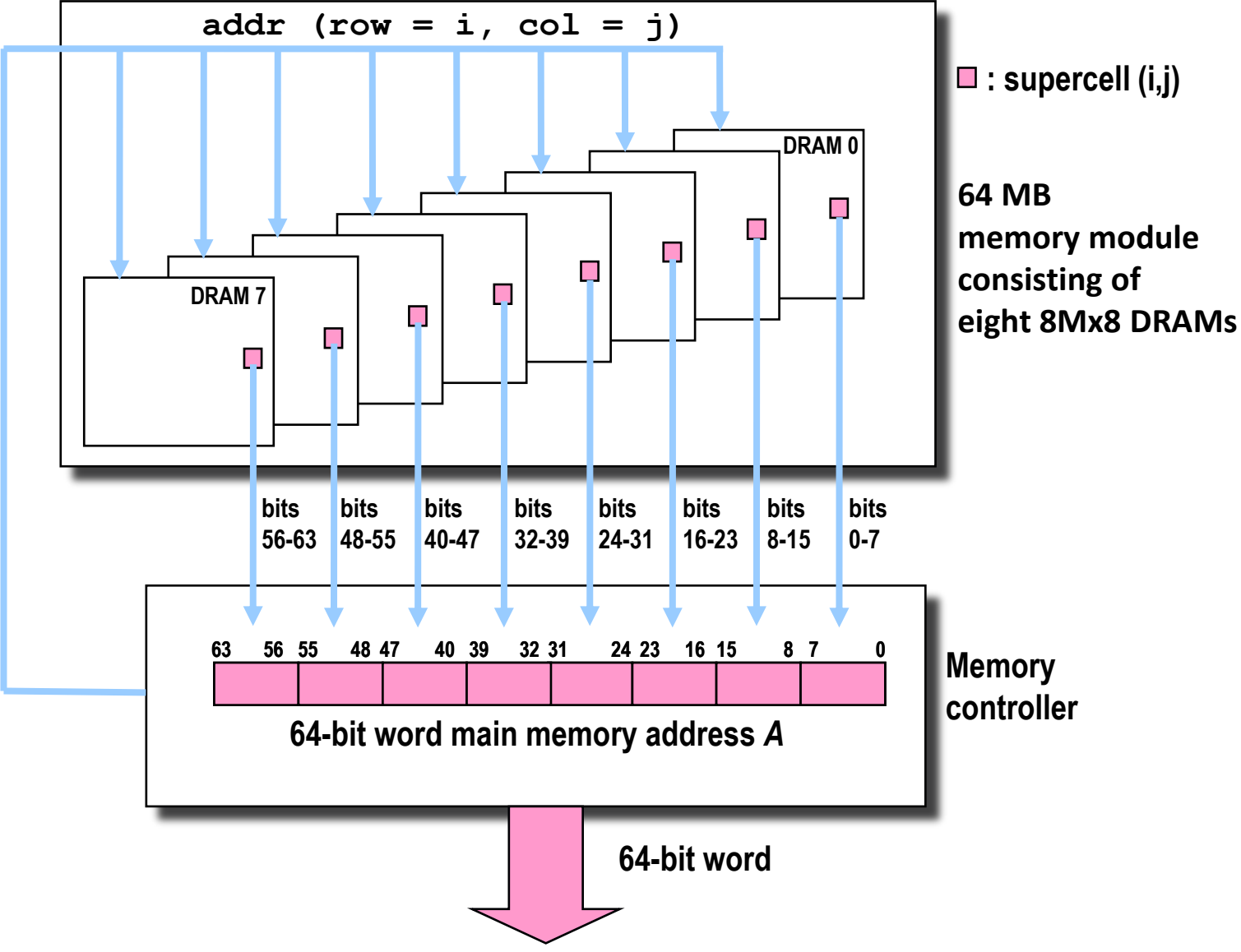
**Main
memory**

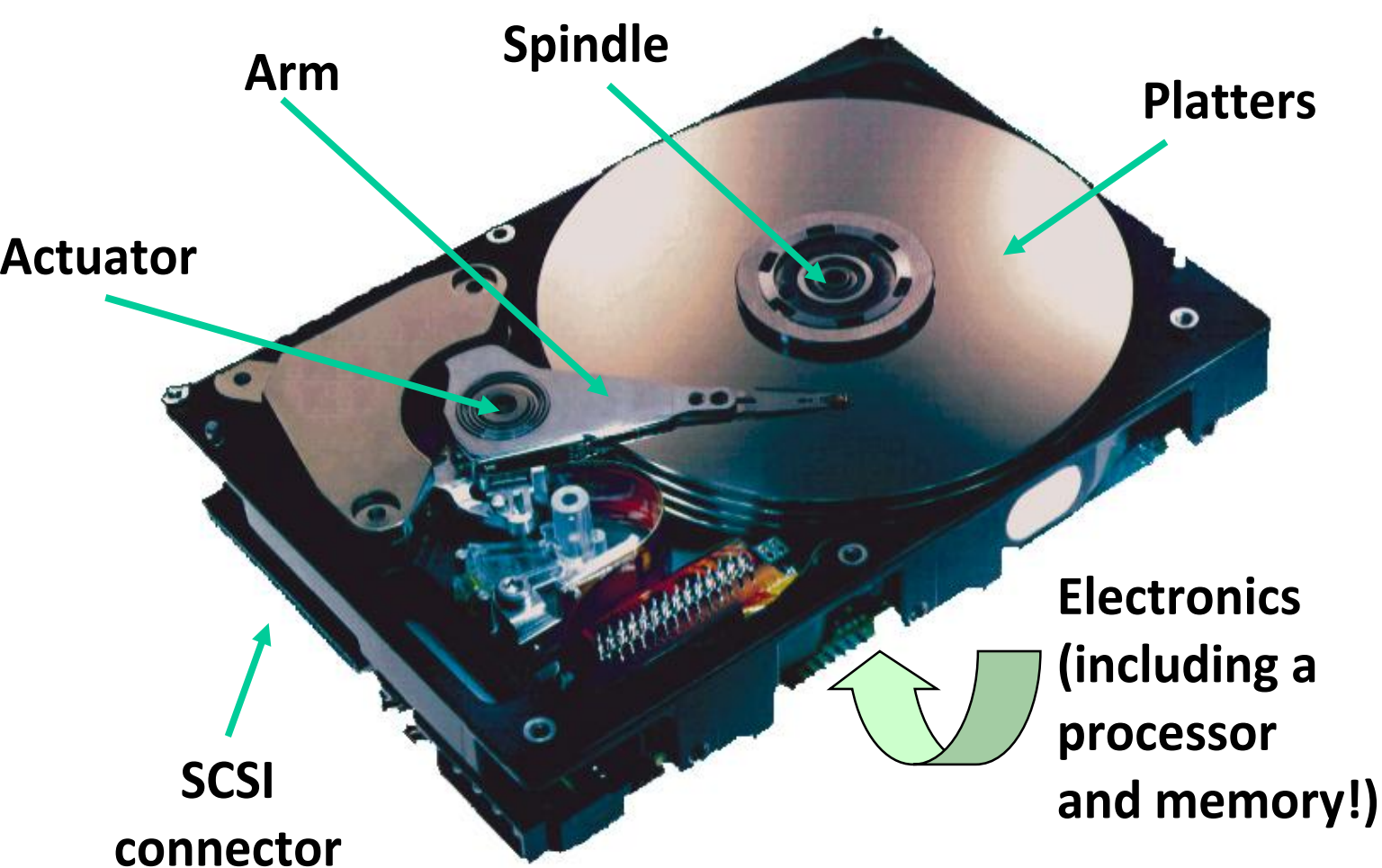


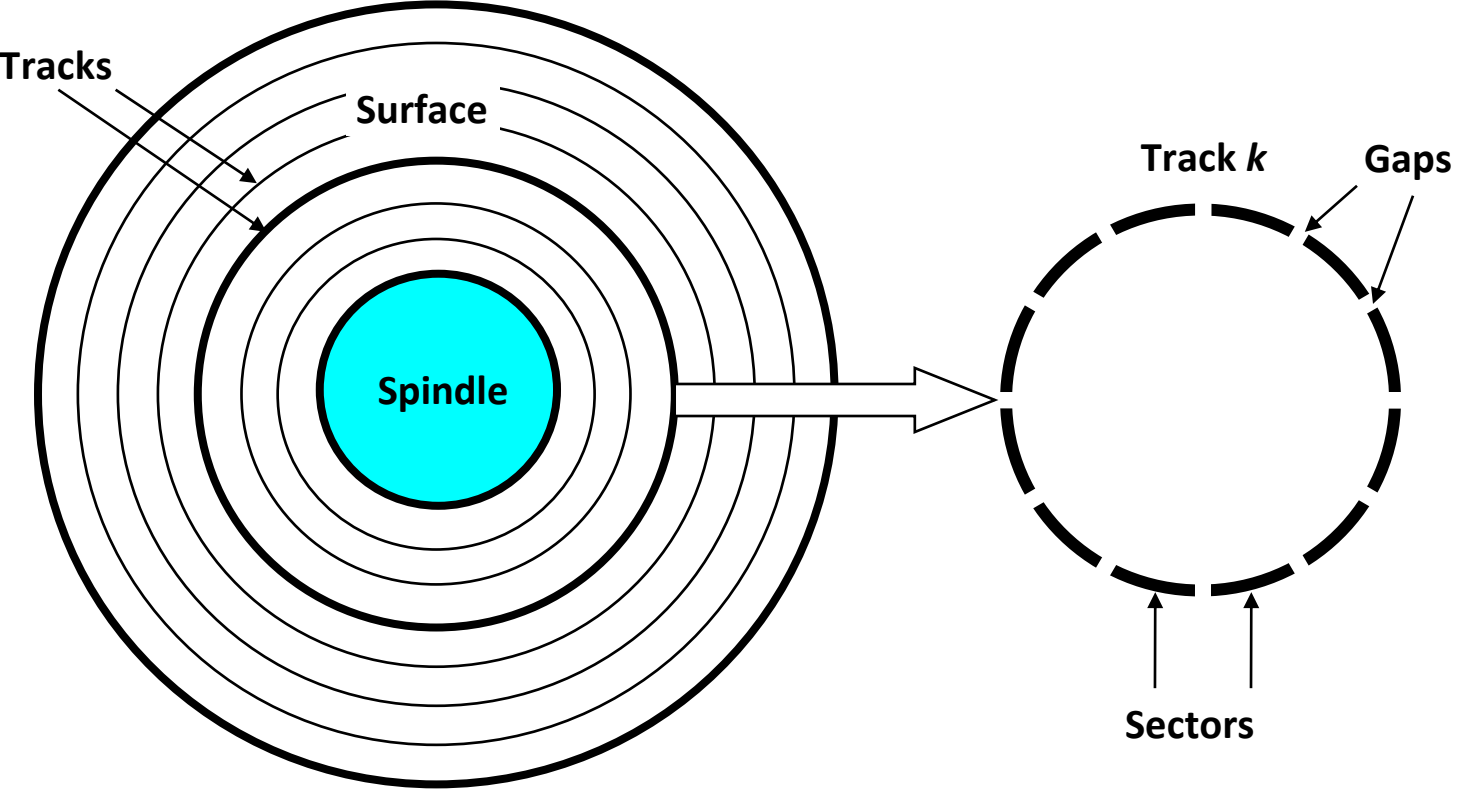




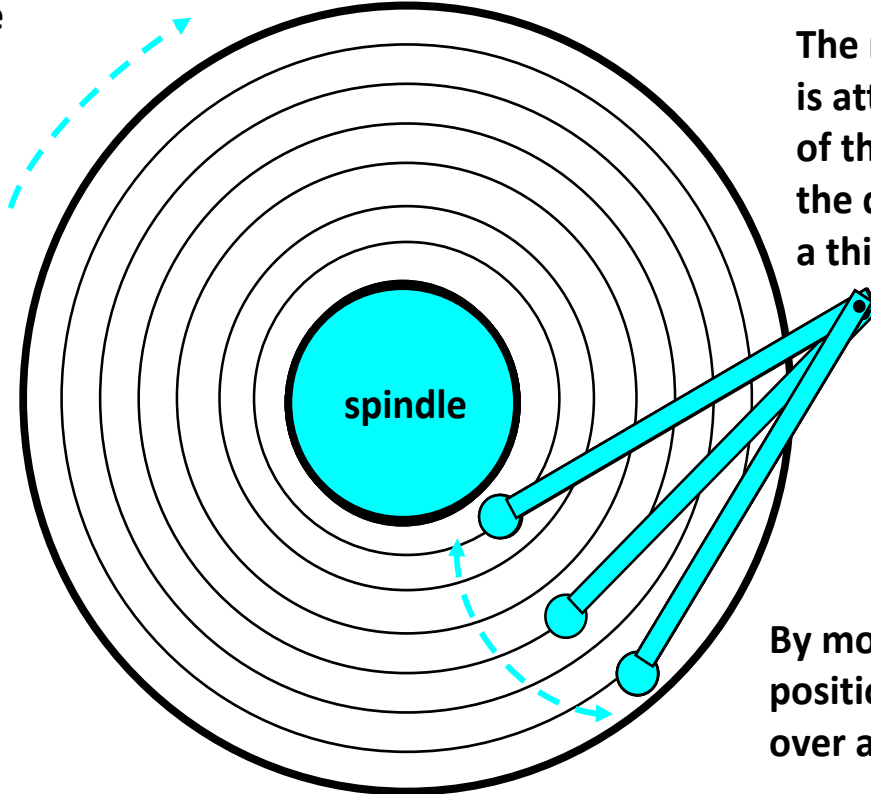






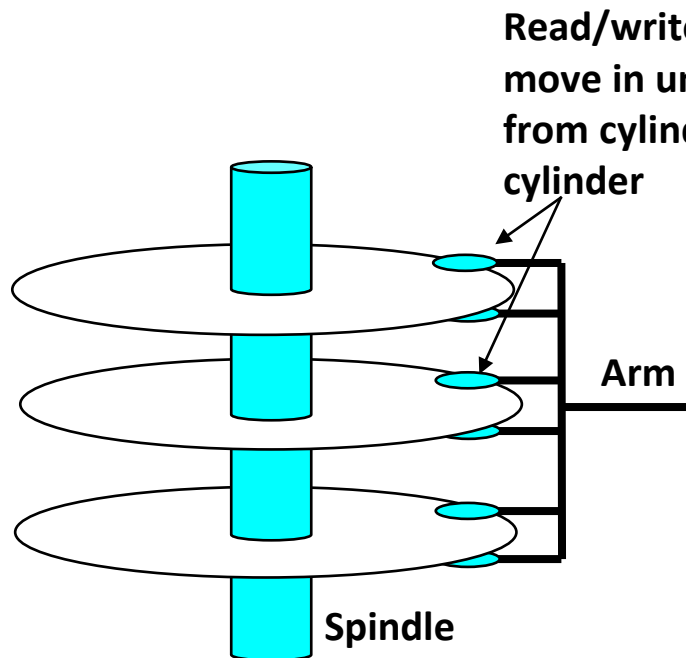


The disk surface spins at a fixed rotational rate



The read/write *head* is attached to the end of the *arm* and flies over the disk surface on a thin cushion of air.

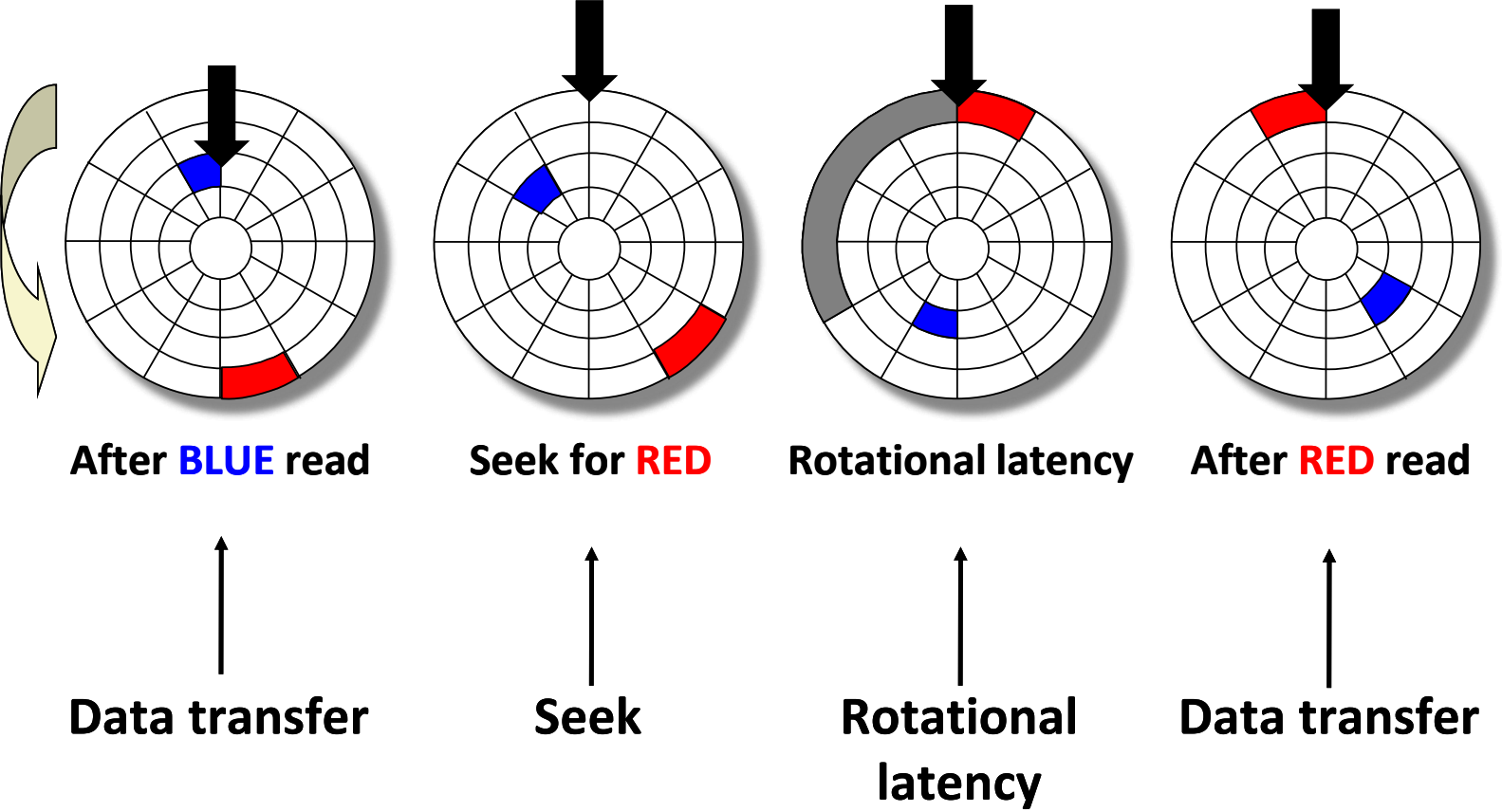
By moving radially, the arm can position the read/write head over any track.



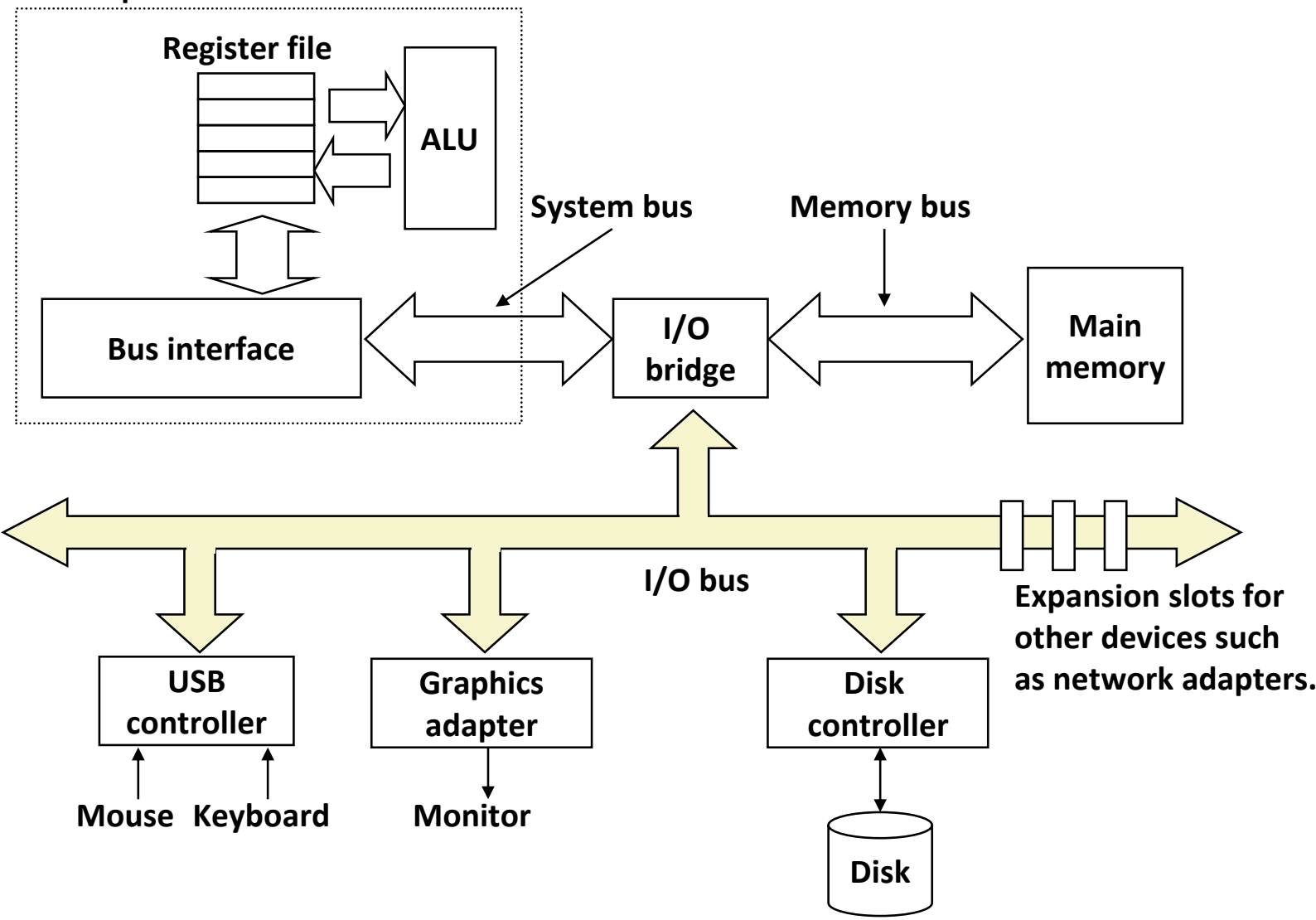
Read/write heads move in unison from cylinder to cylinder

Arm

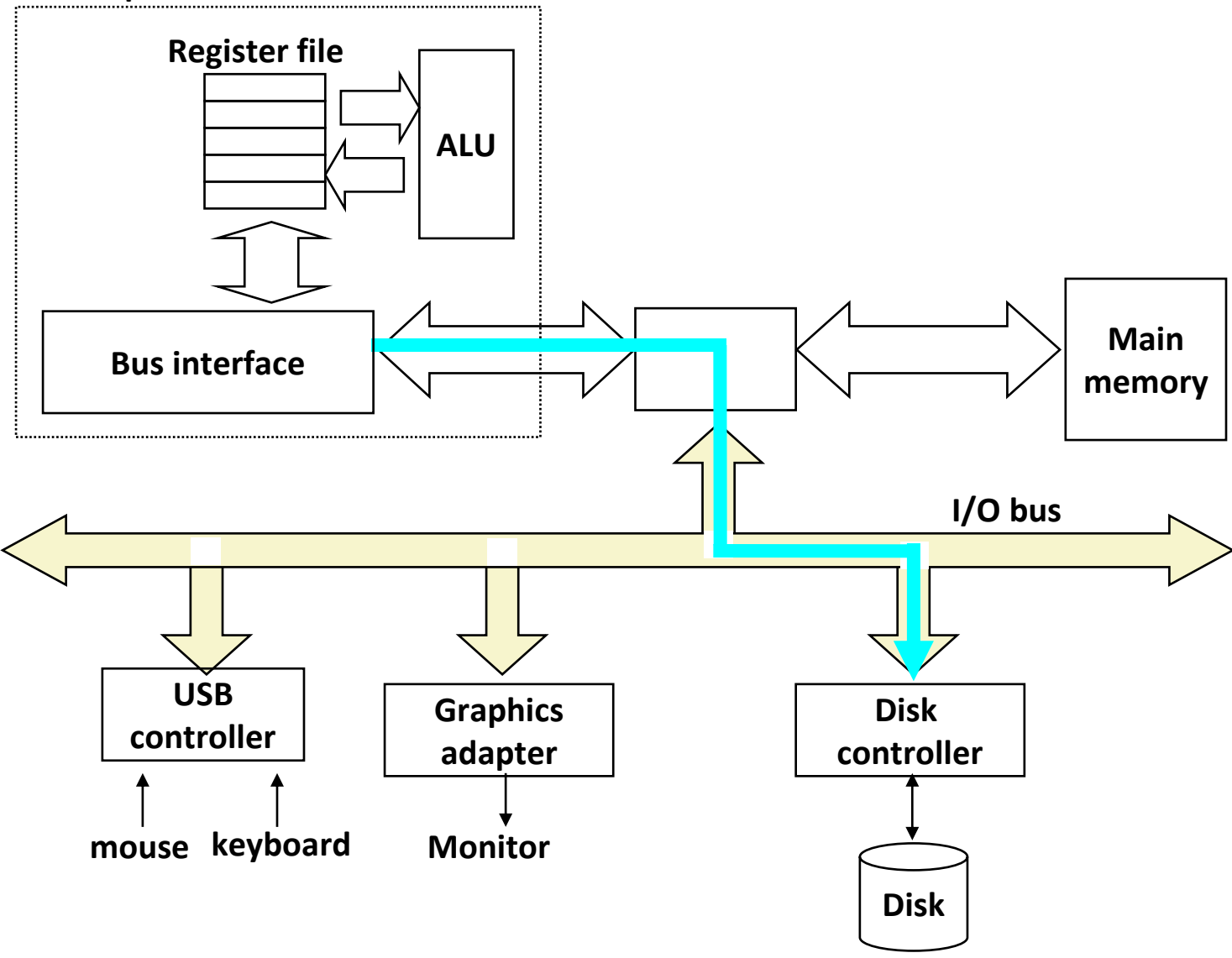
Spindle



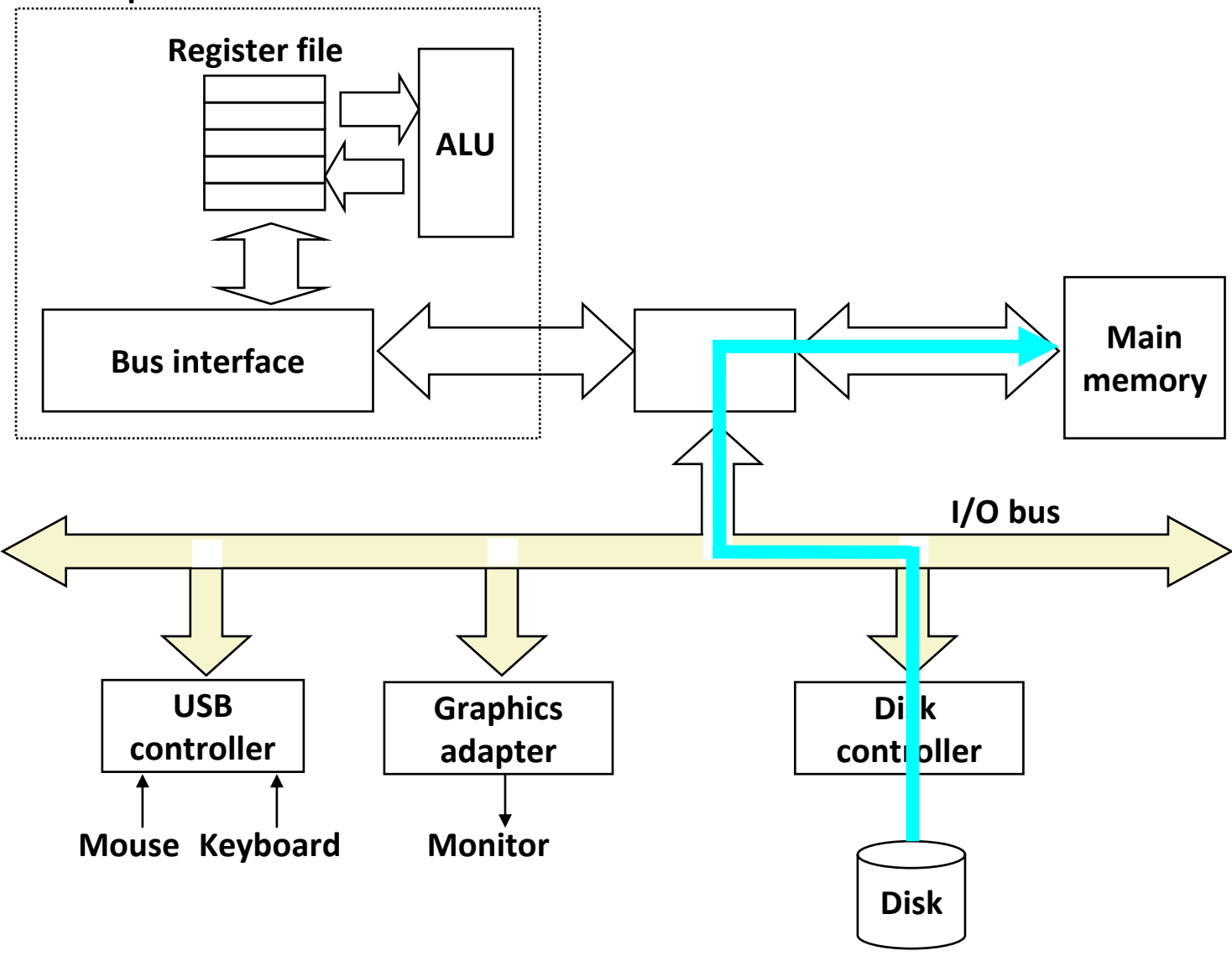
CPU chip



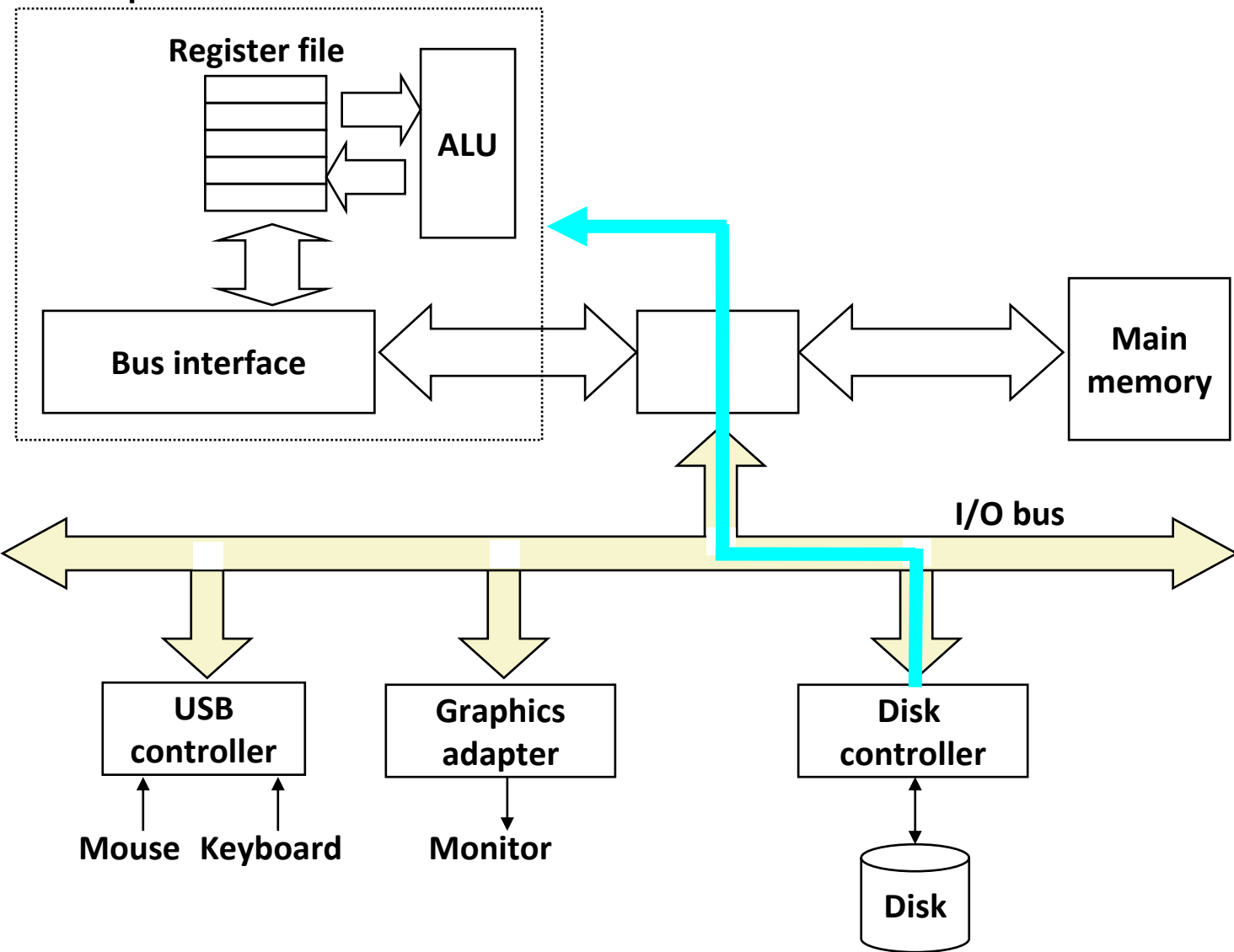
CPU chip



CPU chip



CPU chip



I/O bus

*Requests to read and
write logical disk blocks*

Solid State Disk (SSD)

Flash
translation layer

DRAM
Buffer

Flash memory

Block 0

Block B-1

Page 0

Page 1

...

Page P-1

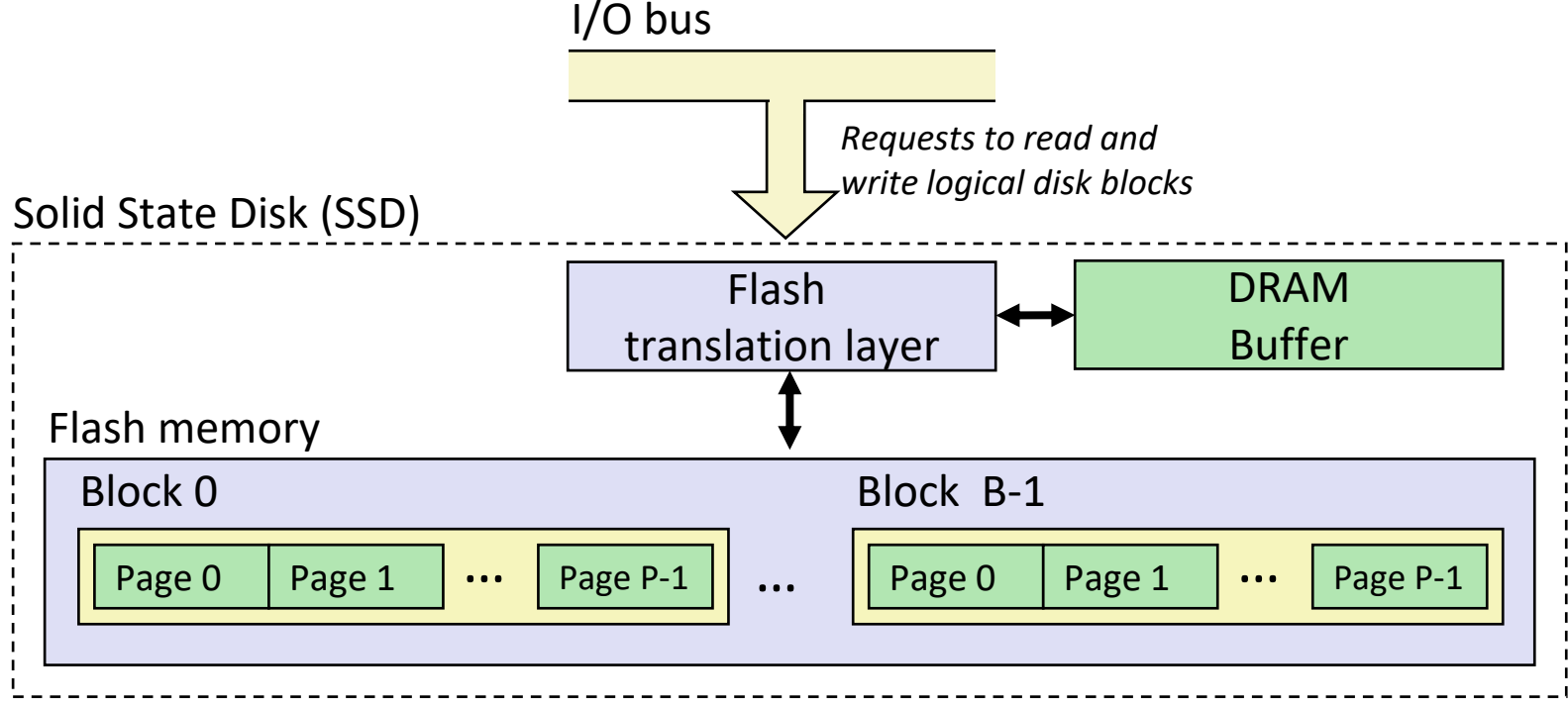
...

Page 0

Page 1

...

Page P-1



Example Memory Hierarchy



Smaller,
faster,
and
costlier
(per byte)
storage
devices



Larger,
slower,
and
cheaper
(per byte)
storage
devices

L0:

Regs

CPU registers hold words retrieved from the L1 cache.

L1:

L1 cache
(SRAM)

L1 cache holds cache lines retrieved from the L2 cache.

L2:

L2 cache
(SRAM)

L2 cache holds cache lines retrieved from L3 cache.

L3:

L3 cache
(SRAM)

L3 cache holds cache lines retrieved from main memory.

L4:

Main memory
(DRAM)

retrieved from local disks.

L5:

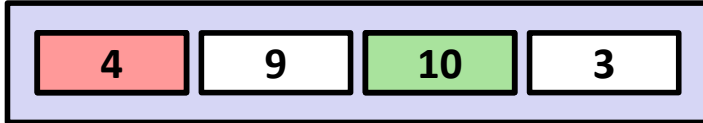
Local secondary storage
(local disks)

Local disks hold files retrieved from disks on remote servers.

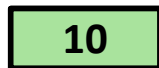
L6:

Remote secondary storage
(e.g., Web servers)

Cache

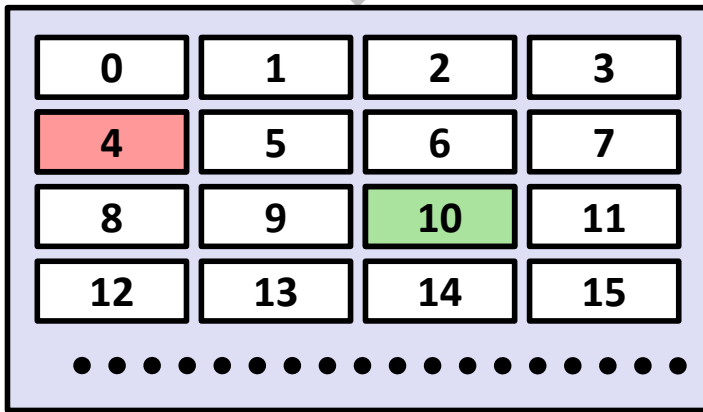


Smaller, faster, more expensive
memory caches a subset of
the blocks



Data is copied in block-sized
transfer units

Memory



Larger, slower, cheaper memory
viewed as partitioned into “blocks”

