CSE 120 Discussion

Final Review

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03/13/2015

Announcements

- Final: Saturday, March 14
  - Tomorrow!!
  - 8:00am-11:00am
  - Peterson Hall 108
  - #2 pencil
- Sample Final on Piazza
- PLEASE fill out CAPEs !
  - To fill out the form, go to cape.ucsd.edu and click on "Fill Out Evals" on the right side of the screen.

Final Exam

- The same pattern as Midterm
  - 40~60 Multiple Choice

- It will focus much more on post-midterm material than pre-midterm (like twice as much).

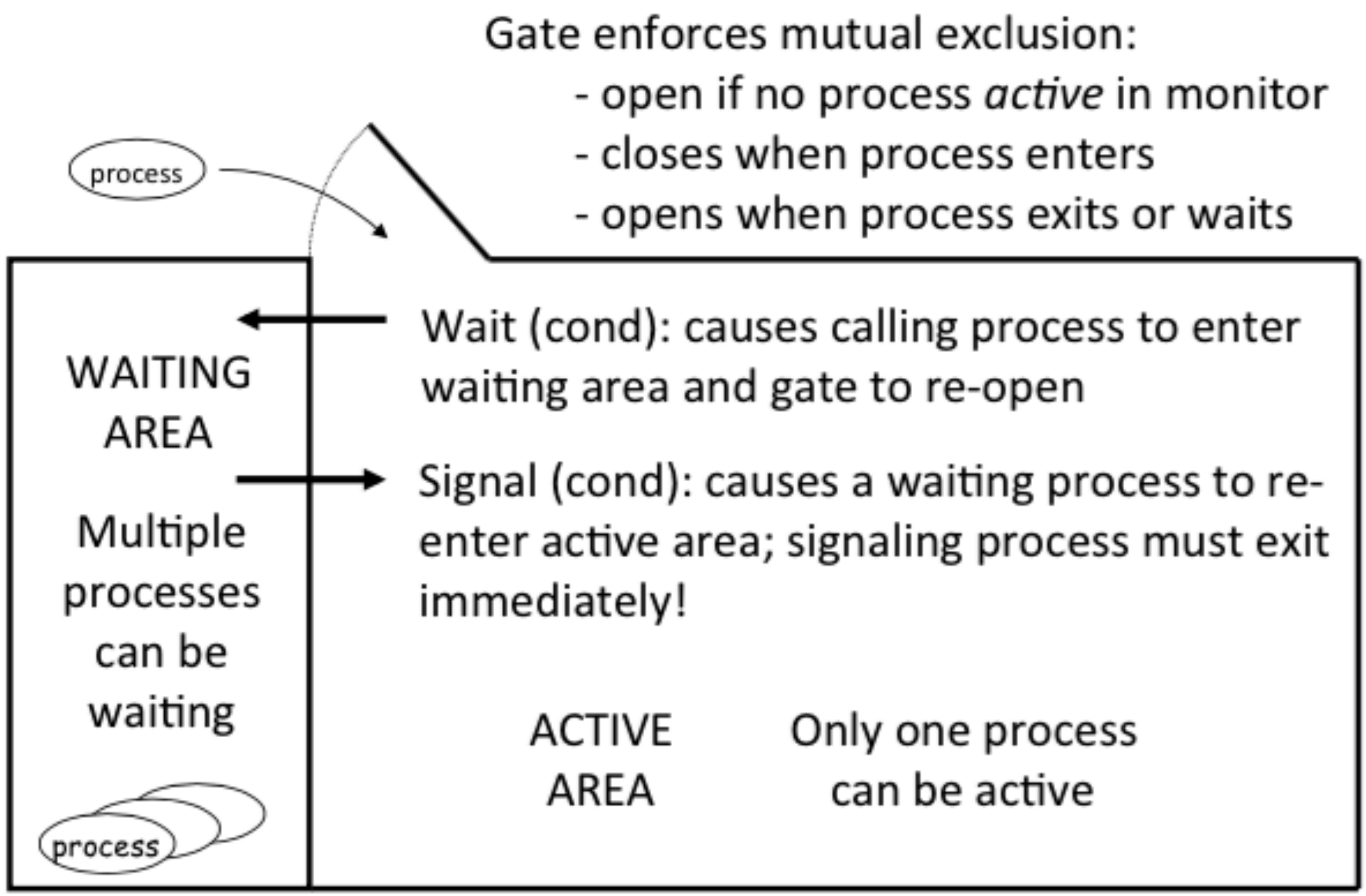
- Projects: PA3 and PA4 (with possibly a few on PA1 and PA2, but mostly the latter PAs).

Pre-Midterm

- Processes
  - What is a process?
  - Scheduling
  - Synchronization
  - Inter-process communication
  - Deadlock

Lecture 6. slide 14

How Synchronization Works



What will happen on the door if calling Signal(cond) by a process that is inside the monitor? The door will keep close!

Issues with Monitors

- Given P_1 waiting on condition c, P_2 signals c
  - P_1 and P_2 able to run: breaks mutual exclusion
  - One solution: Signal just before returning
- Condition variables have no memory
  - Signal without someone waiting does nothing
  - Signal is “lost” (no memory, no future effect)
- Monitors bring structure to IPC
  - Localizes critical sections and synchronization

Memory

- Memory management

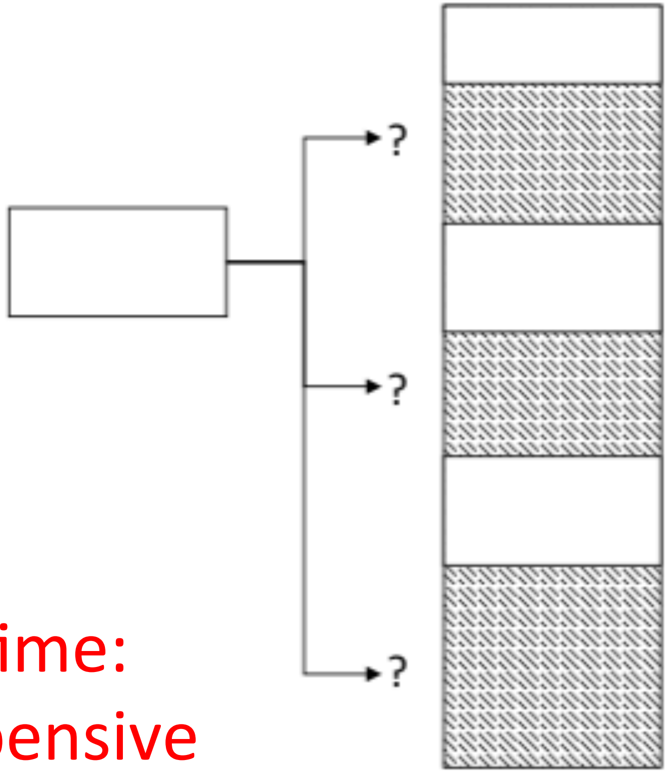
- Logical vs. Physical vs. Virtual
  - Logical Memory: What we'd like them to be
    - Segmentation and paging
  - Physical Memory: What real memory
    - Frame
  - Virtual Memory: Illusion of larger memory to support multi-programming
    - Page replacement algorithms

Memory management

- A program has to be in physical memory for it to run.
- But, since we have multiple processes running, which create and delete lot of data, *the compiler has no idea which part of physical memory is free.*
- Thus compiler generates a logical (virtual address space) for the process from 0 to N-1.

Selecting the Best Hole

- If there are multiple holes, which to select?
- Algorithms
  - First (or next) fit In PA4
  - Best fit
  - Worst fit
- So which is best?



Consider tradeoff: fit vs. search time:
Memory is cheap and time is expensive
→ Waste memory to get speed

Lecture 8. slide 21

50% Rule

- The 50% rule formula: m = n/2
  - What m is? The number of **holes**
  - What n is? The number of **allocated blocks**

- That this is *average* behavior, and not absolutely true
  - Is it possible that there can be 100 blocks and 99 holes?
    - Yes.
  - Is it also possible that there are 100 blocks and 0 holes?
    - Yes. BUT, on average, if there are 100 blocks, there will be 50 holes.

Unused Memory Rule

- $f = k/(k+2)$
  - $k = h/b$, ratio of average block-to-hole size
    - h: average size of holes
    - b: average size of allocated blocks
  - f is fraction space lost to holes

- What does it mean for k to be small, << 1 (avg block size is much larger than avg hole size)

  → f -> 0, which means no space lost to holes

- What does it mean for k to be large, >> 1 (avg block size is much smaller than avg hole size)

  → f -> 1, which means all space lost to holes

- These are *average* values

Buddy System

- Which of the following would ***not*** be a valid chunk size in the buddy system?
  A. 1MB
  B. 2MB
  C. 3MB
  D. 16MB
  Ans: C. Partition into power of 2 size chunks

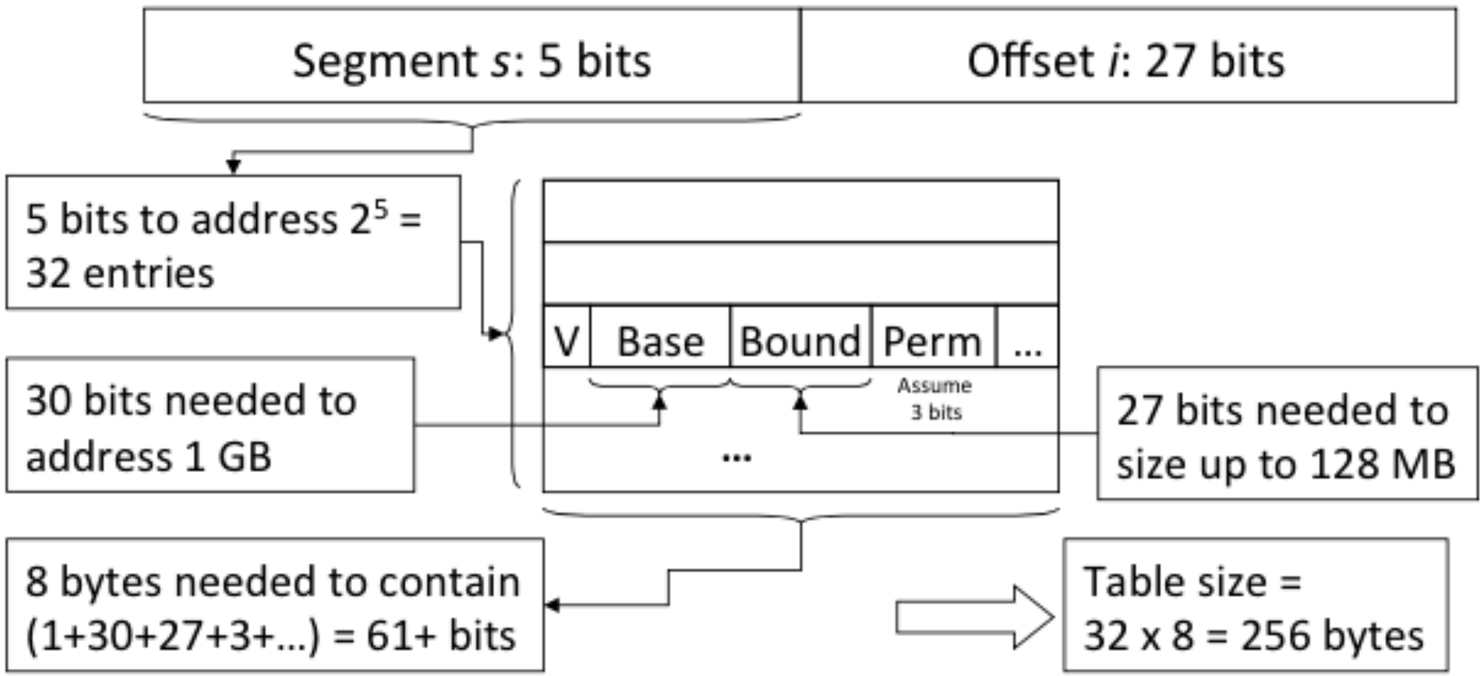
- Which data structure is used to represent the buddy system?
  – Binary tree

Lecture 8. slide 42

Segmentation and Paging

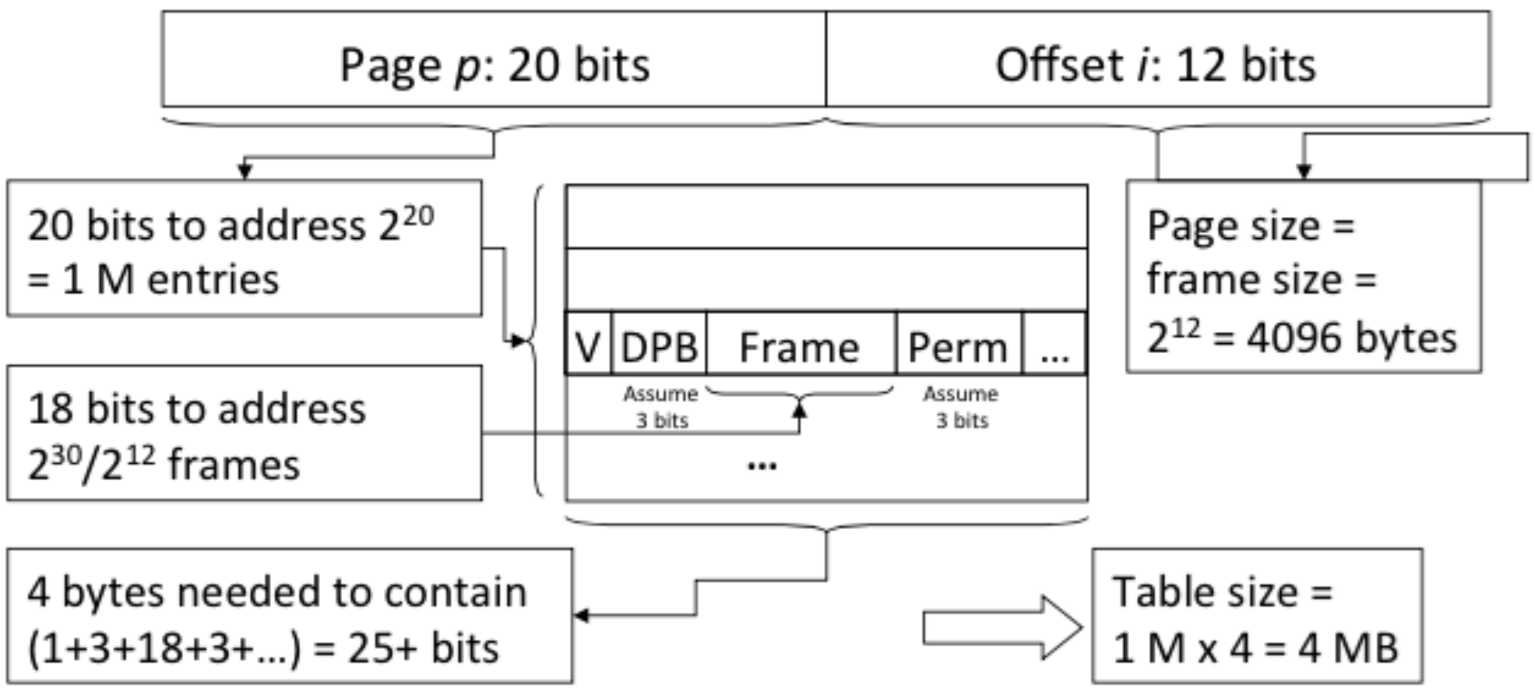
- Segments–Variable sized unit of memory
  – text, data, stack
- Pages–Fixed sized unit of memory access
- Which causes internal fragmentation, and which approach would cause external fragmentation?
  – Segmentation: External fragmentation
  – Paging: Internal fragmentation

Example of Sizing the Segment Table



- Given 32 bit logical, 1 GB physical memory (max)
  - 5 bit segment number, 27 bit offset

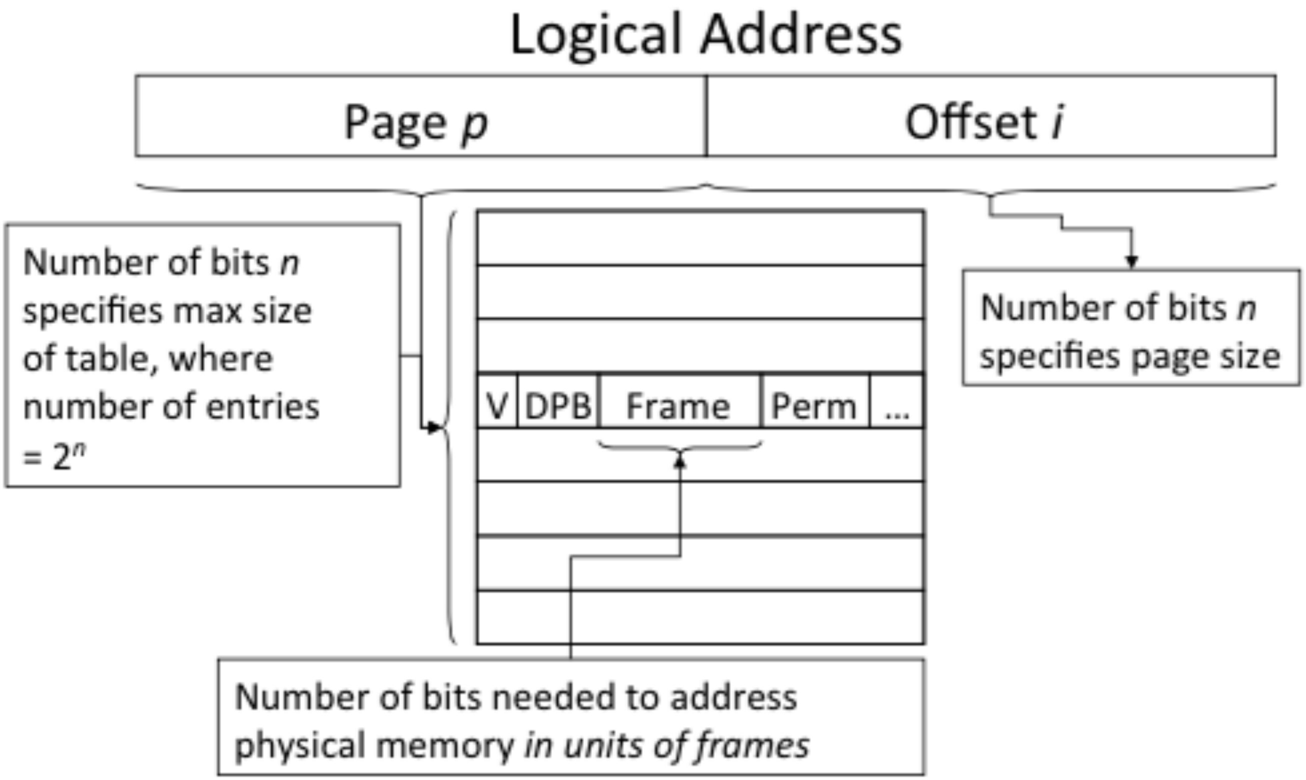
Example of Sizing the Page Table



- Given 32 bit logical, 1 GB physical memory (max)
  - 20 bit page number, 12 bit offset

- Given a 32 bit logical address, page size of 4 KB, 4 GB physical memory:
- what is the size of each entry in the page table?
- What is the total size of the page table?

Sizing the Page Table



Solution:

- Offset: # of bits to represent a page
  - Page size is 4KB → offset i = 12 bits (4KB = 2^{12})
  - Page p + offset i = logical address size
    - → Page p = 20 bits

- Frame bits = PM size/ Frame size

  Frame size = Page size

  → Frame bits = 20 bits, for 4GB/4KB = $2^{32}/2^{12}=2^{20}$

- For **each** entry of the page table, we need:

  1(V)+3(DPB)+ 20(frame)+3(permission) = 27 bits

  → 4 bytes needed for each entry.

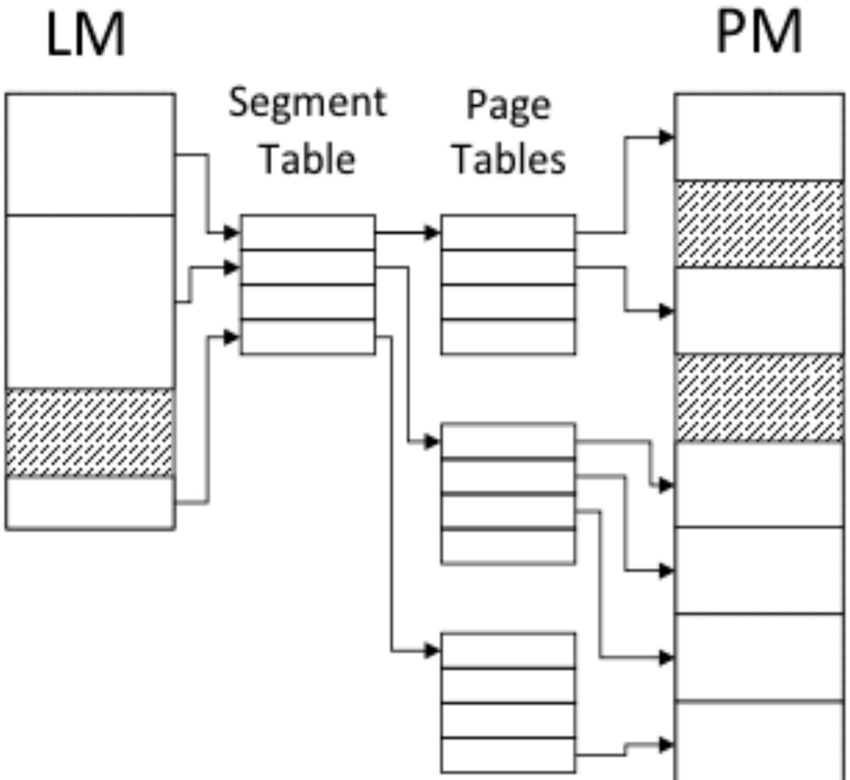
  (convert it into an integer in bytes)

- For the total size of the page table = each entry * # of entries
- # of entries = $2^{\text{page p}}$ = 2^{20}

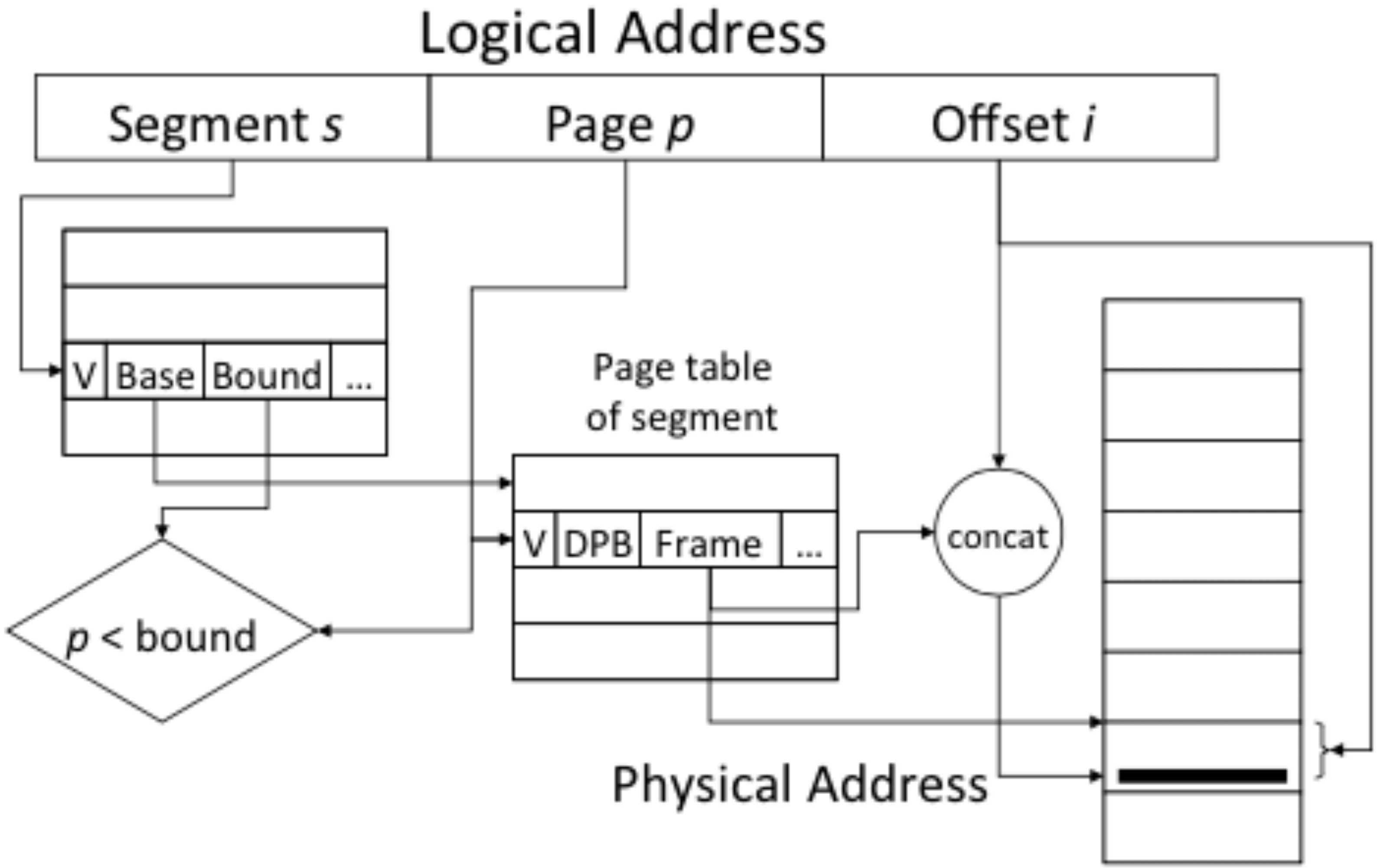
  → 4 * 2^{20} = 4MB

Combining Segments and Pages

- Logical memory composed of segments
- Each segment composed of a set of pages
- Segment table: maps each segment *s* to a page table
- Page tables (like before)



Segment/Page Address Translation



Practice Final #7

TLB – Translation look aside buffer

- Used for logical to physical address lookup on chip.
  - To speed up the translation, a TLB is a separate piece of **hardware** that is used and operates in **parallel** (and works with either paging or segmentation).

- Should be really fast.

- A TLB is normally implemented as a small fully associative cache.

Virtual memory

- Pages are stored on disk by default, and brought into physical memory only when needed.

- This gives us opportunity to allow pages from multiple process to be in physical memory

- Page Fault means page not present in physical memory, and we need to get is from the disk.
  - If valid bit is off, page fault
  - Trap into kernel

Lecture 10, slide 6

Sample Contents of Page Table Entry

Valid	Ref	Mod	Frame number	Prot: rwx

- What will be (V, R, M) bits in case of a memory read of the page?
  - (1, 1, 0)
- Is (1, 0 , 1) a valid combination?
  - No
- Is (0, 1, 1) a valid combination?
  - No

Page Replacement Algorithm

- 1. FIFO
- 2. OPT
- 3. LRU
- 4. Clock Algorithm:
  - Who set the reference bit to 0?
    - OS
  - Who set the reference bit to 1?
    - Hardware

Denning's Working Set Model

- The working set W(t, D), which of following is ***not*** correct?
- A. The set of pages referenced during the last D time units
- B. Working set is a local replacement policy
- C. Compare to Clock, it is easier to implement

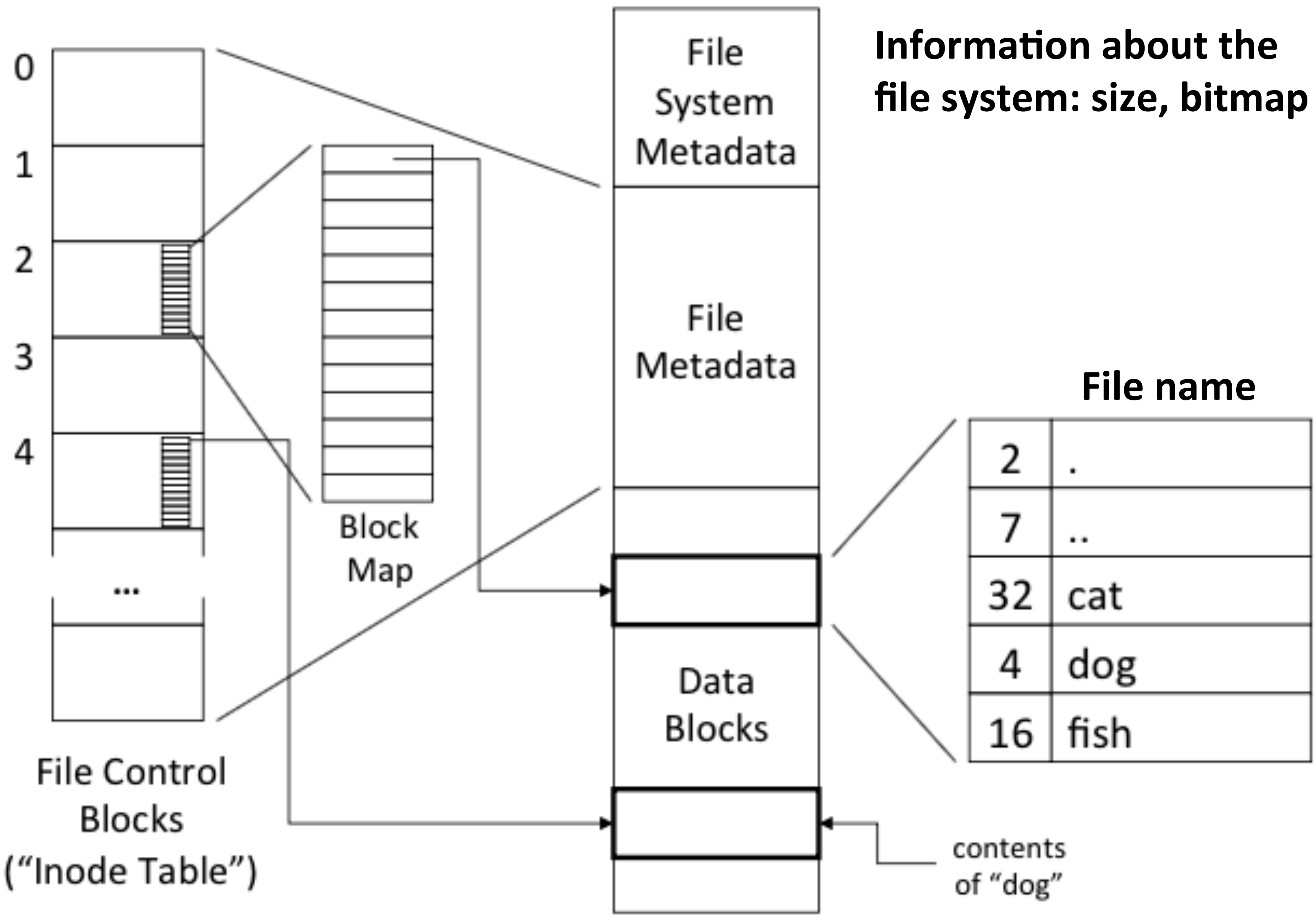
- Ans: C.
- It is difficult to implement. Must timestamp pages in working set, and must determine if timestamp older than t-Δ. Also, how should Δ be determined?

Lecture 11

File Systems

- File system abstraction
- File system structure
- Block allocation and management
- Block cache

The Big Picture



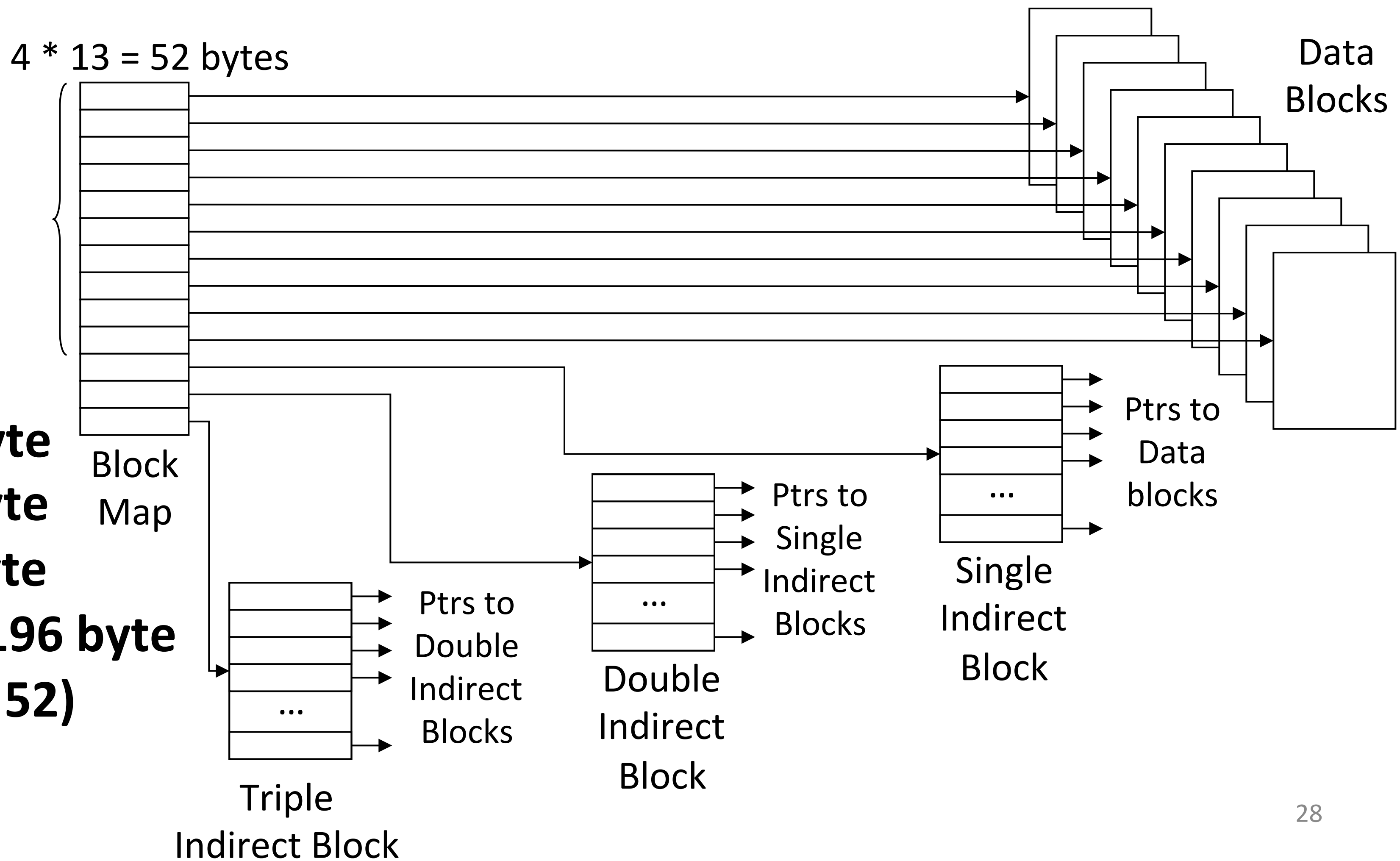
Unix Block Map

- Fixed size
- Part of the file metadata
- Array of pointers to data blocks.
  13 pointers:
  - 10 direct: references 10 data blocks
  - 1 singly-indirect: references N data blocks
  - 1 doubly-indirect: references N^2 data blocks
  - 1 triply-indirect: references N^3 data blocks

(N = Block Size / Pointer Size =1KB/4 Byte = 256)

We want to store a 5 KB file. How many bytes of metadata will we need for our block map?

Assume that Block size: 1 KB (2^{10}) and Pointer size: 4 bytes



A: 20 byte

B: 40 byte

C: 52 byte

D: 262,196 byte (256K + 52)

Answer: C. 52 byte

- A 5 KB file is "broken up" into 5 blocks because each block is of size 1KB. So we need 5 pointers for the 5 blocks.

  →Is A the right answer?

  4 byte *5 = 20 bytes of metadata.

- ***No!***
  - Because you have to initialize **that whole block map(13 pointers)** even if you are only use a part of it. You may think 20 of those bytes of meta data are ACTUALLY being used, **BUT you NEED 52 bytes to represent those 5 blocks.**

We want to store a **100 KB** file. How many bytes of metadata will we need for our block map?

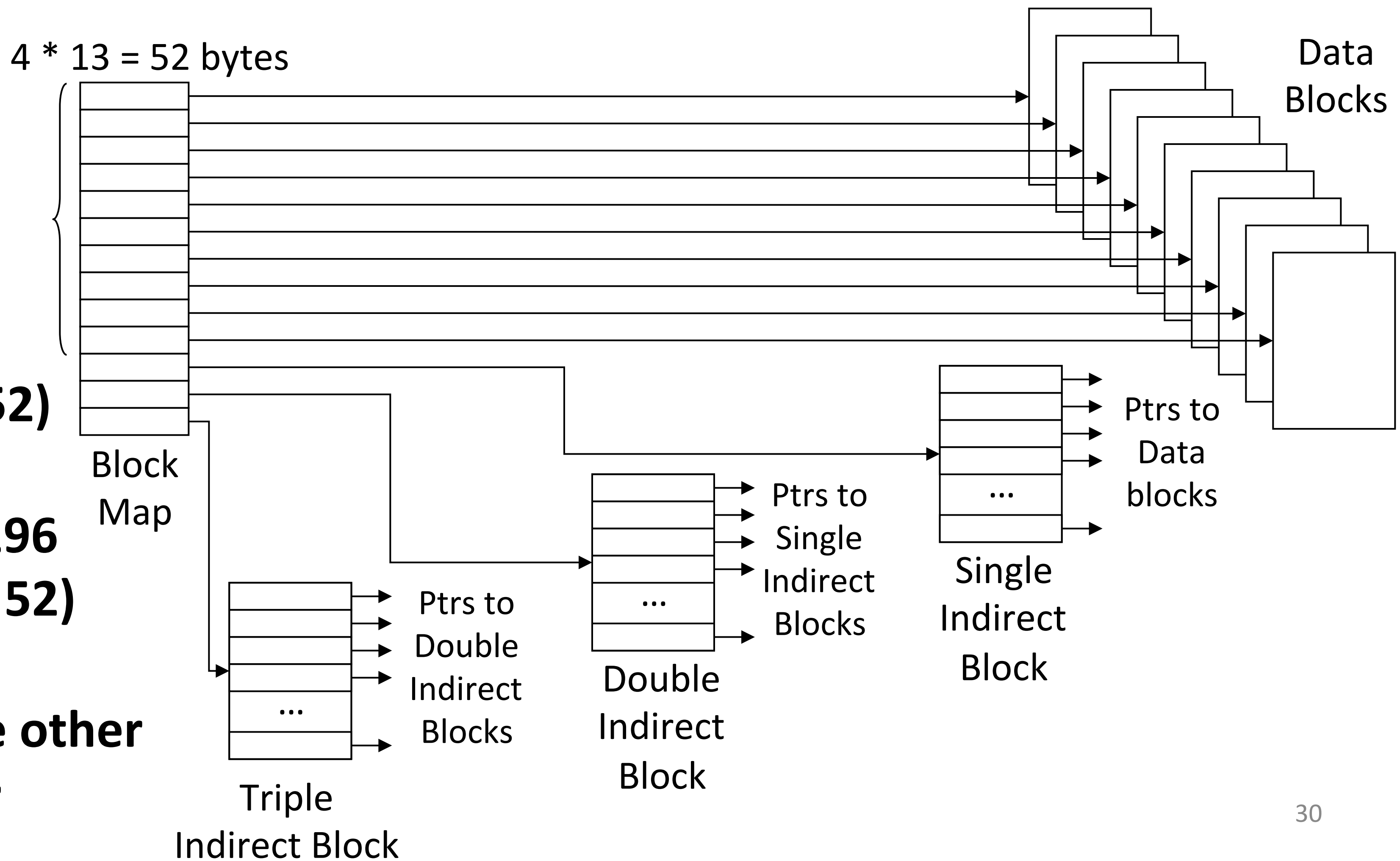
Assume that Block size: 1 KB (2^{10}) and Pointer size: 4 bytes

A: 52

B: 1076 (1KB + 52)

C: 262,196 (256K + 52)

D: some other number



Answer: B. 1KB+52

Assume that Block size: 1 KB (2^{10}) and Pointer size: 4 bytes

- 100 KB file → broken up into 100 data blocks
- We can use the 10 direct pointers to point 10 data blocks

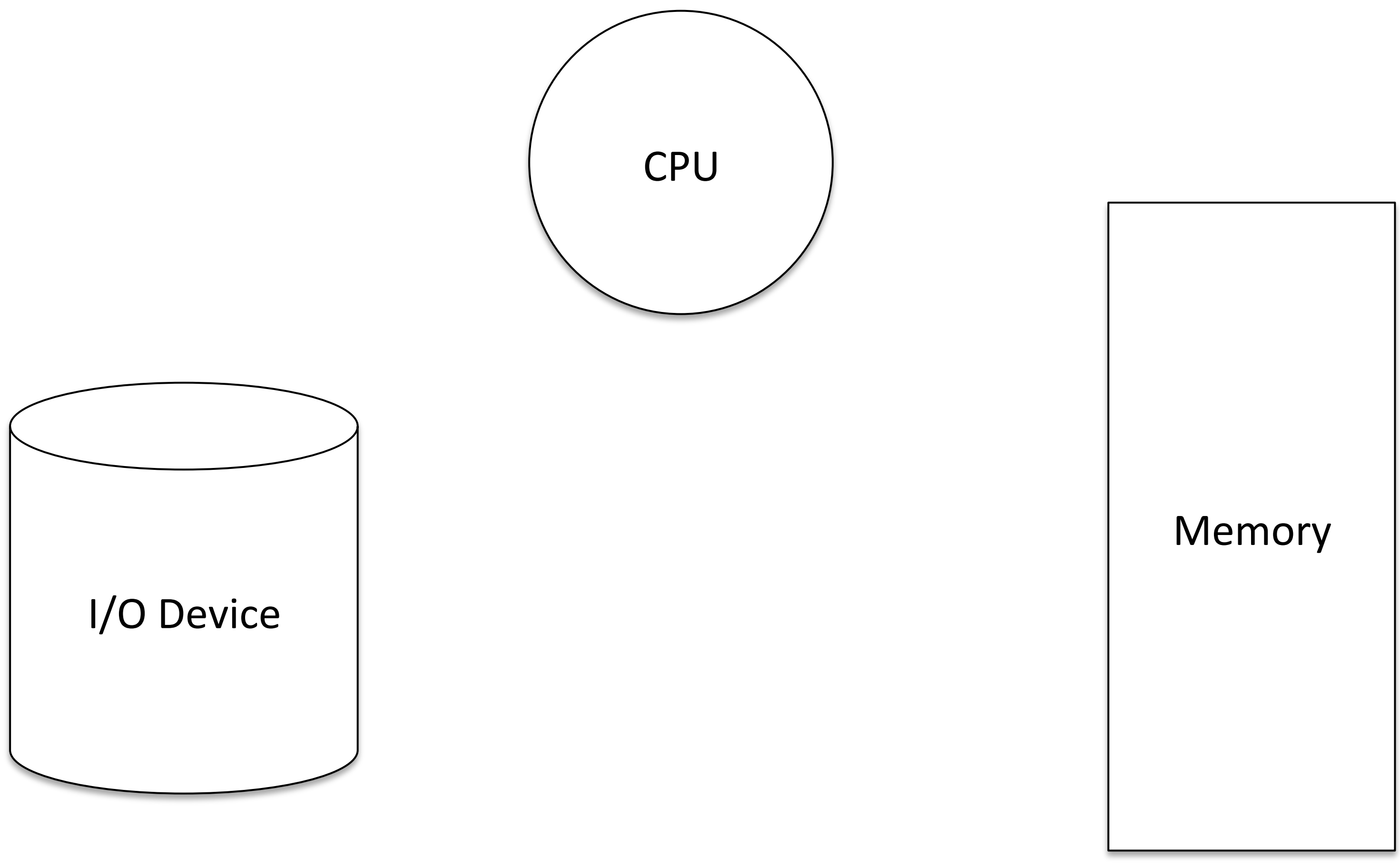
  →but we are still left with 90 unreferenced blocks.
- So we need to use a singly-indirect to references N=256 data blocks. This is enough to hold those 90 pointers.
- 4 byte * 13 (block map) + 1024 byte (first level)

  = 52 byte + 1024 byte = 52 byte +1KB

I/O

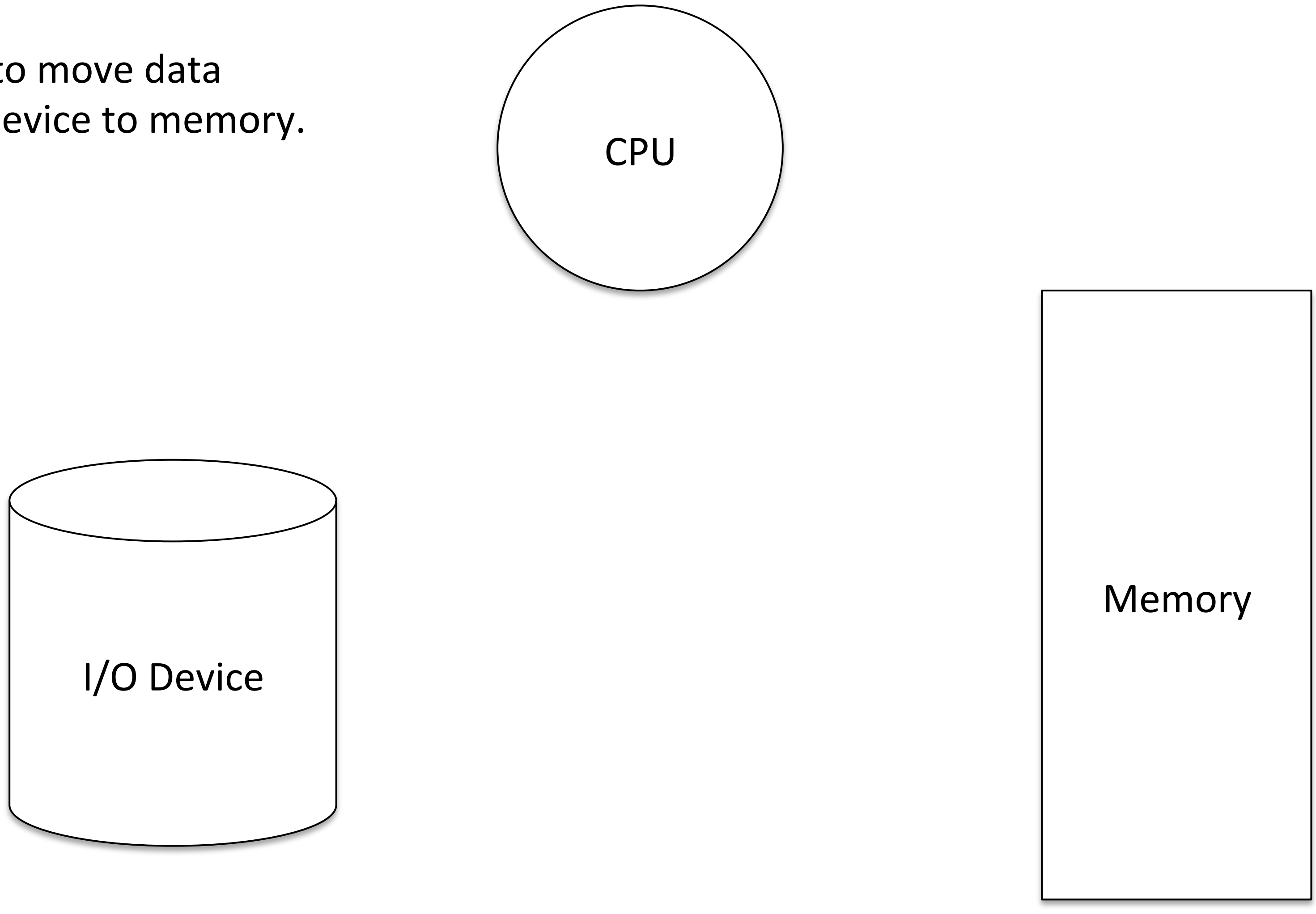
- Structure of I/O system software
  - Functionality of layer
  - Interoperation
- Device drivers
- Buffering
  - Why (and why not) buffer
  - Where to buffer

PIO (programmed IO) vs. DMA (direct memory access)



PIO vs. DMA

Want to move data
from device to memory.



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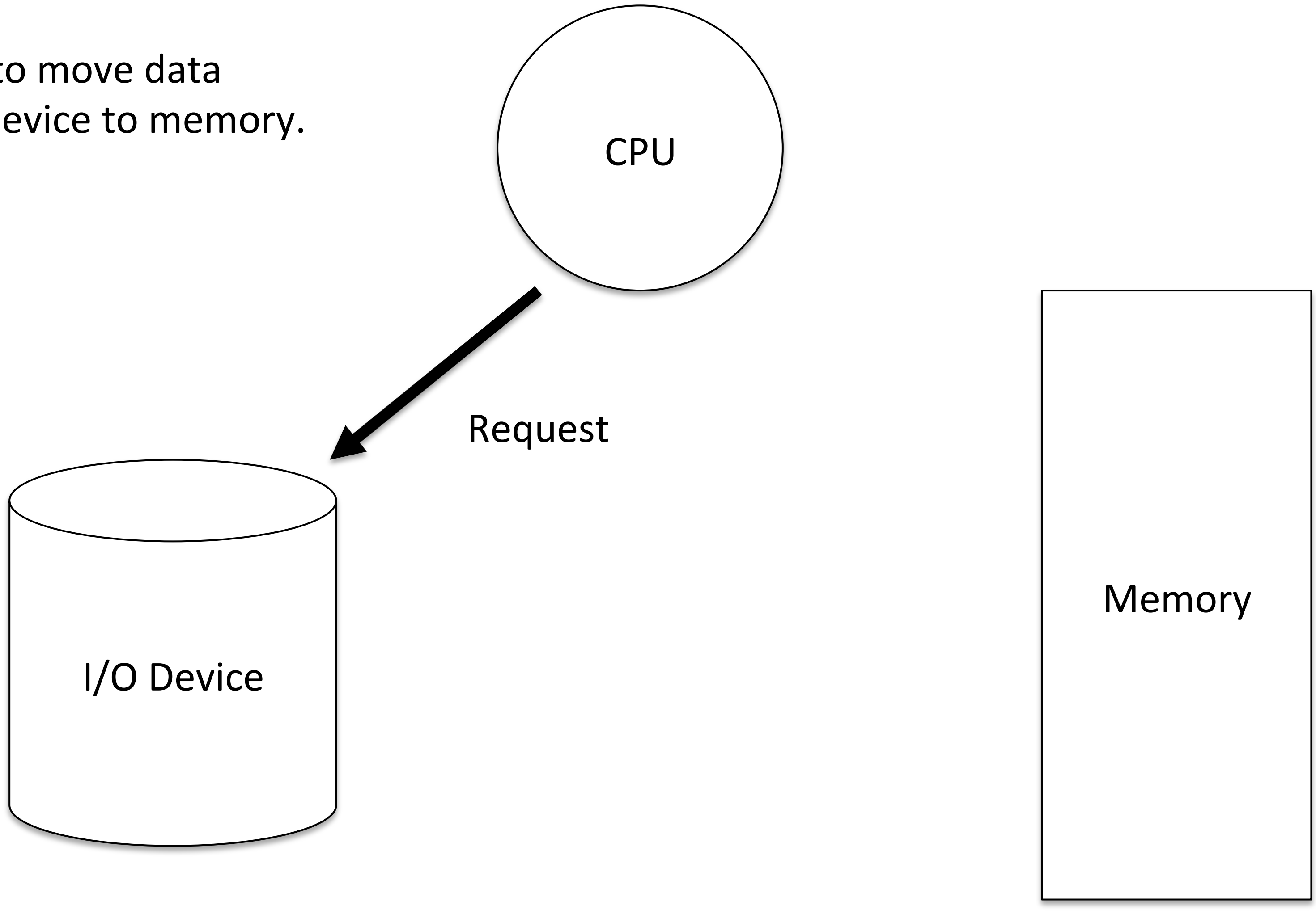

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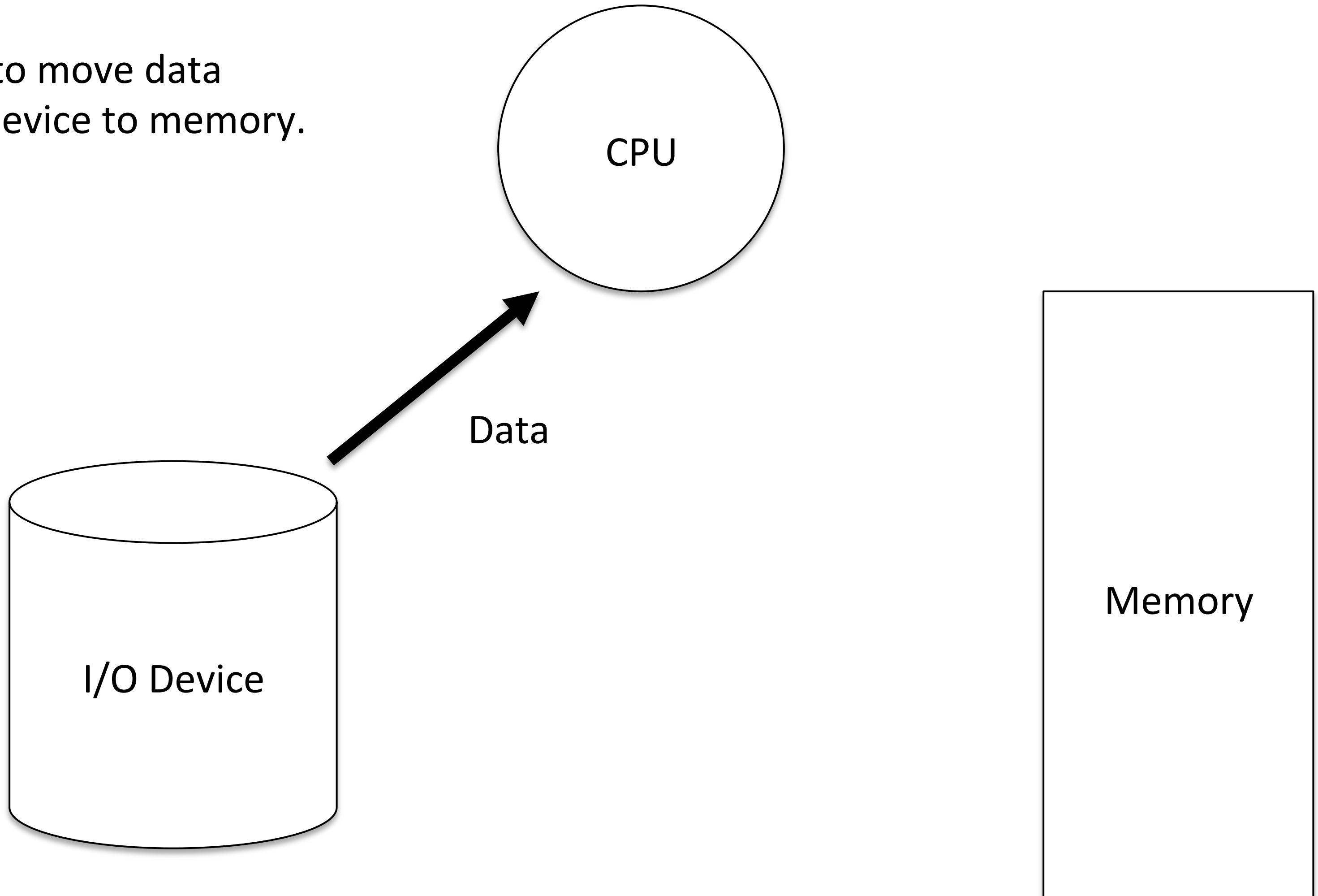

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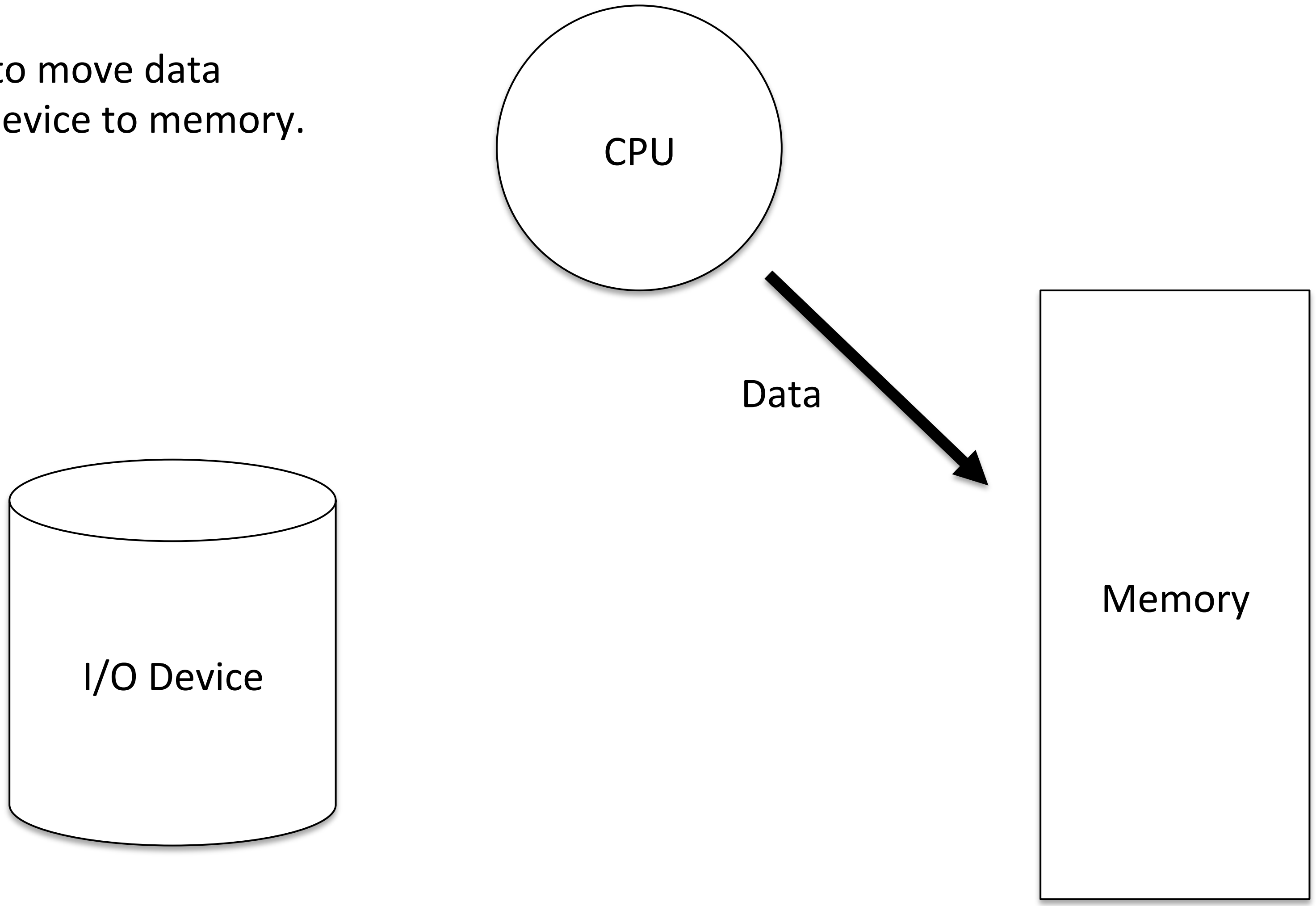

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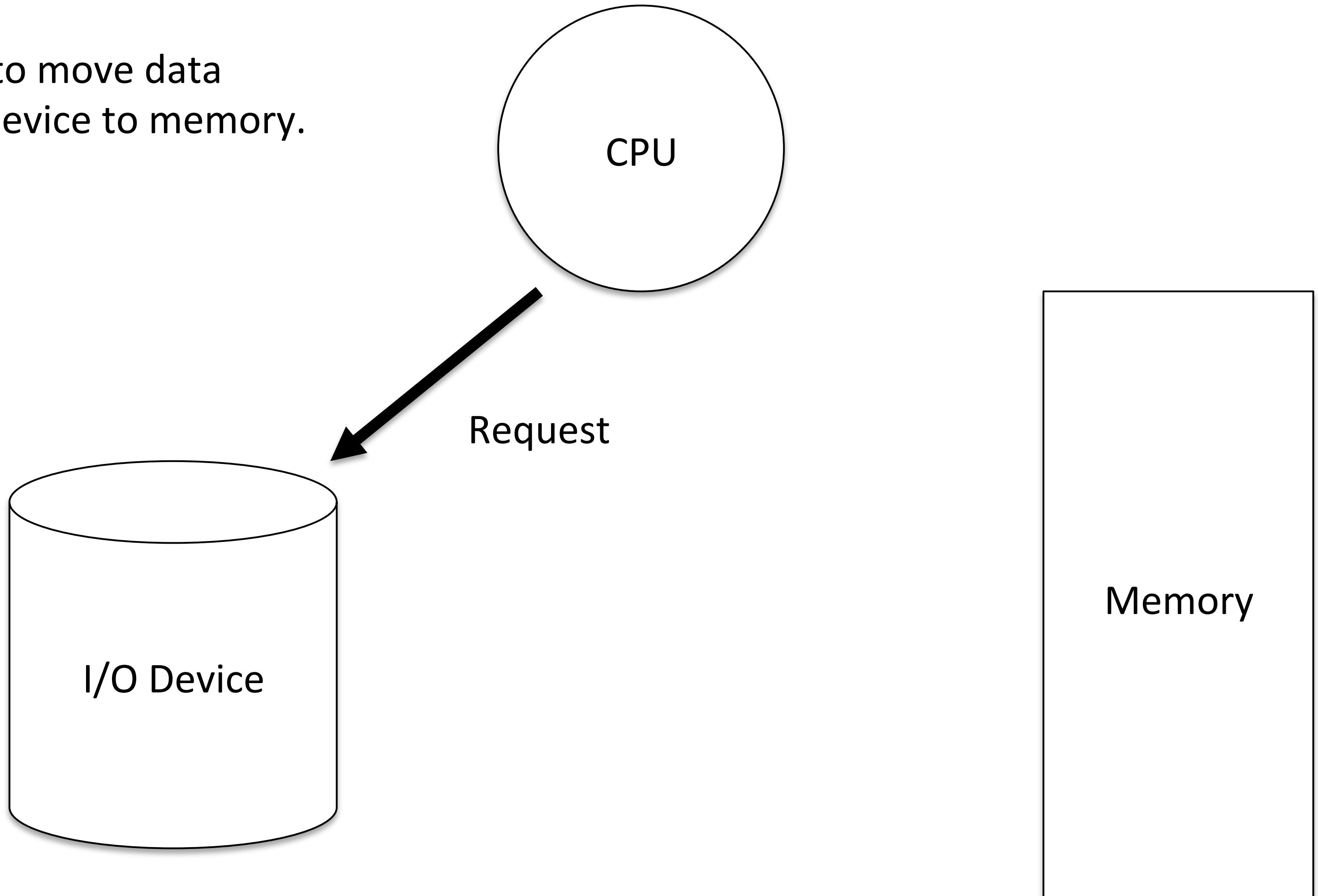

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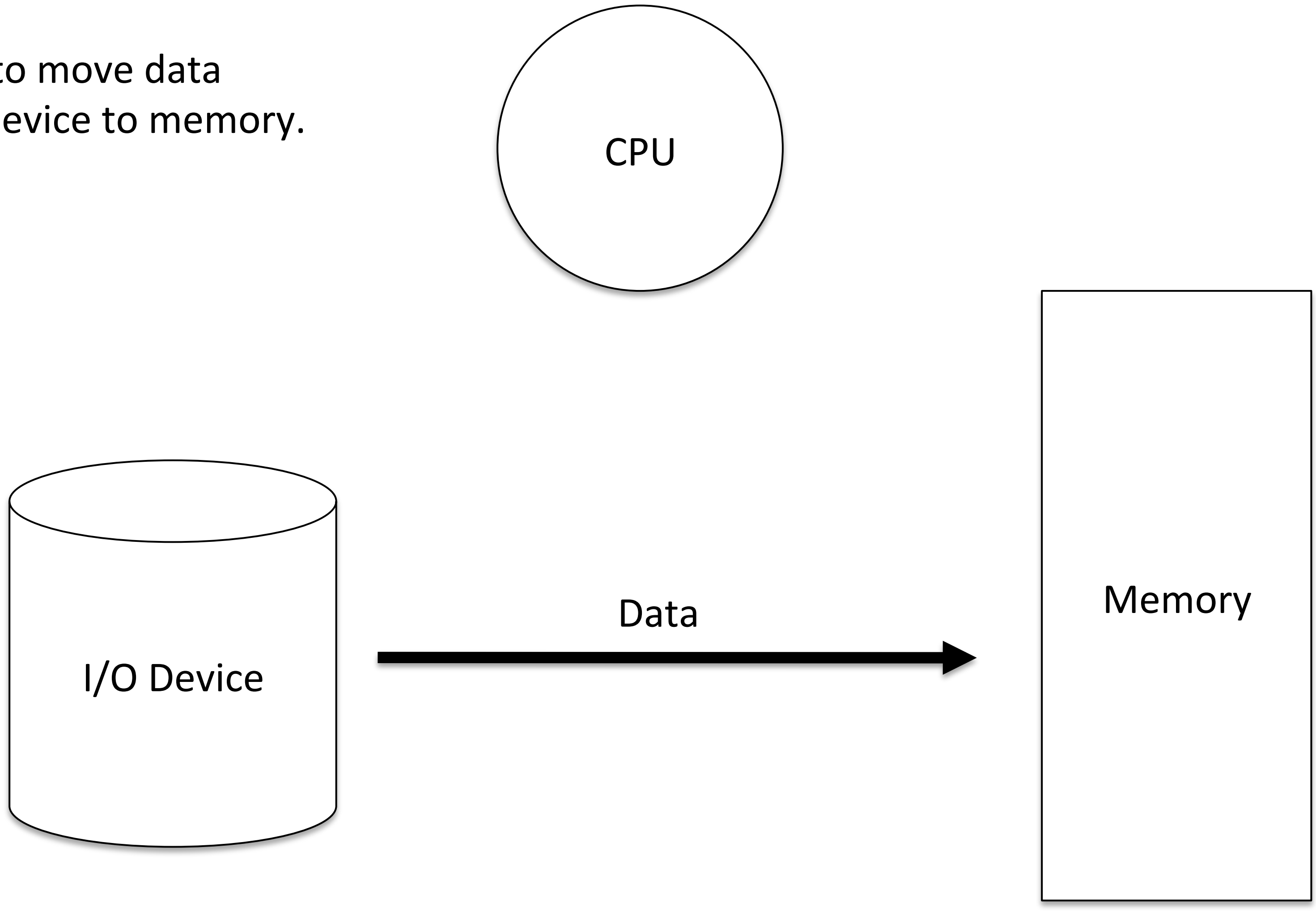
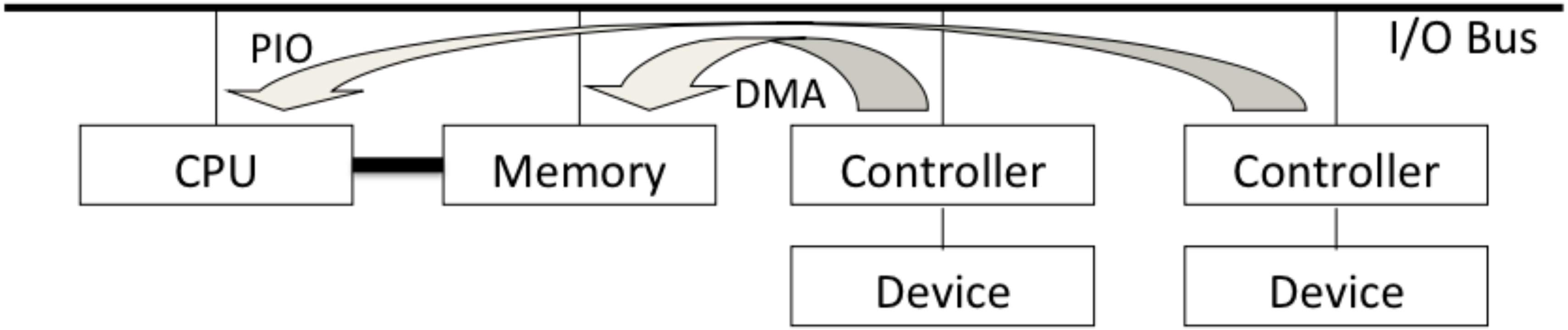




- PIO
  - CPU involved in each byte/word of I/O access
  - If device is slow, CPU will be wasted ---busy waiting
  - Simpler, preferred for low-volume transfers (Keyboard)

- DMA
  - Move data between controller and memory
  - Faster, preferred for large transfers (Disk)

How does OS get data from the IO device

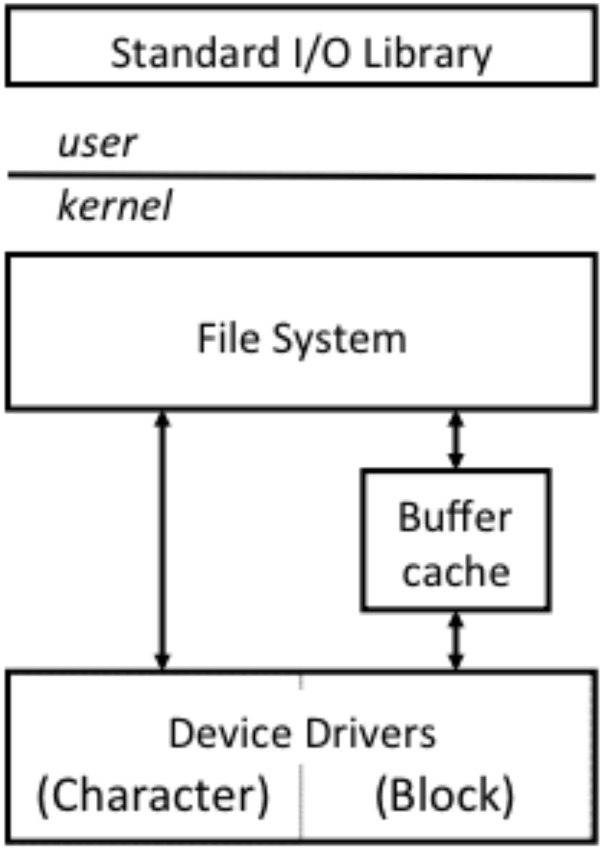
- Two options:
  - Polling: Ask device repeatedly if data is ready
    - Useful when device would be supplying a continuous stream of data
  - Interrupt driven: Device signals data is ready
    - Useful when the input is not continuous

Lecture 12: slide 24

Example: UNIX I/O Model

- Uses file system interface
- stdio.h: C standard I/O library
- Block devices
  - Fixed-size blocks
  - Randomly addressable
  - Uses buffer cache
- Character devices
  - Variable sequence of bytes
  - For non-block devices

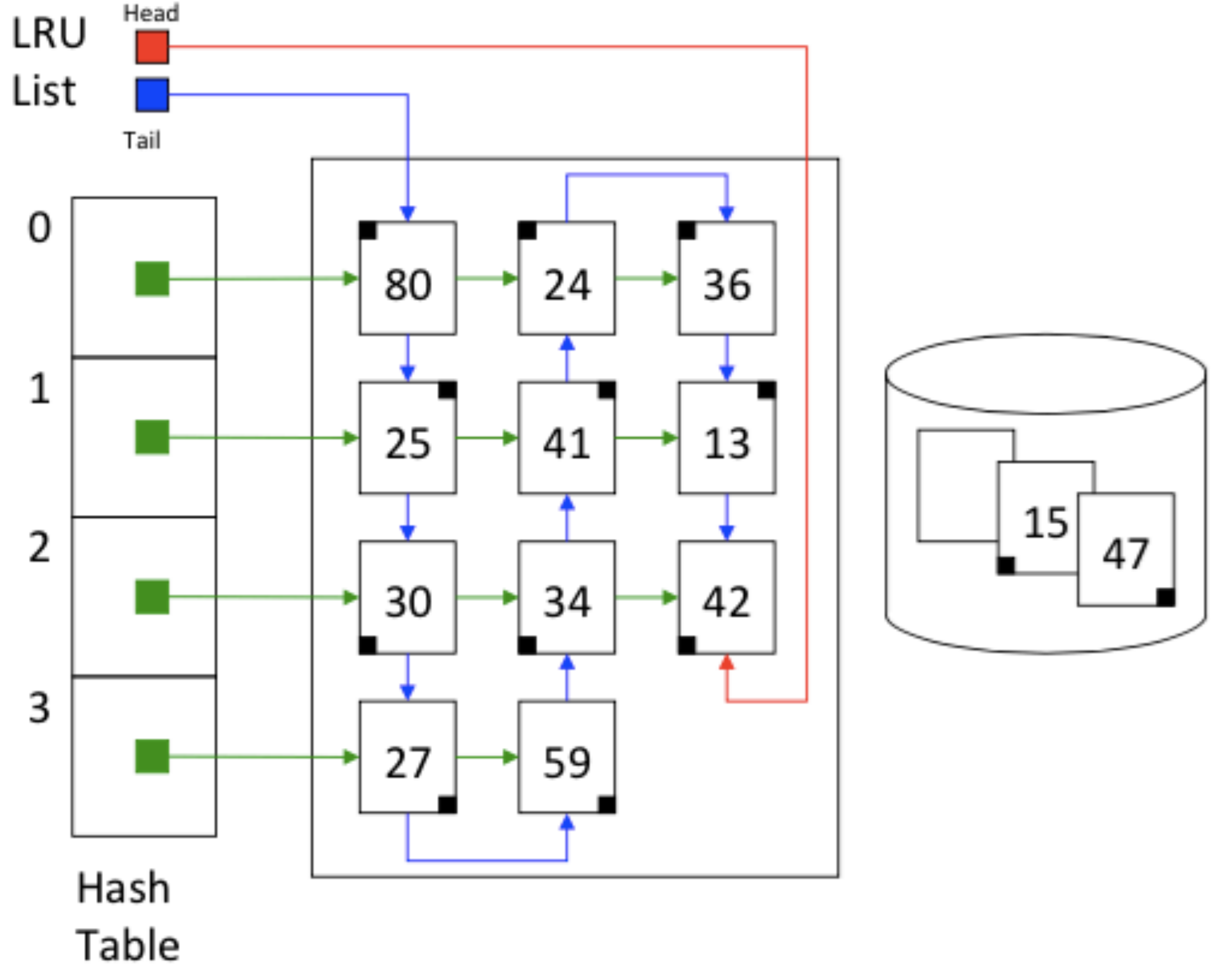
Private buffer keep in user space



Searching the Buffer Cache

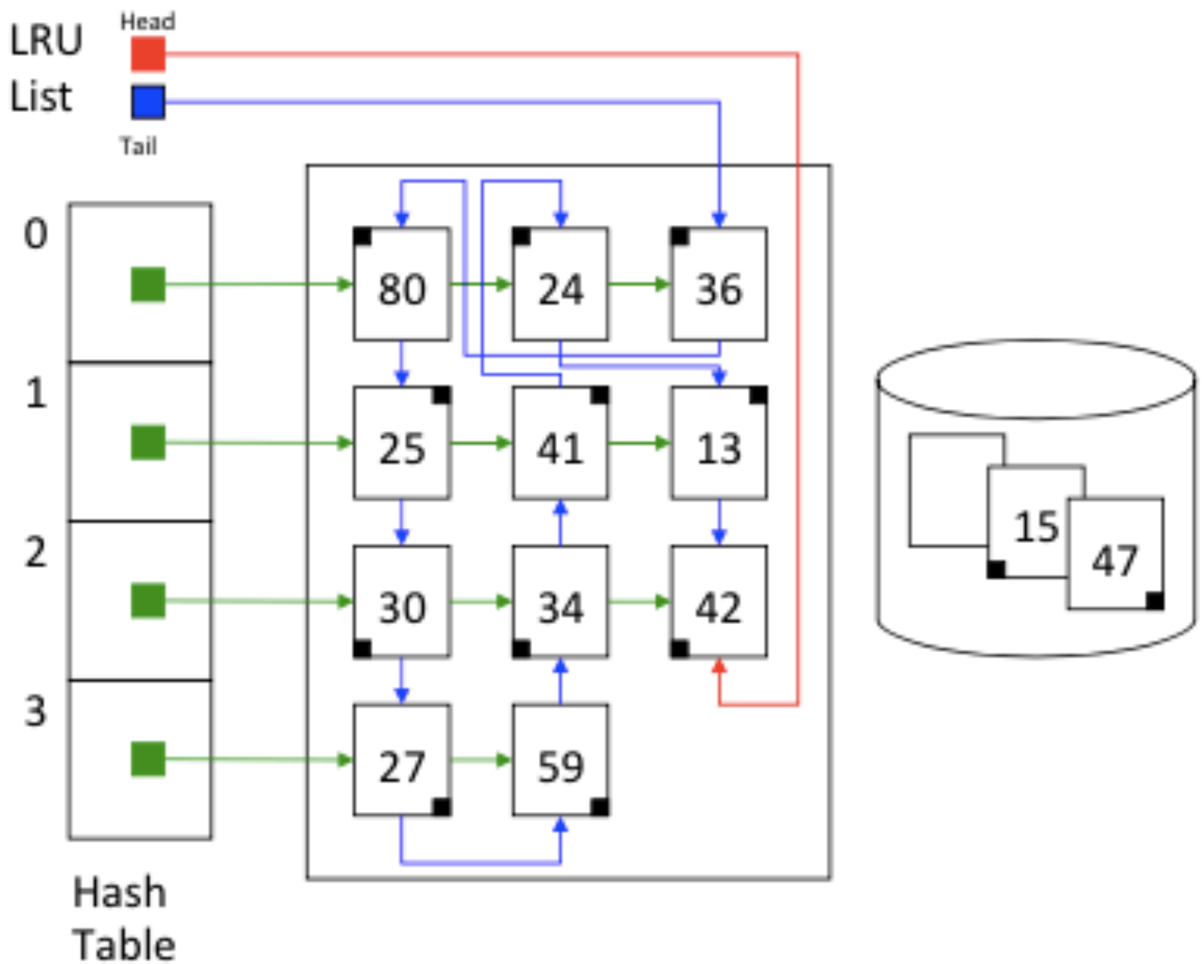
- Read (36)
- 36%4 = 0
- Search list 0 for 36
- Cache hit!

Are we done?



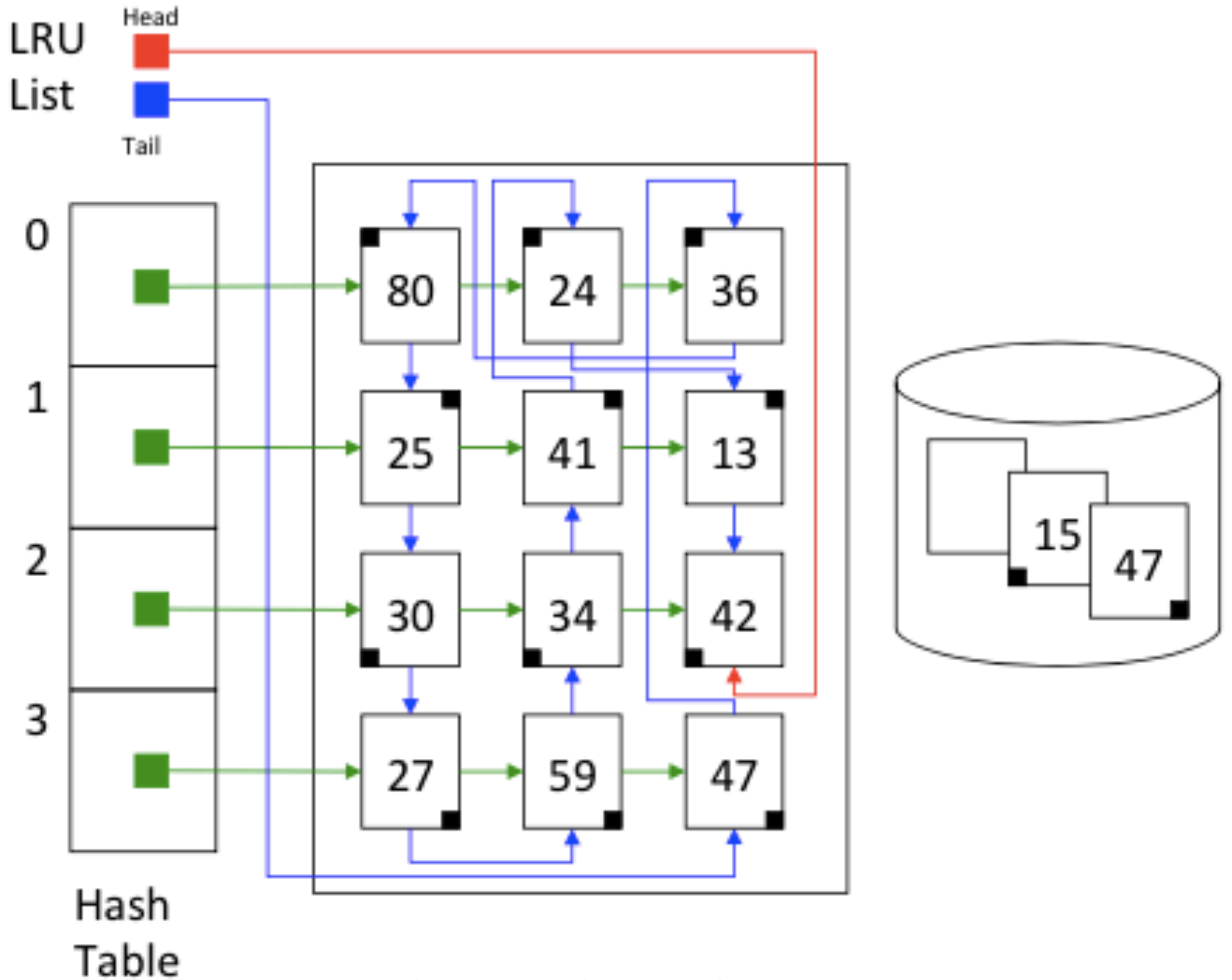
Searching the Buffer Cache

- Read (36)
- 36%4 = 0
- Search list 0 for 36
- Cache hit!
- *Update LRU list*



Searching the Buffer Cache

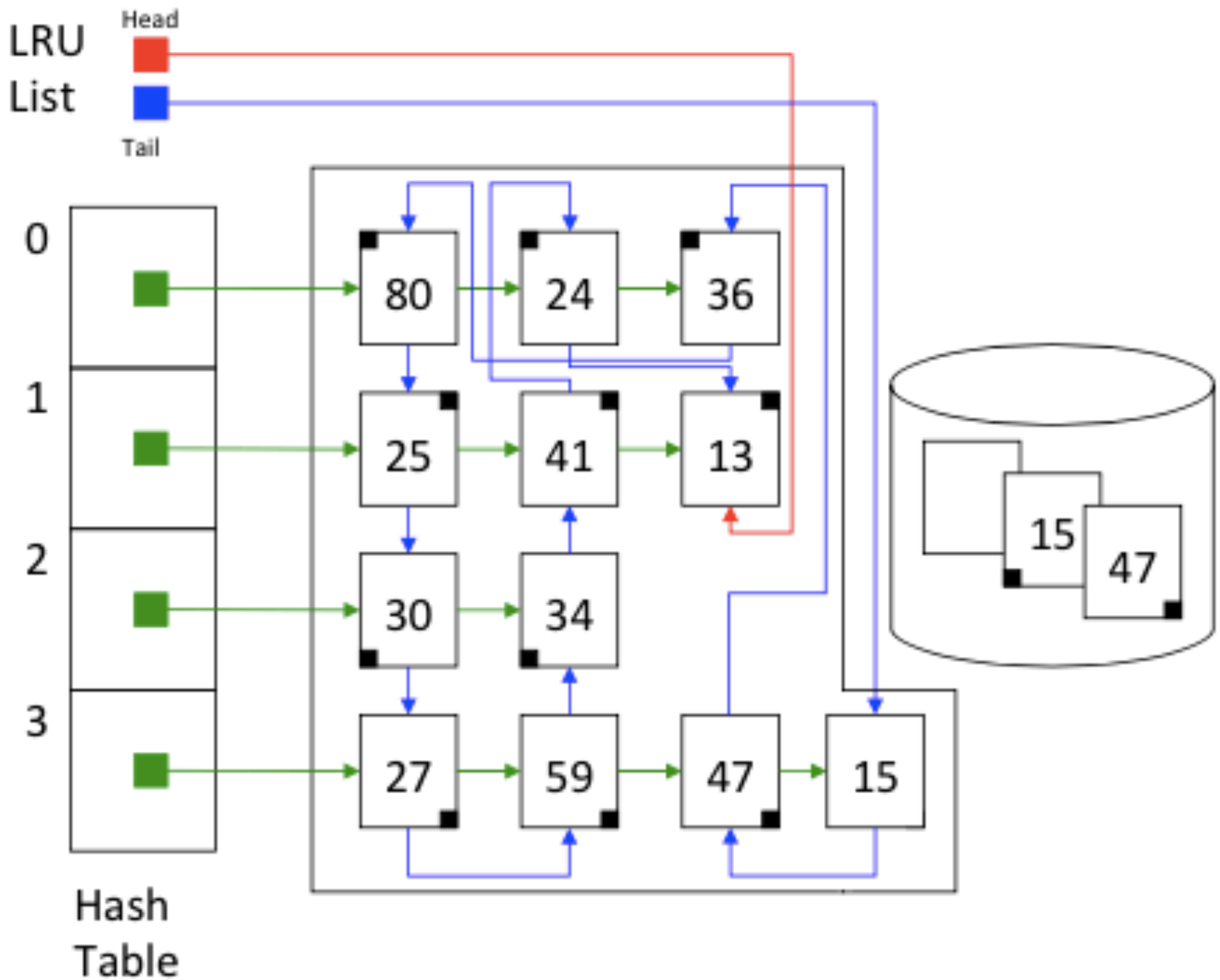
- Read (15)
- 15%4 = 3
- Search list 3 for 15
- Cache miss!



What should we do now?

Searching the Buffer Cache

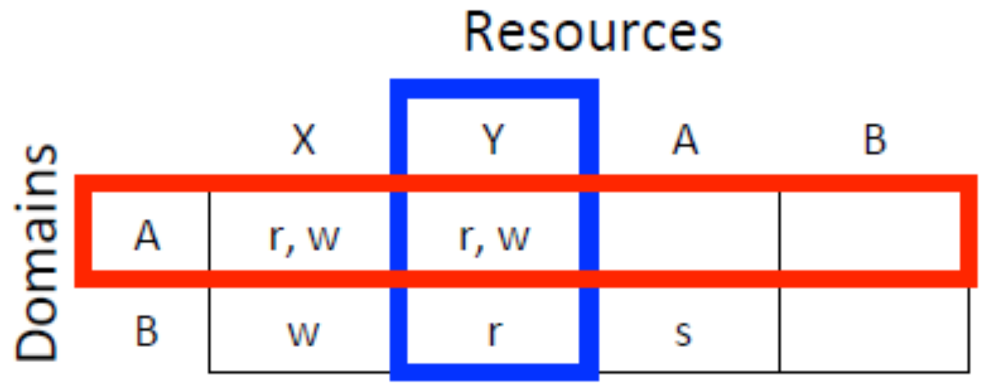
- Read (15)
- 15%4 = 3
- Search list 3 for 15
- Cache miss!
- *Remove 42*
- *Retrieve 15*



- Protection
- Security
- ~~Networks~~
- ~~Distributed Systems~~

Lecture 13: slide 1-25 only

Access Control Lists and Capabilities Lists



- Access Control Lists

  owner/group/world

  – For each resource, list (domain, permissions) pairs
- Capability Lists
  – For each domain, list (resource, permissions) pairs

  X,Y

ACLs vs. Capabilities

- Access control lists (ACLs)
  - Slow lookup
  - Easy to manage (and revoke)
  - The rwx mechanism in Unix
- Capabilities
  - Fast access
  - Hard to manage (revoke)
  - File descriptor returned after a open system call

Public Key vs. Secret Key

- Secret key (symmetric)
  - Same key K is used to encrypt and decrypt
  - Operates fast
  - Difficult to distribute keys

- Public key (asymmetric)
  - Different keys to encrypt and decrypt
  - Time consuming operation
  - Convenient for key distribute

Any question?

GOOD LUCK!