Memory Allocation II

CSE 351 Autumn 2023

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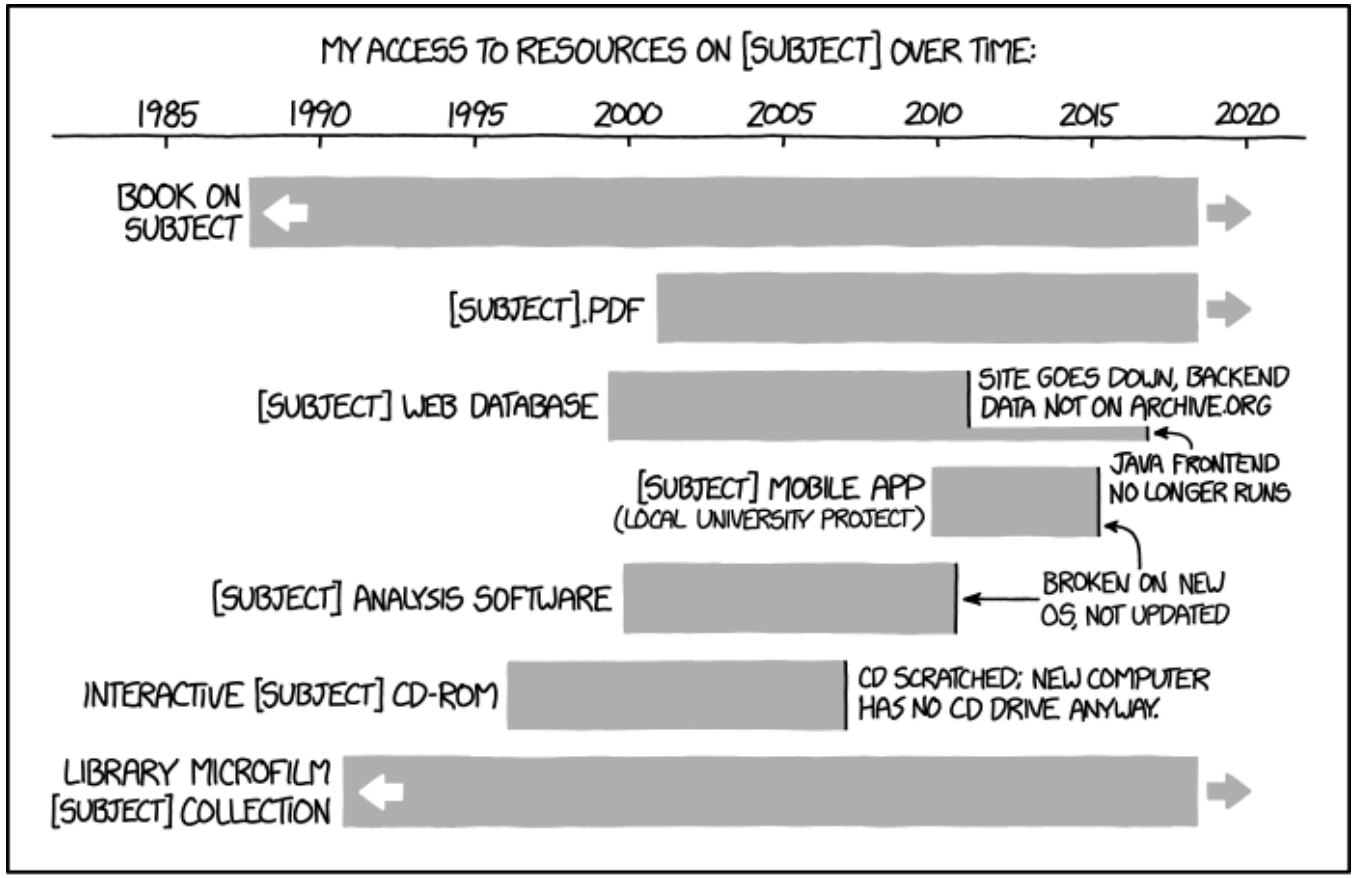


IT'S UNSETTLING TO REALIZE HOW QUICKLY DIGITAL RESOURCES CAN DISAPPEAR WITHOUT ONGOING WORK TO MAINTAIN THEM.

http://xkcd.com/1909/

Relevant Course Information

- HW20 due Monday (11/20)
- HW21 due Friday (11/24)
  - Another double homework, but mostly about Lesson 21 (all but last slide)
  - Probably want to finish by 11/22

- Lab 4 due Monday after Thanksgiving (11/27)
- Lab 5 (Mem Alloc) will be released on Monday (11/20)

Memory Allocation II

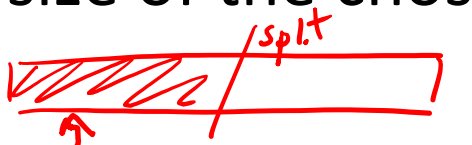
Fulfilling an Allocation Request

1) Compute the necessary block size payload + metadata + padding

2) Search for a suitable free block using the allocator's *allocation strategy*
   - If found, continue
   - If not found, return NULL

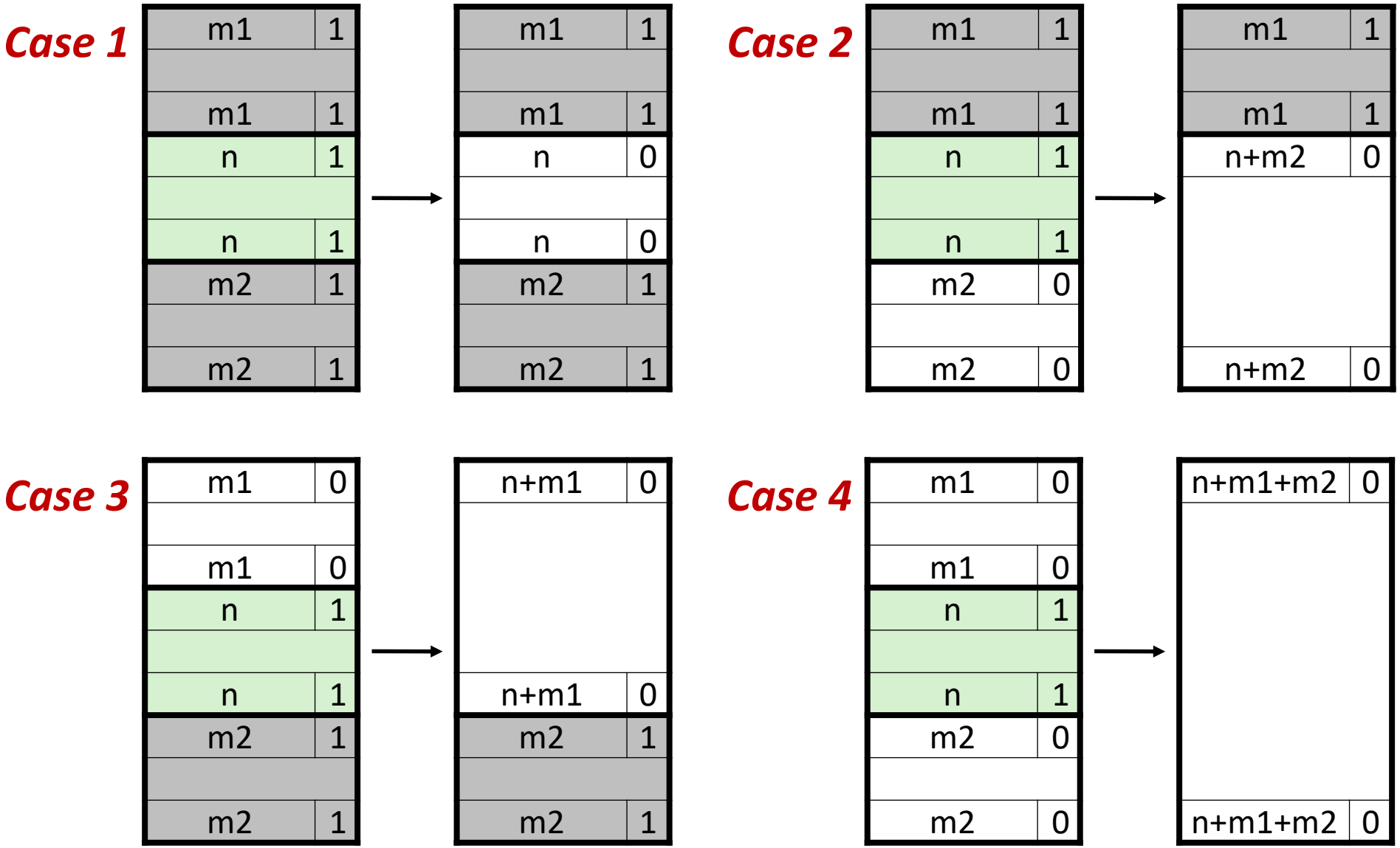
first fit
next fit
best fit

3) Compare the necessary block size against the size of the chosen block
   - If equal, allocate the block
   - If not, *split* off the excess into a new free block before allocating the block

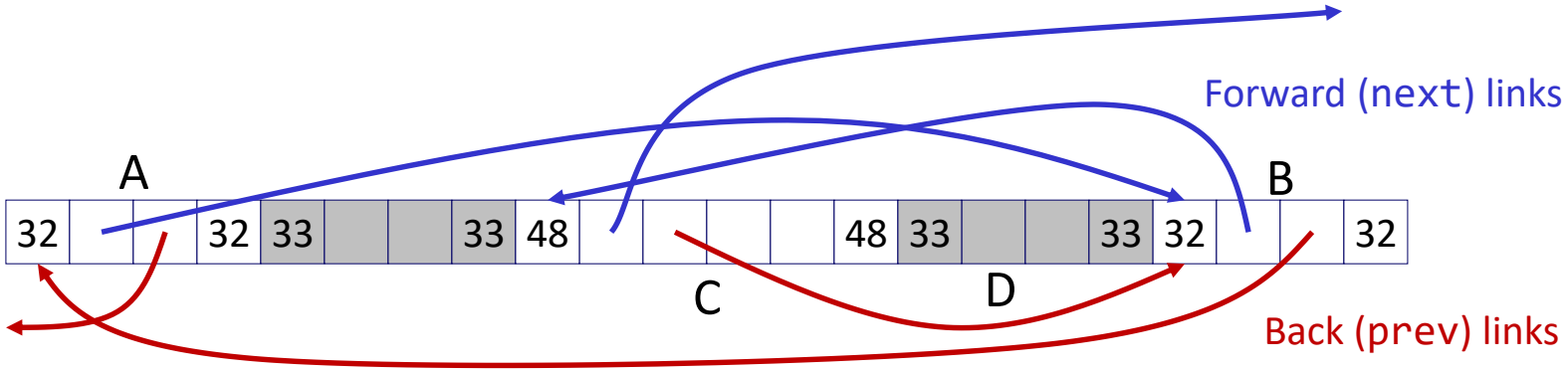


4) Return the address of the beginning of the payload

Deallocation: Constant Time Coalescing



Explicit List Summary



- Comparison with implicit list:
  - Block allocation is linear time in number of free blocks instead of all blocks
    - ***Much faster*** when most of the memory is full
  - Slightly more complicated allocate and free since we need to splice blocks in and out of the list
  - Some extra space for the links (2 extra pointers needed for each free block)
    - Increases minimum block size, leading to more internal fragmentation

Lesson Q&A

- Terminology:
  - Allocation strategies: first fit, next fit, best fit
  - Necessary block size, splitting, minimum block size, coalescing, boundary tags
  - Explicit free list (doubly-linked list)

- Learning Objectives:
  - Evaluate changes to the state of the heap for a sequence of allocations and deallocations.
  - Explain the tradeoffs between different allocator implementations, policies, and strategies.

- What lingering questions do you have from the lesson?

Memory Allocation II – Context

Allocation Policy Tradeoffs

- Data structure of blocks on lists
  - Implicit (free/allocated), explicit (free), segregated (many free lists) – others possible!
  - Metadata (*i.e.*, what tags we use in the boundary tags)
- Placement policy: first-fit, next-fit, best-fit
  - Throughput vs. amount of fragmentation
- When do we split free blocks?
  - How much internal fragmentation are we willing to tolerate?

Memory Allocation II – Practice

Practice Question

- Which allocation strategy and requests removes *external* fragmentation in this Heap? B3 was the last fulfilled request.

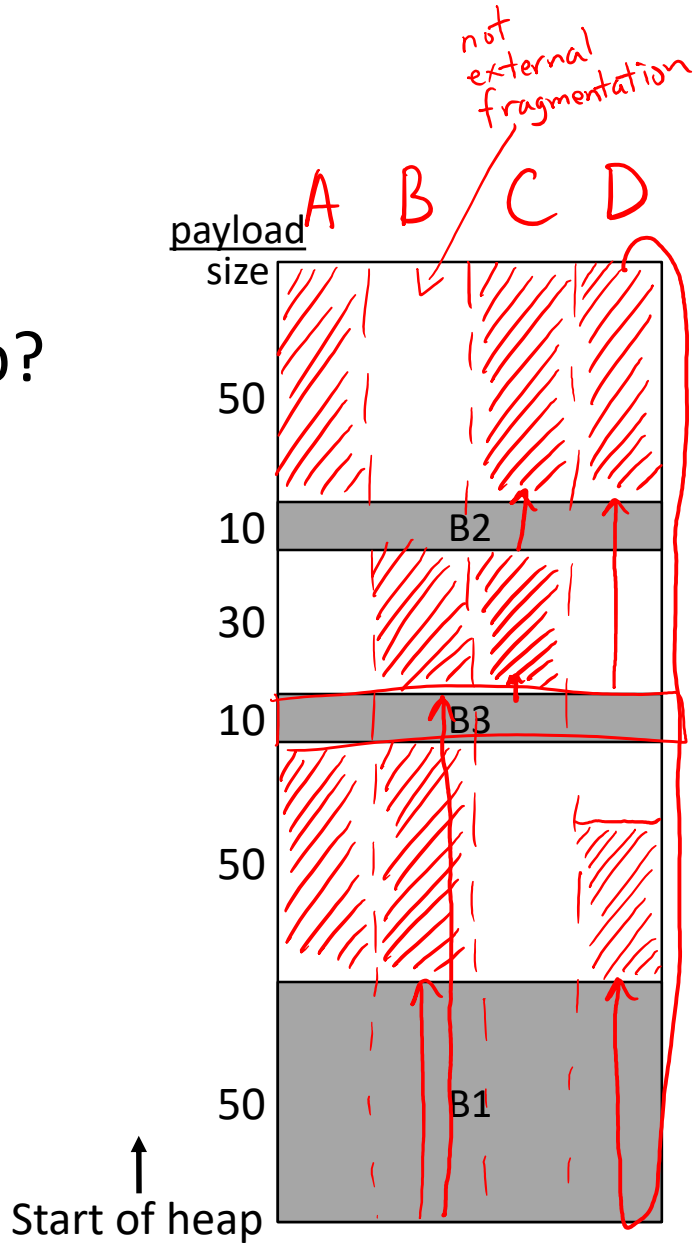
space between blocks

(A) Best-fit: `malloc(50), malloc(50)`

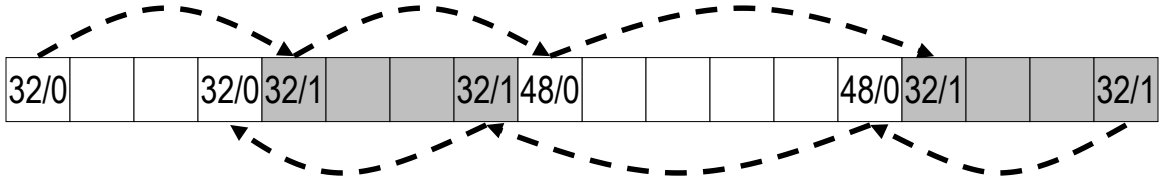
(B) First-fit: `malloc(50), malloc(30)`

(C) Next-fit: `malloc(30), malloc(50)`

(D) Next-fit: `malloc(50), malloc(30)`



Free List Review Questions



- What is the block header? What do we store and how?

  stores info about block

  size of block, is-allocated?
  ↑ lowest bit of header

- What are boundary tags and why do we need them?

  header and footer (same info)

  so we can traverse list in either direction (particularly for coalescing)

- When we coalesce free blocks, how many neighboring blocks do we need to check on either side? Why is this?

  just 1 — adjacent free blocks should have already been coalesced

Group Work Time

- During this time, you are encouraged to work on the following:
  1) If desired, continue your discussion
  2) Work on the homework problems
  3) Work on the current lab

- Resources:
  - You can revisit the lesson material
  - Work together in groups and help each other out
  - Course staff will circle around to provide support