Memory Allocation II

CSE 351 Winter 2024

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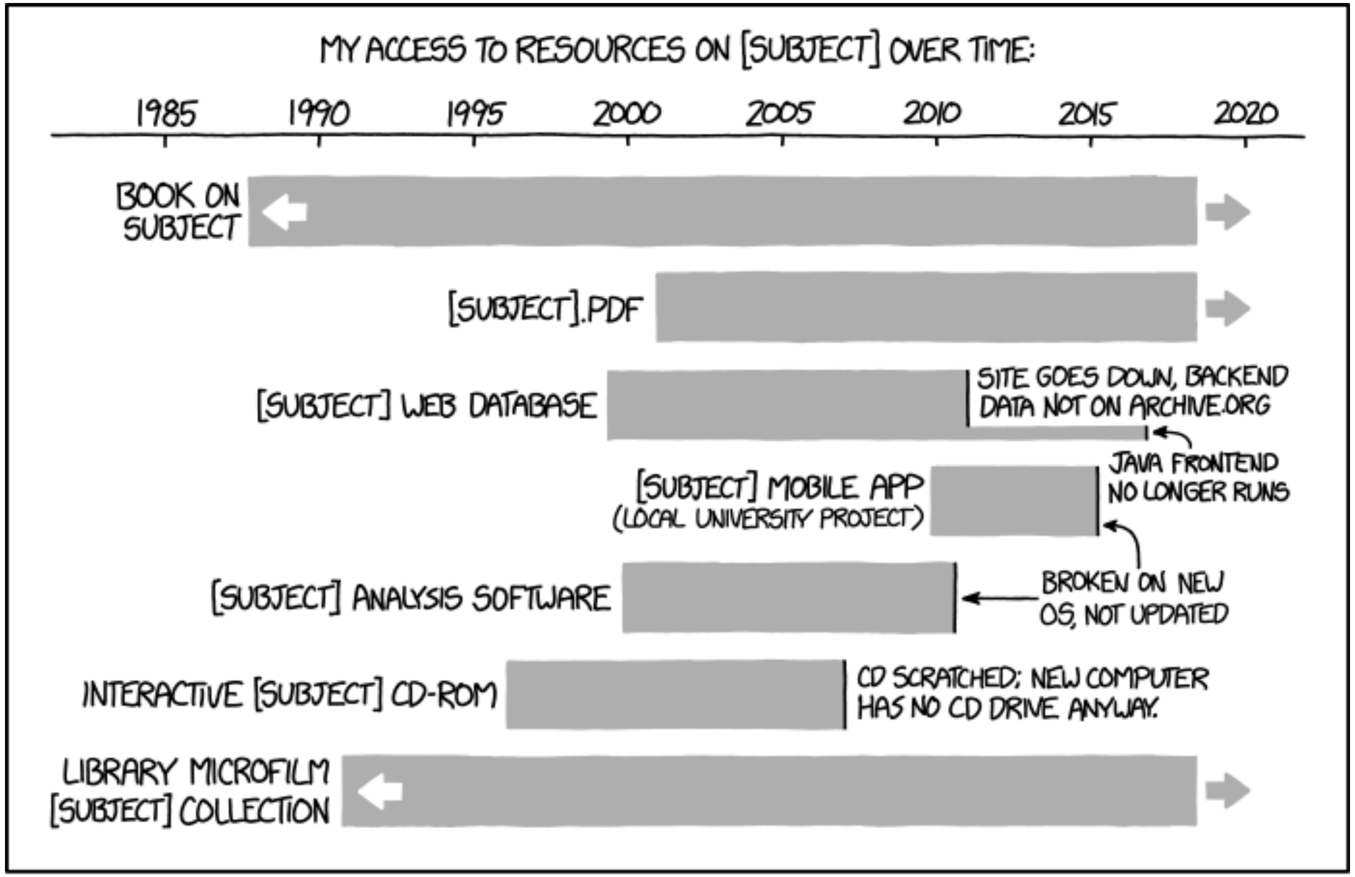

MY ACCESS TO RESOURCES ON [SUBJECT] OVER TIME:
1985
1990
1995
2000
2005
2010
2015
2020
BOOK ON SUBJECT
[SUBJECT].PDF
[SUBJECT] WEB DATABASE
SITE GOES DOWN, BACKEND DATA NOT ON ARCHIVE.ORG
JAVA FRONTEND NO LONGER RUNS
[SUBJECT] MOBILE APP (LOCAL UNIVERSITY PROJECT)
[SUBJECT] ANALYSIS SOFTWARE
BROKEN ON NEW OS, NOT UPDATED
INTERACTIVE [SUBJECT] CD-ROM
CD SCRATCHED; NEW COMPUTER HAS NO CD DRIVE ANYWAY.
LIBRARY MICROFILM [SUBJECT] COLLECTION

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

http://xkcd.com/1909/

Relevant Course Information

- HW18 due tonight!
- HW19 due Monday (2/26)
- HW20 due Wed (2/28)
  - Mostly a walk through of the heap simulator.

- Lab 4 due next Friday (3/1)
- Lab 5 (Mem Alloc) released!
  - Due Friday of finals week so a little over 2 weeks from now.

Memory Allocation II

Lesson Summary (1/4) - Fulfilling an Allocation Request

1) Compute the necessary block size

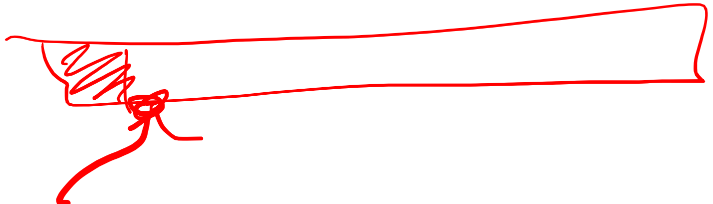
payload, padding, metadata

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

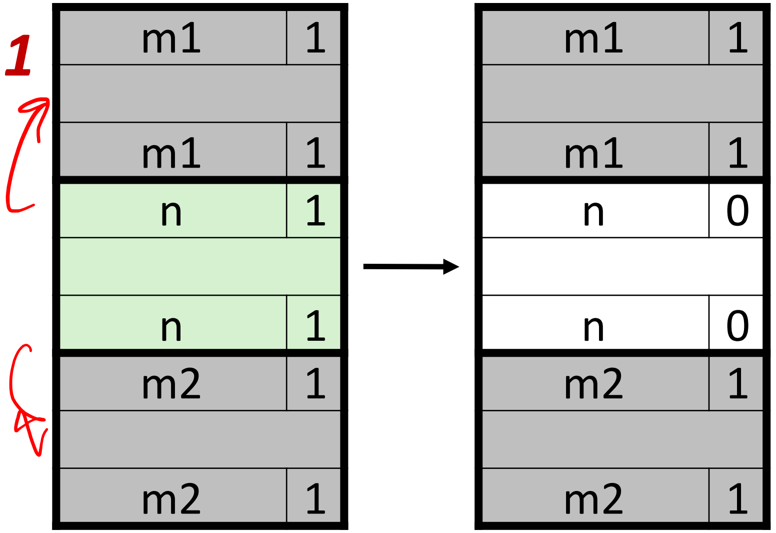
3) Compare the necessary block size against the size of the chosen block
   - If equal, allocate the block
   - If not, *split* off the excess into a new free block before allocating the block

4) Return the address of the beginning of the payload

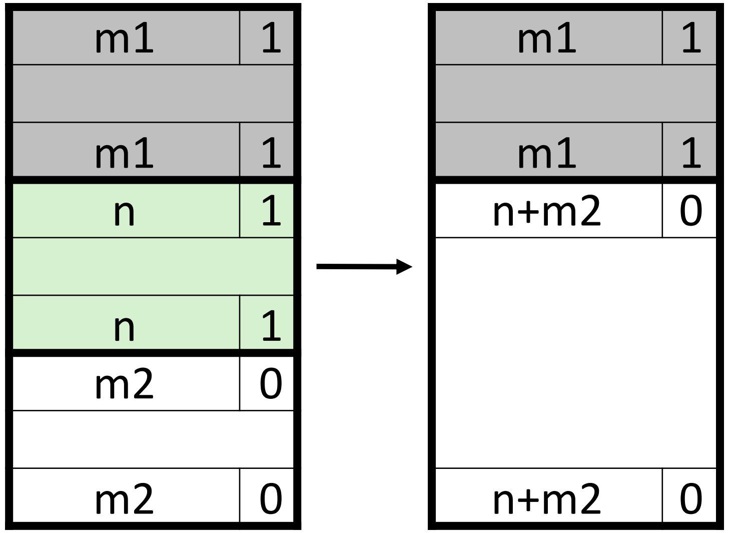


Lesson Summary (2/4) - Constant Time Coalescing

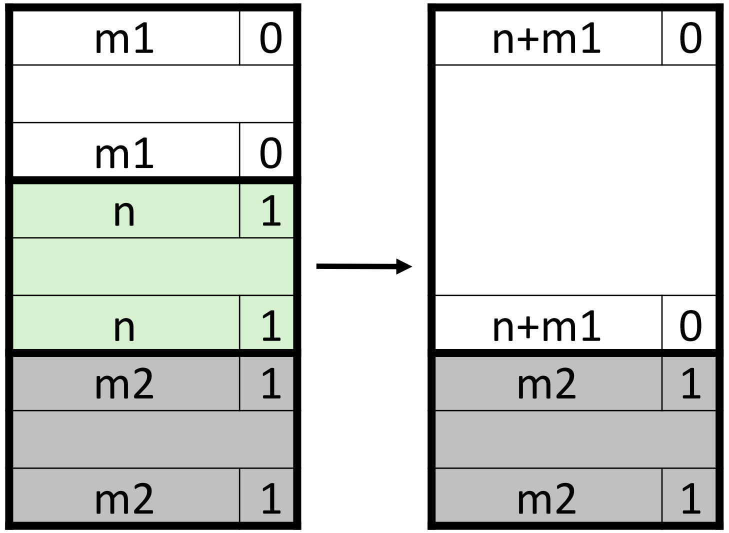
Case 1



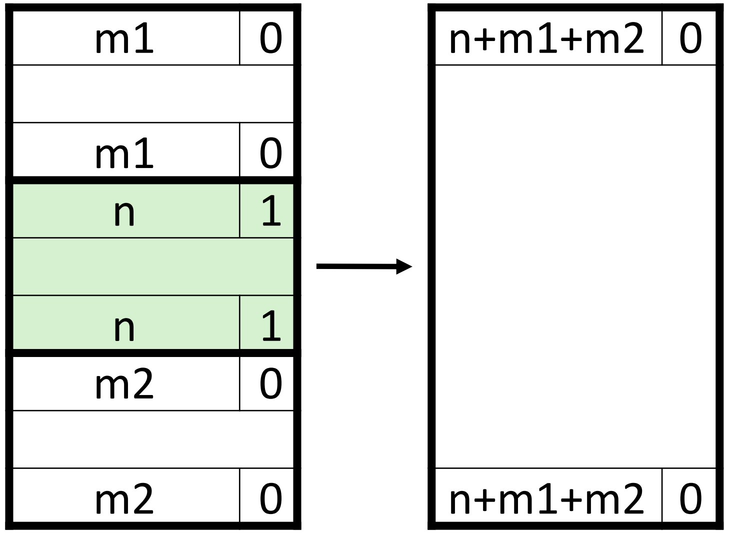
Case 2



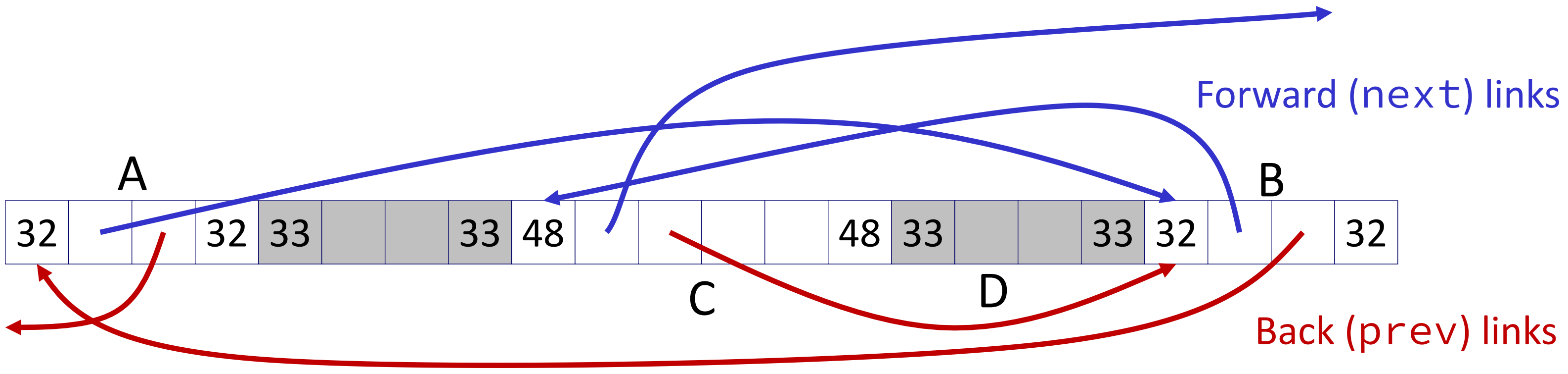
Case 3



Case 4

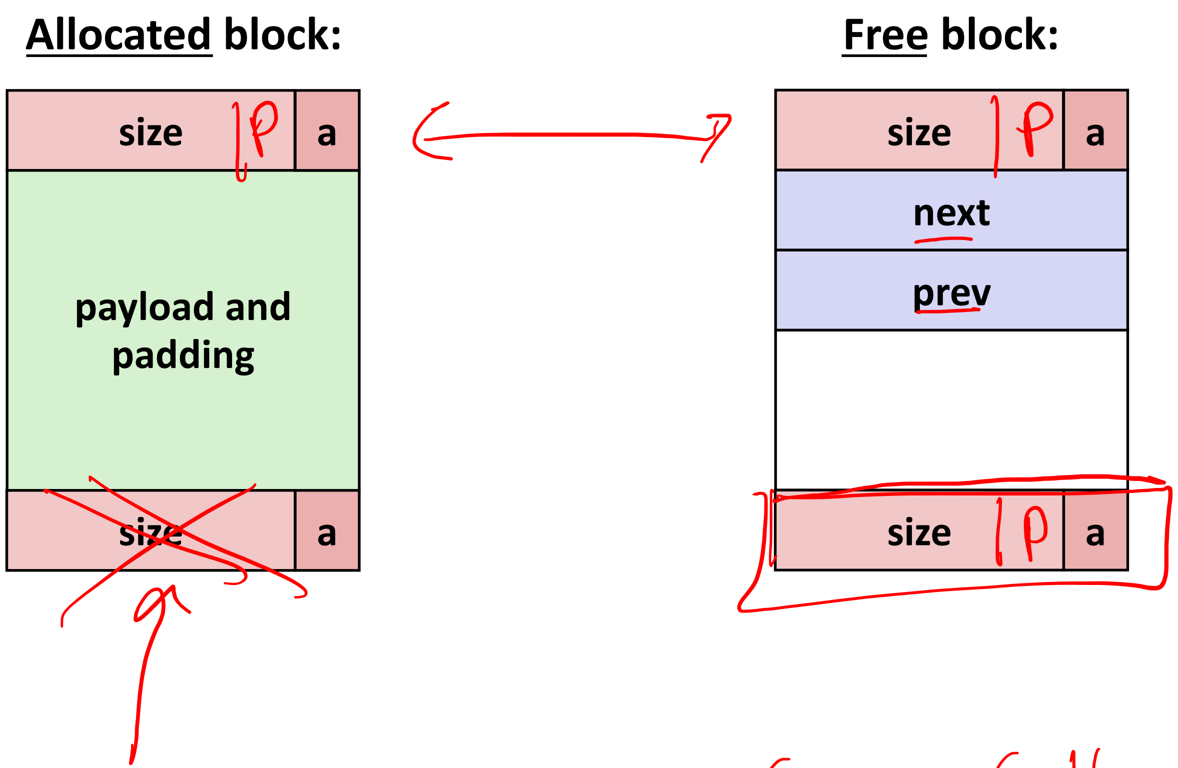


Lesson Summary (3/4) - Explicit List Summary



- 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 Summary (4/4) - Block Anatomy and Minimum Block Size



Allocated block:

size |p	a
payload and padding	
~~size~~	a

Free block:

size |p	a
next	
prev	
size |p	a

mbs = Max(min(alloc), min(free))

Lesson Q&A

- 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!
  - Cache implications (how tolerant are we to variable stride access patterns)
  - Alignment (*i.e.*, how many tags can we use in the header/footer)

- Placement policy: first-fit, next-fit, best-fit
  - Throughput vs. amount of fragmentation

- When does the allocator free allocated blocks?
  - Deferred coalescing

Memory Allocation II – Practice

Practice Question (1/2)

Determine the minimum block sizes (mbs) for the given memory allocators

allocated blocks must have a **payload size of at least 1*

boundary tags (headers and footers) are **8 bytes*

Alignment	Allocated blocks	Free blocks	Free list type	mbs alloc.	mbs free	mbs
8	header & footer 8 + 8 + ~~8~~ 1 + 7	header & footer 8 + 8	implicit	? 24	? 16	? → 24
8	header 8 + 1 → 16	header & footer 8 + 8 + 16	explicit	? 16	? 32	? → 32
16	header & footer 8 + 8 + 1	header & footer 8+8 + 16	explicit	? 32	? 32	? → 32

17 → 32

32

Practice Question (2/2)

header = size | prev-used | is-allocated

Imagine we take a snapshot of the heap after a series of malloc and free calls. Come up with at least 2 issues/bugs with the below heap (there are 4)

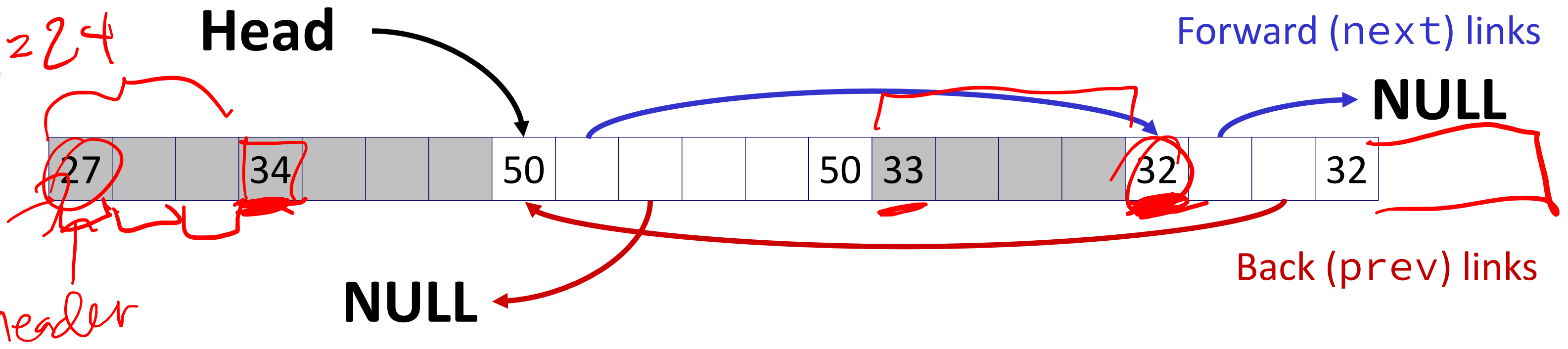
mbs = 32

- Explicit free list
- Alignment: 8
- Boundary tags: 8 bytes
  - Allocated blocks: header
  - Free blocks: header, footer

□ **= 8 bytes**

1. 0b100010
   0b100011 = 35
2. size(block #1) < mbs
3. 0b100000
   0b100010 → 34
4. no term. block at end of heap
   p|1

0b11000 = 24



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