

Memory Allocation I

CSE 351 Autumn 2023

Instructor:
Justin Hsia

Teaching Assistants:

Afifah Kashif	Malak Zaki
Bhavik Soni	Naama Amiel
Cassandra Lam	Nayha Auradkar
Connie Chen	Nikolas McNamee
David Dai	Pedro Amarante
Dawit Hailu	Renee Ruan
Ellis Haker	Simran Bagaria
Eyoel Gebre	Will Robertson
Joshua Tan	

WHEN WILL WE FORGET?

BASED ON US CENSUS BUREAU
NATIONAL POPULATION PROJECTIONS

ASSUMING WE DON'T REMEMBER CULTURAL
EVENTS FROM BEFORE AGE 5 OR 6

BY THIS YEAR:	THE MAJORITY OF AMERICANS WILL BE TOO YOUNG TO REMEMBER:
2016	RETURN OF THE JEDI RELEASE
2017	THE FIRST APPLE MACINTOSH
2018	NEW COKE
2019	CHALLENGER
2020	CHERNOBYL
2021	BLACK MONDAY
2022	THE REAGAN PRESIDENCY
2023	THE BERLIN WALL
2024	HAMMERTIME
2025	THE SOVIET UNION
2026	THE LA RIOTS
2027	LORENA BOBBITT
2028	THE FORREST GUMP RELEASE
2029	THE RWANDAN GENOCIDE
2030	OT SIMPSON'S TRIAL
2038	A TIME BEFORE FACEBOOK
2039	VH1's I LOVE THE 90s
2040	HURRICANE KATRINA
2041	THE PLANET PLUTO
2042	THE FIRST IPHONE
2047	ANYTHING EMBARRASSING YOU DO TODAY

Adapted from
<https://xkcd.com/1093/>

Relevant Course Information

- ❖ hw17 due tonight
- ❖ hw19 due Friday (11/17)
 - Lab 4 preparation!
- ❖ hw20 due Monday (11/20)

- ❖ Lab 4 due Monday after Thanksgiving (11/27)
 - Section tomorrow intended to help prepare you for Lab 4

- ❖ Midterm scores posted
 - See Ed post #966 for common misconceptions and deductions
 - Regrade requests open from Nov. 16-18 (Thu-Sat)

Growth vs. Fixed Mindset



- ❖ Students can be thought of as having either a “growth” mindset or a “fixed” mindset (based on research by Prof. Carol Dweck)
 - “In a **fixed mindset** students believe their basic abilities, their intelligence, their talents, are just fixed traits. They have a certain amount and that's that, and then their goal becomes to look smart all the time and never look dumb.”
 - “In a **growth mindset** students understand that their talents and abilities can be developed through effort, good teaching and persistence. They don't necessarily think everyone's the same or anyone can be Einstein, but they believe everyone can get smarter if they work at it.”

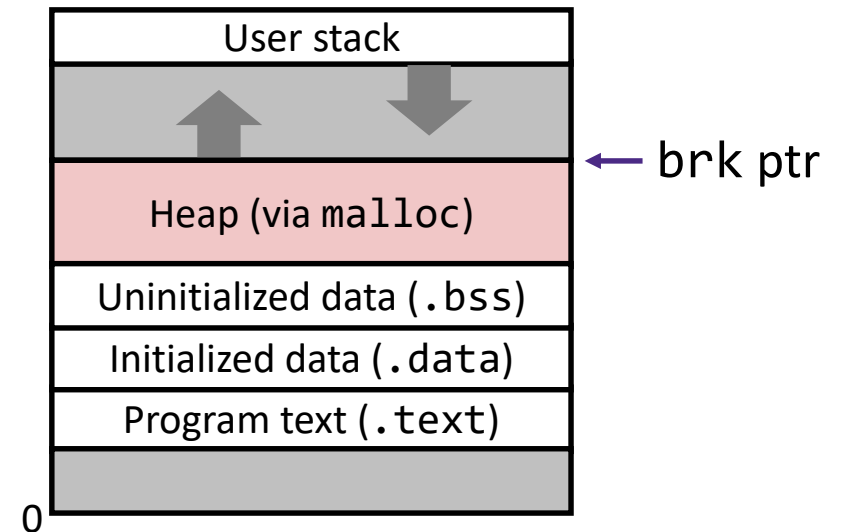
A detailed, colorful micrograph of a microchip die, showing a complex grid of circuitry and various colored regions (purple, blue, yellow, green, red) representing different functional blocks.

Memory Allocation I

Lesson Summary (1/3)

❖ **Dynamic memory allocation** is used when size or lifetime is not known until runtime

- Memory allocated in the heap segment of memory:
- In C: `void* malloc(size_t size)`
- In C: `void free(void* p)`
- In Java: `new`

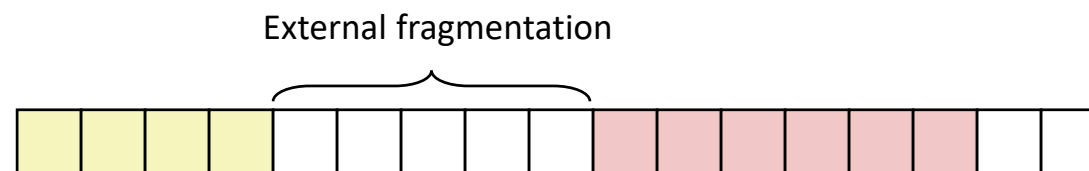
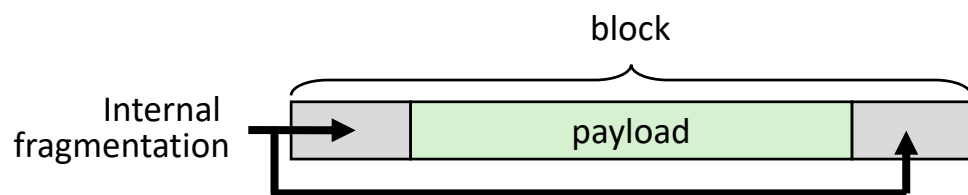


❖ Managed by dynamic memory allocator

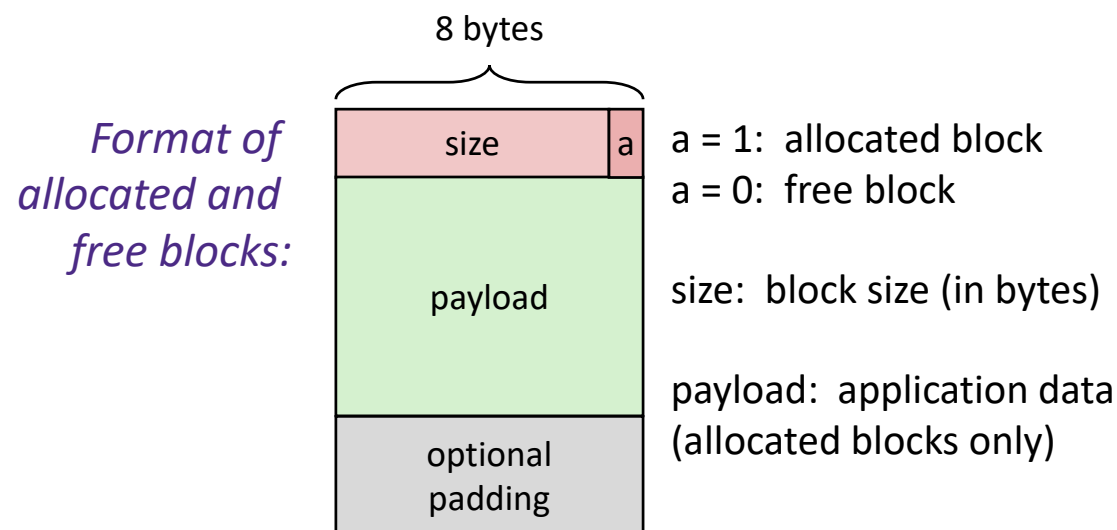
- Implicit: automatic deallocations, Explicit: manual deallocations
- Performance metrics: throughput, memory utilization

Lesson Summary (2/3)

- ❖ The heap is divided into allocated and free **heap blocks**
 - Fragmentation: internal is non-payload space within blocks, external is free space between allocated blocks



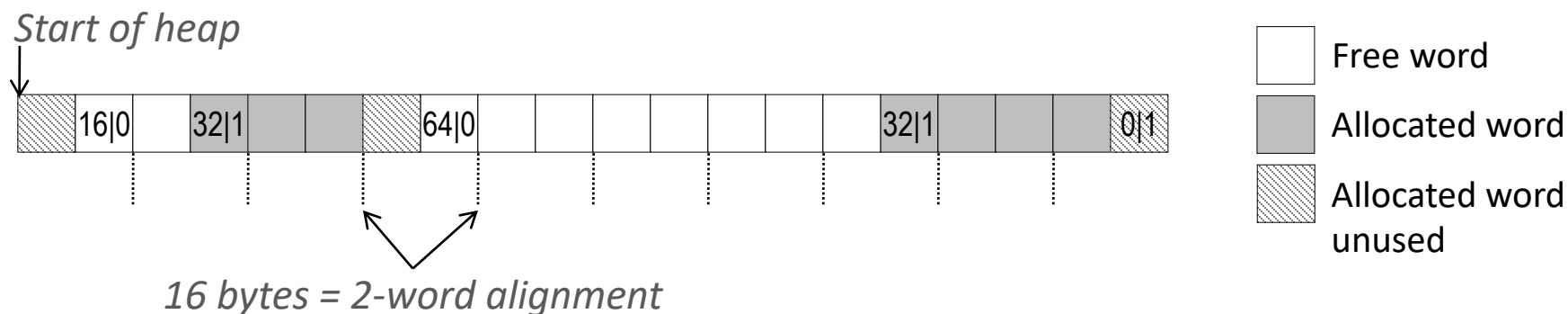
- Blocks have headers with size and is-allocated? Information:



Lesson Summary (3/3)

□ = 8-byte word

- ❖ Implicit free list example
- ❖ Heap blocks (size | is-allocated?): 16 | 0, 32 | 1, 64 | 0, 32 | 1



- ❖ 16-byte alignment for (1) *heap block size* and (2) *payload address*
 - Padding for size is considered part of *previous* heap block (internal fragmentation)
 - May require initial padding at start of heap
- ❖ Special one-word marker (0 | 1) marks end of list
 - Zero size is distinguishable from all other blocks

Lesson Q&A

- ❖ Terminology:
 - Dynamically-allocated data: malloc, free
 - Allocators: implicit vs. explicit allocators, heap blocks, implicit vs. explicit free lists
 - Heap fragmentation: internal vs. external, padding, alignment
 - Header, heap block size, is-allocated? bit

- ❖ Learning Objectives:
 - Use `malloc` and `free` in C programs to manage dynamic data.
 - Explain the tradeoffs between different allocator implementations, [policies, and strategies].

- ❖ What lingering questions do you have from the lesson?

A detailed, colorful micrograph of a microchip die, showing intricate patterns of circuitry in shades of purple, blue, green, and yellow. The text is overlaid on this background.

Memory Allocation I – Practice

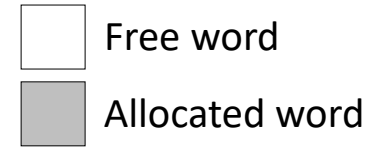
Practice Questions (1/2)

- ❖ Which of the following statements is FALSE?
 - A. Temporary arrays should *not* be allocated on the Heap
 - B. `malloc` returns an address of a payload that is filled with mystery data
 - C. Peak memory utilization is a measure of both internal and external fragmentation
 - D. An allocation failure will cause your program to stop
 - E. We're lost...

Practice Questions (2/2)

- ❖ How many “flags” can we fit in our header if our allocator uses 16-byte alignment?
- ❖ If we placed a new “flag” in the second least significant bit, write out a C expression that will extract this new flag from header

Homework Setup



❖ *Implicit free list* that uses **8-byte headers** and **8-byte alignment**. The current blocks on the heap are numbered and sized as follows.

- Draw out the heap starting at address “0”. What is the address of each allocated block’s payload?
- How much padding does each allocated block have?

#	Size	Type	Request
1	16 B	allocated	malloc(8)
2	40 B	free	n/a
3	32 B	allocated	malloc(20)
4	16 B	free	n/a
5	48 B	allocated	malloc(35)
6	24 B	free	n/a

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