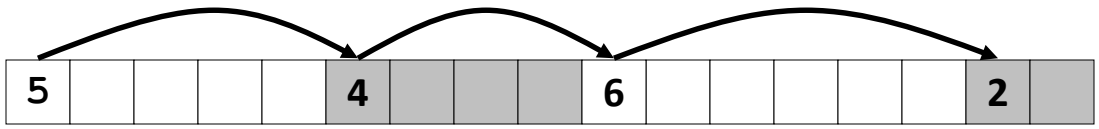
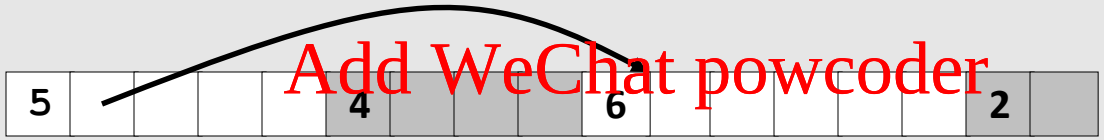
Keeping Track of Free Blocks

- Method 1: ***Implicit free list*** using length—links all blocks



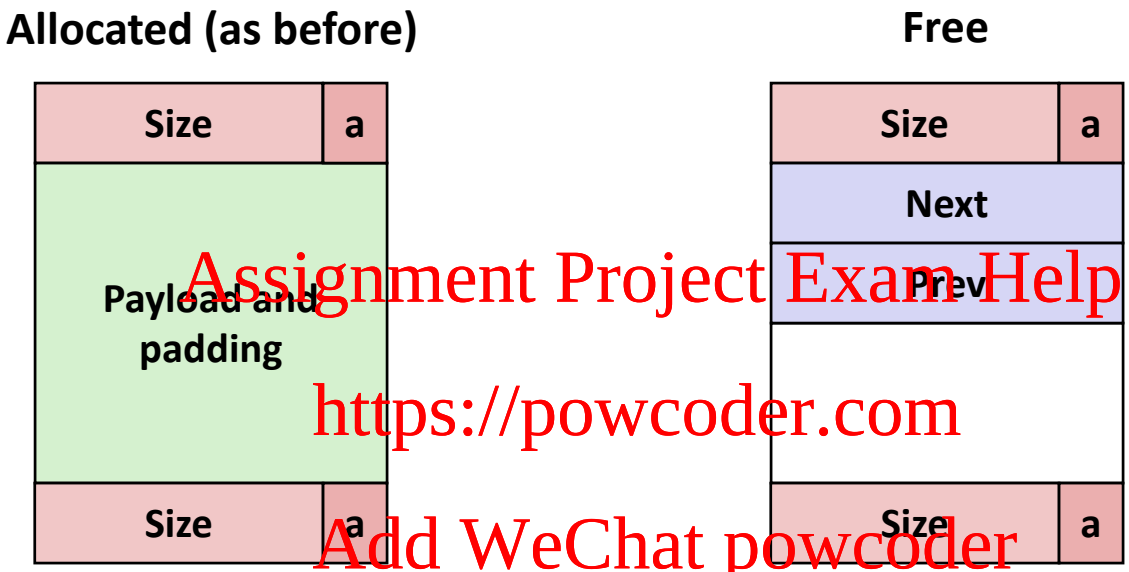
- Method 2: ***Explicit free list*** among the free blocks using pointers



- Method 3: ***Segregated free list***
  - Different free lists for different size classes

- Method 4: ***Blocks sorted by size***
  - Can use a balanced tree (e.g. Red-Black tree) with pointers within each free block, and the length used as a key

Explicit Free Lists

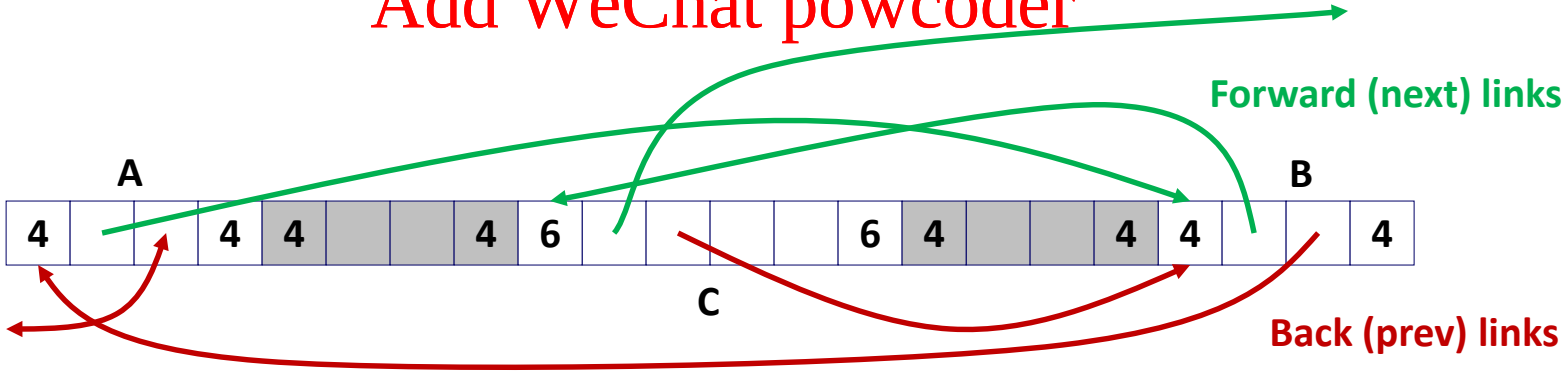


- **Maintain list(s) of *free* blocks, not *all* blocks**
  - The "next" free block could be anywhere
    - So we need to store forward/back pointers, not just sizes
  - Still need boundary tags for coalescing
  - Luckily we track only free blocks, so we can use payload area

Explicit Free Lists

- Logically:

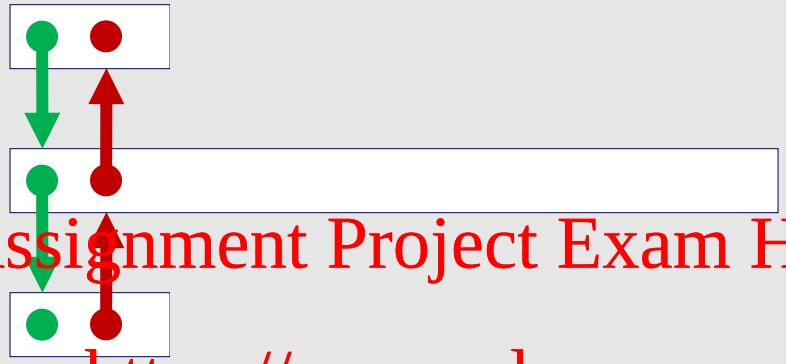
- Physically: blocks can be in any order



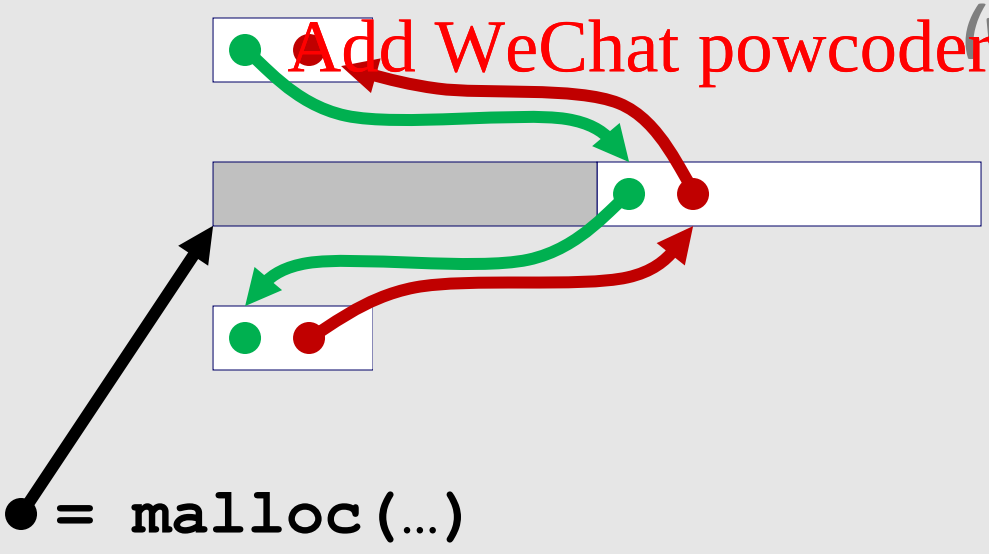
Allocating From Explicit Free Lists

conceptual graphic

Before



After *(with splitting)*



Freeing With Explicit Free Lists

- ***Insertion policy*: Where in the free list do you put a newly freed block?**
  - **LIFO (last-in-first-out) policy**
    - Insert freed block at the beginning of the free list
    - ***Pro:*** simple and constant time
    - ***Con:*** studies suggest fragmentation is worse than address ordered
  - **Address-ordered policy**
    - Insert freed blocks so that free list blocks are always in address order:

      addr(prev) < addr(curr) < addr(next)

    - ***Con:*** requires search
    - ***Pro:*** studies suggest fragmentation is lower than LIFO

Explicit List Summary

- **Comparison to implicit list:**
  - Allocate 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 needs to splice blocks in and out of the list
  - Some extra space for the links (2 extra words needed for each block)
    - Does this increase internal fragmentation?
- **Most common use of linked lists is in conjunction with segregated free lists**
  - Keep multiple linked lists of different size classes, or possibly for different types of objects