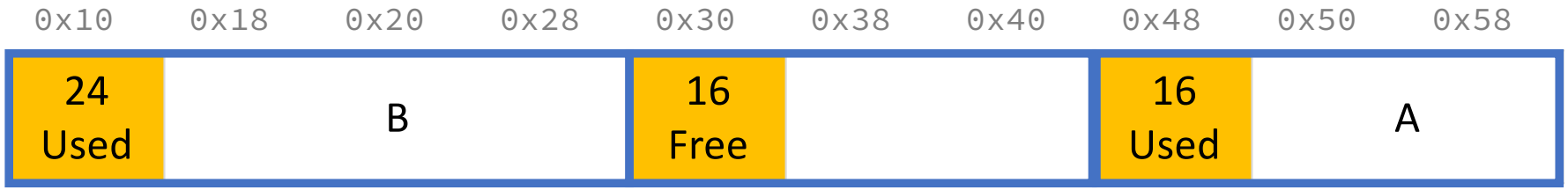
CS107 Lecture 23
Managing The Heap, Take III

Reading: None

Explicit Allocation and Coalescing Etude 1

For the following heap layout, what would the heap look like after the following request is made, assuming we are using an **explicit** free list allocator with a **first-fit** approach and **coalesce on free**?




```
free(b);
```

Heap Allocator Goals Revisited

Can we do better?

1. Can we avoid searching all blocks for free blocks to reuse?

   Yes! We can use a doubly-linked list.

2. Can we merge adjacent free blocks to keep large spaces available?

   Yes! We'll illustrate this in a few minutes.

3. Can we avoid copying/moving data during `realloc`?

   Sometimes! We'll illustrate this ~~ne~~ NOW! ~~e.~~

Next time has arrived! ⏰

Explicit Allocators and In-Place `realloc`

For our implicit allocator, **`realloc`** isn't even remotely clever. We always **`malloc`** a new block, **`memcpy`** the data from old to new, and **`free`** the old block before returning the new payload address.

Always!

Sometimes we can **resize in place**. Your **explicit allocator** should try this:

- **Case 1:** size is **bigger**, but we added **padding to the block**, and we can just use that.
- **Case 2:** size is **smaller**, so we can use the **existing block** and perhaps even **clip off the excess** to create another free node.
- **Case 3:** size is **bigger**, and current block isn't big enough, but adjacent blocks are free.

Explicit Allocators and In-Place `realloc`

```
void *a = malloc(42);
...
a = realloc(a, 48);
```

Case 1:

a's earlier request couldn't do anything with the **excess eight bytes**, so it was just **lumped into the payload as padding**.

Now they are requesting a larger size that **can accommodated with that padding**! **`realloc`** can return the **same address** without doing anything else.

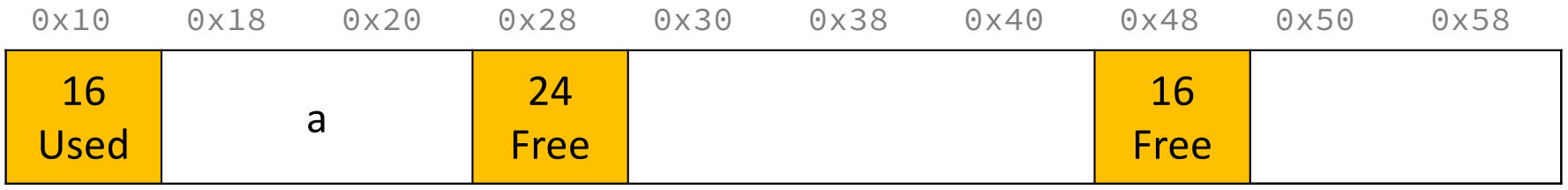
Explicit Allocators and In-Place `realloc`

```
void *a = malloc(42);
...
a = realloc(a, 16);
```

Case 2:

If **`realloc`** is being asked to **reduce the size of the block**, we can always **return the same address**.

If the new size is **at least 24 bytes** less than the old size, the **excess payload** can be **cordoned off into another block**.
Woo!



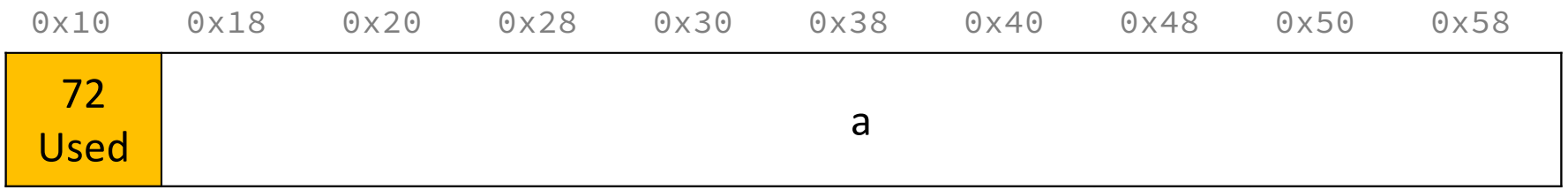
Explicit Allocators and In-Place `realloc`

```
void *a = malloc(42);
...
a = realloc(a, 72);
```

Case 3:

Even with the padding, **there isn't enough space** within the original block to accommodate the larger size.

The **right neighbor is free**, so **`realloc`** can **absorb** that right neighbor into the **original**. (Had there been **excess payload**, we'd have **clipped off a new free block**.)



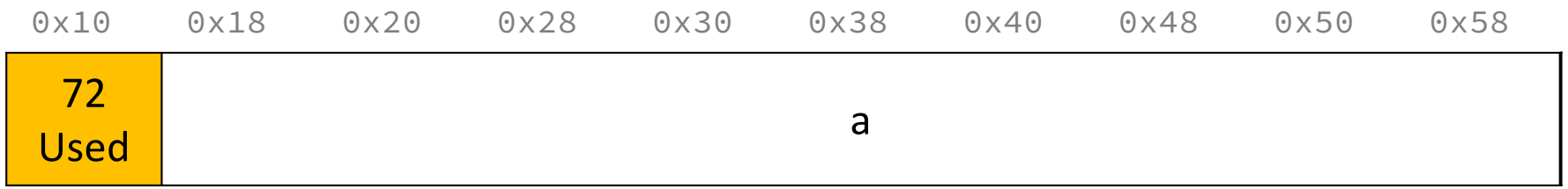
Explicit Allocators and In-Place `realloc`

```
void *a = malloc(8);
...
a = realloc(a, 72);
```

Case 3 Generalized:

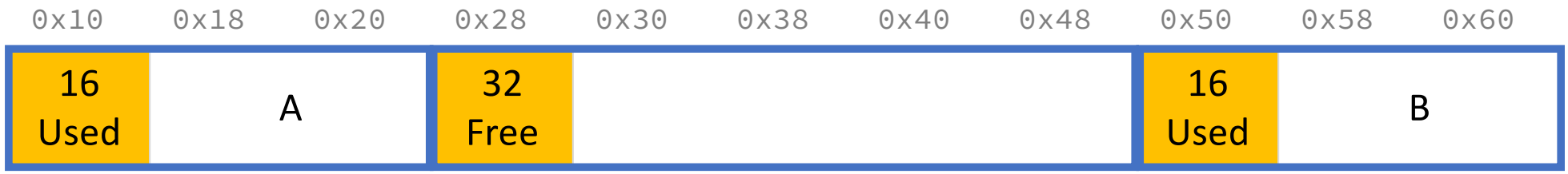
For **`assign6`**, you should **combine with your right neighbors** as much as possible until there's enough space, or until you **run out of free blocks** and **resort to a move**.

(If you **run out of blocks** and still can't **`realloc`** in place, you **don't need to revert or restore the original blocks**.)

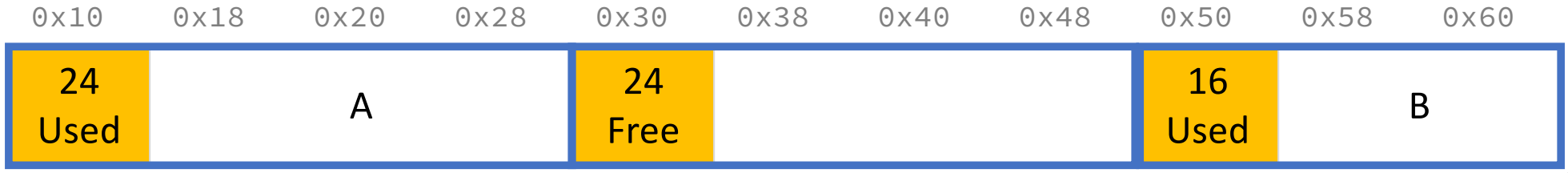


Explicit Allocation and Coalescing Etude 2

For the following heap layout, what would the heap look like after the following request is made, assuming we are using an **explicit** free list allocator with a **first-fit** approach and **coalesce on `free`** + **in-place `realloc`**?

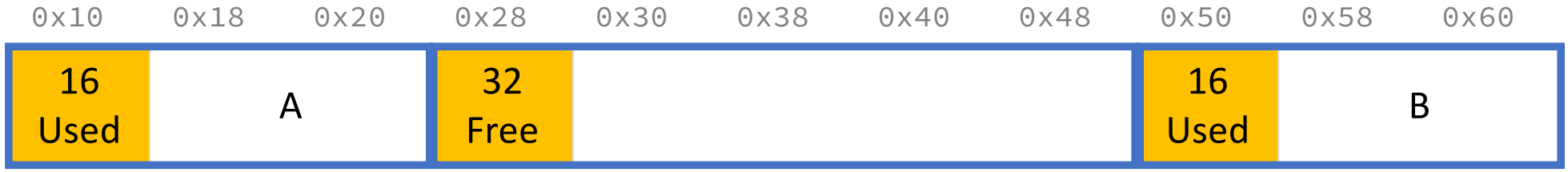



```
a = realloc(a, 24);
```

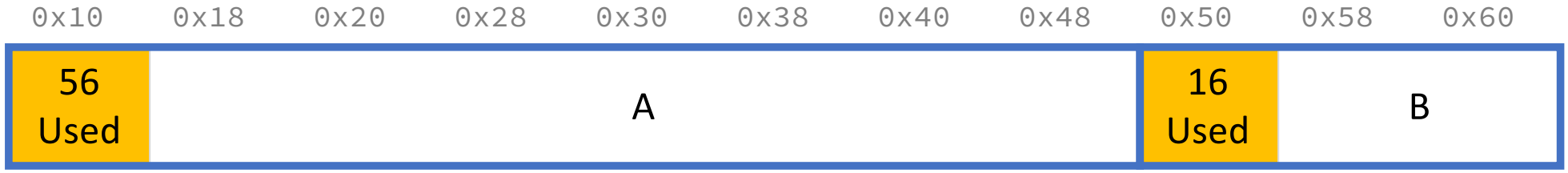


Explicit Allocation and Coalescing Etude 3

For the following heap layout, what would the heap look like after the following request is made, assuming we are using an **explicit** free list allocator with a **first-fit** approach and **coalesce on `free`** + **in-place `realloc`**?

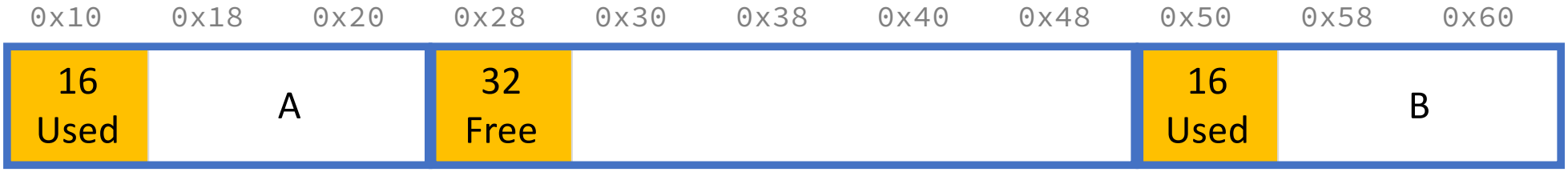



```
a = realloc(a, 56);
```



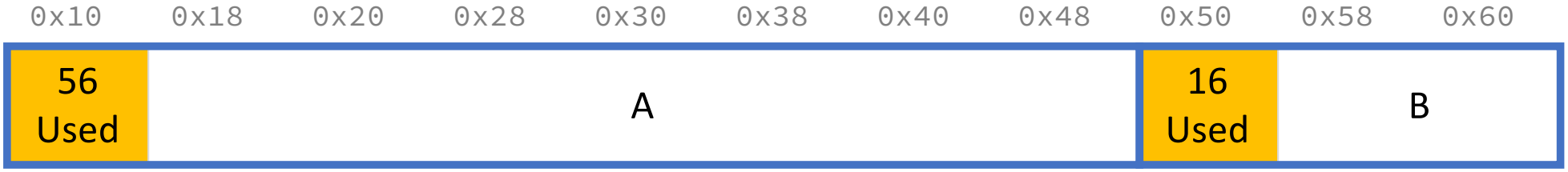
Explicit Allocation and Coalescing Etude 4

For the following heap layout, what would the heap look like after the following request is made, assuming we are using an **explicit** free list allocator with a **first-fit** approach and **coalesce on `free`** + **in-place `realloc`**?




```
a = realloc(a, 48);
```

For our explicit allocator, **we can't have a payload with less than 16 bytes**. The only sensible option for the remaining eight bytes is to **add it in as padding**.



Final Assignment: Explicit Allocator

- **Must have** headers that track block information as with implicit (size, status in-use or free). You can **copy your implicit version** to get started.
- **Must have** an explicit free list managed as a **doubly-linked list**, using the first 16 bytes of each free block's payload for **`next`** and **`prev`** pointers.
- **Must have** a **`malloc`** implementation that **searches the explicit list** of free blocks and **ignores blocks marked as in use**.
- **`free`** **must right-coalesce** its neighbor **whenever possible**. You may, though you're not required to, right-coalesce more than one if you'd like.
- **Must support** in-place **`realloc`** **whenever possible**. When in-place **`realloc`** is **not possible**, you should still **absorb all adjacent free blocks** until you **exhaustively absorb all of them**.